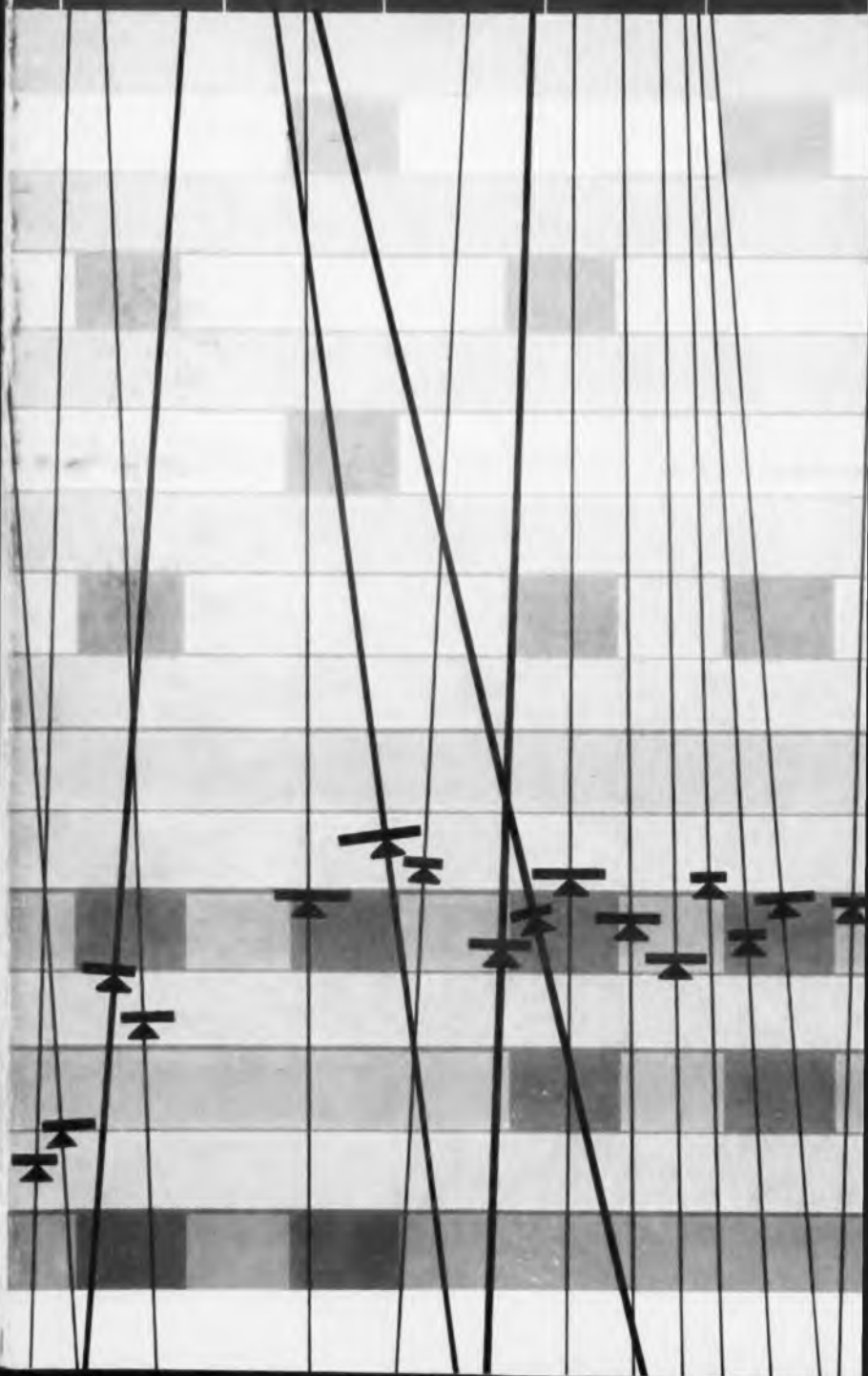


ELECT D



RONIC E S I G N

MANUSCRIPT



Forty diodes plus all necessary interconnections
in this single semiconductor converter... p 64

Quantum Electronics — A Staff Report . . . p 26

RESOLVERAMP

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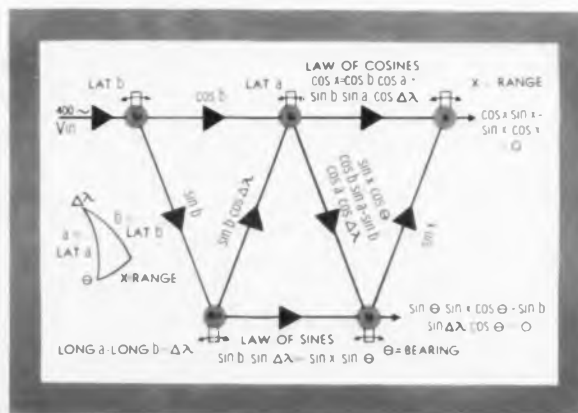
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CIRCLE 1 ON READER-SERVICE CARD



COVER: Background design represents a silicon wafer containing 40 diodes in a solid-state BCD-to-decimal converter. Black lines bearing diode symbols are at left and illustrate the multitude of elements that can be fabricated on a single wafer.

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ELECTRONIC DESIGN - ONE DAY SERVICE USE BEFORE APRIL 26th, 1961

A

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Company _____

Company Address _____ City _____ Zone _____ State _____

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608	618	628	638	648	658	668	678	688	698	708	718	728	738	748	758	768	778	788	798	808	818	828	838	848	858	868	878	888	898
609	619	629	639	649	659	669	679	689	699	709	719	729	739	749	759	769	779	789	799	809	819	829	839	849	859	869	879	889	899

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Sidelights of This Issue

Electronic Frontiersmen

In the orderly, often obscure laboratories where physicists bend quietly to probing the unknowns of quantum electronics, the maser is defined by an off-the-shelf joke. "Maser," say the industry's new frontiersmen, means Money Acquisition Scheme for Expensive Research.

Since July 1960 when Hughes Aircraft announced the first optical maser, well over a dozen major companies have joined the hunt for new materials, new operating devices.

ELECTRONIC DESIGN's technical editor, Manfred (now Maser) Meisels, has kept a watchful eye on developments. His up-to-the-minute report, "Quantum Electronics: A Key to the Future," opens on p 26 of this issue and is required reading for Space Age engineers.

About 75 per cent of the research being done in quantum electronics, Editor Meisels has found, is concentrated on masers and variations thereof.

Most of the researchers by far—at least 90 per cent—are physicists. But a curious thing, our man has noticed: they think more like engineers than like physicists; they are highly interested in applications. And in a field as new as quantum electronics, the experimental device is the operating device.

Idea Man of the Year

The phone jangled at the Martin Co. in Baltimore for group engineer Roy P. Foerster recently and what he heard at the other end of the line sounded suspiciously like the jingle of a cash register. When he had regained his professional calm, he realized that he was \$500 richer. Just like that. **ELECTRONIC DESIGN** was calling to inform him that his Idea for Design had won the 1960 Idea of the Year Award.

Mr. Foerster's Idea, selected for its broad usefulness, was published in the June 22 issue of *ED*. It shows how an LC ringing circuit can be used in transistorized blocking oscillators or multivibrators to stabilize the triggering points and to enhance the frequency stabilization. Mr. Foerster's Idea represents an adaptation of a circuit used successfully in vacuum-tube type TV sets.

This year's Idea for Design competition is in full swing in *ED*. So send in your Idea. The big prize this year: \$1,000.

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FEATURES

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Down to 1 kc in
One Wide Video Sweep.
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- Highly Stable, Narrow-Band
Video Frequency Sweeps
(20 kc on Variable Bands,
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Low-End Expansion.
Linear Sweeps 0.2 cps to
30 cps; Linear Sweep Locked
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8 Fixed, Narrow-Band
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- Fundamental Frequency
10 mc to 220 mc.
(Widths to 30 mc Plus.)
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Center Freqs.
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- High-Level RF Output—
1.0-V rms into 70 ohms.
AGC'd to ± 0.5 db
Over Widest Sweep.

PRICE: \$1295.00 F.O.B.
Factory (\$1425.00 F.A.S.
New York). Includes variable
and audio bands. (Fixed-fre-
quency bands to customer
specified frequencies; add
\$17.00 per band. Pulse-type
frequency markers at \$17.00
each.)

New Audio Frequency
Sweeping Oscillator
Sona-Sweep M
Booths 3512-3518
IRE SHOW

To provide this wide and continuous coverage, the SKV makes maximum use of both fundamental and beat-frequency oscillator techniques. Three beat-frequency bands are provided—each optimized for *high stability* consistent with sweep width required. These circuits are carefully shielded and filtered to prevent spurious output signals, and are carefully balanced to preserve pure wave-shapes. The beat-frequency system also provides effective frequency coverage in a single frequency sweep, permitting a continuous single display from 1 kc to 10 mc. For high-frequency work, 9 sweep bands, operating at fundamental frequencies, provide wide, stable sweeps from 10 to 220 mc. At the low end of the spectrum, an audio-frequency sweep from 200 to 20,000 cps is provided.

For checking high-Q circuits and low-frequency response characteristics, variable rep-rates down to 0.2 cps are available. This wide choice of sweep rates (continuous to 30 cycles, and a fixed 60-cycle lock) makes it easy to select the highest *rep-rate* which gives both an *accurate response* display and easiest, brightest viewing on the scope screen. A nominally logarithmic 30-cycle sweep, most useful for studying audio and video low-pass circuits, provides an expanded view of the low-frequency end, while showing over-all frequency characteristic.

In addition to the variable-center-frequency sweep signals, a front-of-panel control permits selection of any one of 8 narrow, highly stable, fixed sweep bands at frequencies between 20 kc and 12 mc (as specified by the customer). These bands are extremely useful for repetitive alignment of a variety of narrow-band, tuned circuits.

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CIRCLE 3 ON READER-SERVICE CARD

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Electronic designers are turning increasingly to quantum electronics to extend the limits of attainable power, frequency, sensitivity and accuracy of equipment

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MicroWaves

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The Greeks had a word for it, which escapes us at the moment. And we should have a better word for it, but we haven't. In this day and age, a pedestal is not a simple device to hold something up. Rather, at least in the electronics industry, it is a unique and complex portion of an antenna system.

Canoga designs, develops and manufactures rugged, reliable, light-weight, low-cost pedestals for almost any radar and telemetry, optical and infra-red use—land-based, ship-borne, on trailers, on roof-tops; for use in the arctic, in the desert or in the tropics.

LET'S TALK ABOUT PEDESTALS



Canoga pedestals are slim, minimizing wind loading and permitting the mounting of counter-balances significantly closer, thereby greatly reducing polar moments of inertia.

Gear trains and related electronics are completely enclosed—providing protection from weather, fouling, corrosion, breakage, etc. Up to 810° of travel are available without slip-rings for non-rotational tracking and slip-ring models are available for all around tracking capability. (Canoga has developed the Tri-Ped antenna which provides complete flexibility by the addition of a third, or traverse, axis to the conventional azimuth and elevation axes.)

A single stowing lock secures both elevation and azimuth gears and disengages servos in one operation. Elevation of 200° permits "plunging" for boresight purposes.

Canoga pedestals offer compact, double planetary, interchangeable drive modules with eccentric backlash adjustment, modular interchangeable data packages, balanced elevation yoke which eliminates eccentric loading of the azimuth bearing, yielding increased high-elevation angle accuracy and minimizing the perpendicularity problem. Also, a synchro-torque transmitter hand-wheel follow-up feature eliminates unexpected pedestal accelerations when switching from the slaved to local mode of operation.

Canoga pedestals can accommodate paraboloidal dish antennas up to 28' in diameter and various helix arrays.

Standard bolt circle and bolt dimensions provide for adaptability to standard mounts or mounting can be engineered to customer specifications.

Canoga Electronics Corporation also manufactures complete radar systems, microwave ferrite devices and components, radar and telemetry antennas, radar reflectors, range instrumentation, test equipment and special electronics equipment to customer specifications. **CANOGA**

FCC Acts on Pay-TV; Hopes For UHF-VHF Sets

Commission Approves Hartford RKO-Zenith Pay-Television Tests, Again Asks Congress For Expanded Power Over Set Standards

A GREEN light by the Federal Communications Commission for the trial of pay-TV in Hartford, Conn., appears the most significant of several recent developments in the commercial television industry.

The Phonevision trial is expected to prove the feasibility of the over-the-air, pay-TV system that Zenith Radio Corp. has developed for RKO General, Inc. The system is based on a scrambling process that cuts the picture horizontally into segments. Unless program charges are accepted, the scrambled pictures are shown in inverted, or negative, form on the set owner's screen.

The FCC also has asked Congress to reconsider granting the commission control over minimum performance standards of sets shipped over state lines or imported into the country.

Zenith Radio Corp., in another development, announced plans to produce a line of color television sets in the fall.

Expansion into UHF Region Is Sought by U.S. Agency

The FCC hopes that its request for legislation will lead to increased production and sales of

TV sets able to receive both uhf and vhf programs. The commission believes that television will not expand into the uhf region until many more uhf sets exist than at present. It does not feel that availability of uhf receivers in uhf areas, or the offering of uhf converters as optional extras, are sufficient incentives for potential uhf television broadcasters.

The commission is hopeful that its request for authority will be granted. Its similar request of last year's Congress was introduced late in the session and did not get past the Interstate and Foreign Commerce Committee of either chamber.

The electronic industry, through the Electronic Industries Assoc., is opposing the request, as it did last year. The EIA maintains that enough all-channel sets are available in areas that need them and that users elsewhere should not have to pay the \$20 or \$25 it says would have to be added to the price of receivers equipped with uhf converters. In addition the EIA objects to Government control of set standards.

The FCC believes that mass production of circuitry capable of receiving both uhf and vhf would keep the added cost of all-channel sets to

consumers to around \$15 or less.

By deciding to manufacture color TV sets, Zenith will join RCA, Admiral, Emerson, Olympic, and Packard Bell. A new demodulation system is planned for the Zenith sets. The sets are expected to use the latest RCA 21-in., three-gun shadow-mask tube, some of which may be manufactured by the Zenith organization. The sets will have horizontal chassis and hand-wired rather than printed circuits.

The color demodulation system was described by the company as a Zenith-developed system that uses a new receiving tube, also developed by the company. The price of consoles is expected to be more than \$600, Zenith announces.

Pay-TV System Based on Elaborate Coding and Decoding Techniques

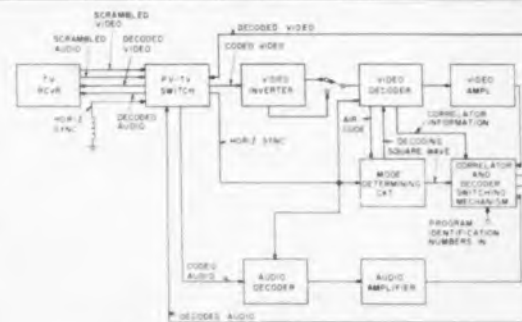
In the Phonevision system being installed in the Hartford area, all equipment is standard except for special decoders at each receiver and an encoder at the company's center. The encoder receives programs from broadcasters via wire or other link and returns coded signals for rebroadcast. It also generates another signal that in-



Decoding unit of Phonevision pay-TV system being installed in Hartford, Conn., enables subscribers to receive programs sent in scrambled form. It contains tape that records programs viewed, charges and quality of reception. Current models of the Zenith decoder have a two-way switch.



Video scrambled by encoder appears similar to this on screen until charges have been accepted. Picture segments are displaced horizontally, divisions between segments are randomly shifted from field to field, and the scene is displayed as a negative. Actual appearance appears more scrambled than the view here.



Decoder for receivers contains video delay line, for 1.7- μ sec delay, and circuitry operated by square-wave coding signals sent from transmitting station. When correct numbers are dialed, proper signal is formed from arriving signal and program is reconstituted.

structs the decoders to unscramble.

The decoder is set for operation by individual subscribers, who, initially, will pay from 25 cents to about \$3.50 per program on a credit basis. (Later the decoders may be made token-operated.) Newspaper ads and program booklets will list decoding numbers and charges for each program. Subscribers may also pay an installation-maintenance-rental charge that may amount to 75 cents a week.

Phonevision signals to be encoded pass through a stabilizing amplifier at the operating center, where sync pulses are stripped off for use in a local sync generator, which is a convenient source of signals for operating the coder.

Video output of the amplifier goes to an inverter in the video coder, which decreases amplitude of the video signal on receipt of a blank signal. In the inverter, blanks of proper polarity and phase are added, and the signal is sent to the remaining portion of the coder, including the combined delay line and switch, where actual scrambling takes place. Also added here are coding pulses from a correlated random-code generator, which eventually instruct the decoder, and pedestal and sync signals.

The coding pulses go to a mode-determining circuit, where a square-wave signal is produced that replaces the original coding signal and, in effect, codes the code for additional security against unauthorized viewing.

The scrambled video signal containing coding pulses is returned to the master control of the TV station for transmission to subscribers.

Sound is scrambled by raising all audio components 2.6 kc in frequency.

Decoder is Essentially A Delay Line and Switch

The subscribers' decoder is basically a video delay line and switch that uses the final square wave generated by the encoder but in inverse phase. It removes the coding pulses, separates them by frequency discrimination, and detects them. The frequencies may be routed many ways from six detectors to five actuating terminals, only four of which operate critically.

Only when the decoder is properly set will it interpret the coding correctly and produce the required square wave.

The system is said to be suitable for vhf, ulf and for color television. Hartford Phonevision Co., a subsidiary of RKO General, will start tests when 2,000 customers have subscribed to the planned system.

The trials will run for three years under strict conditions imposed by the FCC. ■ ■



The KIN TEL Model 501B 4-digit, over-ranging digital voltmeter measures DC from ± 0.0001 to ± 1000.0 volts to an accuracy within 0.01% of reading ± 1 digit. An extra fifth digit in the left decade indicates "0" or "1" to provide ten times greater resolution at decade (1, 10, 100) voltage points than standard 4-digit voltmeters. Ranging and polarity indication are entirely automatic. The measured voltage, decimal point and polarity symbol are displayed on an in-line readout in a single plane—no superimposed outlines of "off" digits.

An adjustable sensitivity control permits decreasing sensitivity to allow measurement of noisy signals. Ten-line, parallel input printers can be driven directly, and converters are available for driving other types of printers, typewriters, and card or tape punches. The input may be floated up to ± 300 volts DC without affecting accuracy, up to ± 500 volts DC and keep an accuracy within 1 digit of that specified. Stepping switches are energized by DC as in telephone service to provide long, trouble-free operation (covered by warranty for two years).

The 501B is one of a complete line of KIN TEL digital instruments. Others include AC converters, AC and DC preamplifiers, ratiometers, comparators, and multi-channel input scanners.

IMPORTANT SPECIFICATIONS

Display...Six decades display 5 digits (Left digit "0" or "1" only), decimal point, polarity symbol. Ranging and polarity indication are automatic. Projection system readout employs bayonet-base lamps with 3000-hour minimum life rating. Readout contains no electronic circuitry and can be remotely mounted.

Automatic Ranges... ± 0.0001 to ± 1000.0 volts DC in four ranges: 0.0001 to 1.9999; 02.000 to 19.999; 020.00 to 199.99; 0200.0 to 1000.0

Accuracy...0.01% ± 1 digit (of reading).

Input Impedance...10 megohms on all ranges at null.

Reference Voltage...Chopper-stabilized supply, continually and automatically referenced to standard cell.

Stepping-Switch Drive...DC voltage within stepping-switch manufacturers rating applied by transistor drive circuit at rate of approximately 20 steps per second.

Controls...Three: on-off; sensitivity; and mode of operation (standby, normal, print auto, print remote).

Printer Drive...Built-in for parallel input printers. Automatic or remote.

Dimensions and Net Weights...Control unit: 45 lbs. 5 1/4" H x 19" W x 16" D.
Readout: 10 lbs. 3 1/2" H x 19" W x 9" D.

Price: \$2995

KIN TEL manufactures electronic instruments for measurement and control, and closed circuit TV. Representatives in all major cities. Write for detailed literature or demonstration.

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CIRCLE 5 ON READER-SERVICE CARD

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SPECIFICATIONS

A.C. INPUT: 208/230/460 volt $\pm 10\%$,
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MRST28-200	24-32	200	$\pm 0.1\%$	$\pm 6V$	22" x 36" x 22"	550
MRST28-300	24-32	300	$\pm 0.1\%$	$\pm 6V$	22" x 36" x 24"	700
MRST28-400	24-32	400	$\pm 0.1\%$	$\pm 6V$	26" x 66" x 30"	1250
MRST28-500	24-32	500	$\pm 0.1\%$	$\pm 6V$	22" x 68 1/2" x 32"	1650
MRST28-600	24-32	600	$\pm 0.1\%$	$\pm 6V$	22" x 68 1/2" x 32"	1650
MRST2440-250	24-40†	250	$\pm 0.1\%$	$\pm 2V$	26 1/4" x 69" x 38"	1650

* For Full Load Charge

† In 2 Ranges

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NEWS

Thin-Film Memory Planes Marketed by Burroughs

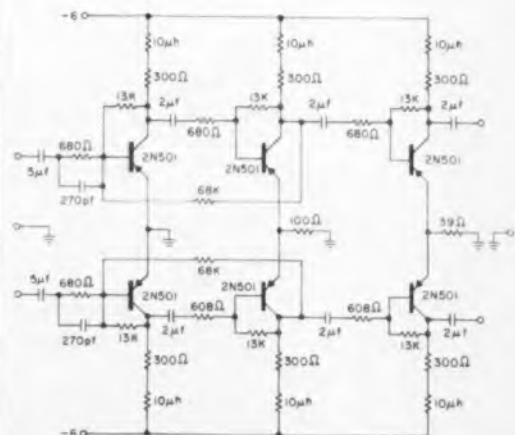
*Glass Plates Hold 160 Ni-Fe Spots
That Can Be Switched in 0.2 μ sec*

THIN-FILM memory planes are being offered to designers off-the-shelf for the first time by Burroughs Corp.'s Electronic Tube Div., Plainfield, N.J.

The BIP-1000 planes, which store 20 words of 8 bits each, are priced at \$175. Switching speeds of 0.2 μ sec are achieved with the 2,000 Å thick, nickel-iron films.

The films are vacuum-deposited on glass substrates in the form of vaporized metal. The magnetic domains in the film, which is a single domain thick, are oriented in one direction by an applied magnetic field during deposition. This direction, and the one opposite to it, are known together as the "easy" direction. One polarity represents a ONE stored in the film, and the opposite polarity represents a ZERO. The perpendicular directions are termed the "hard" direction, since a relatively large coercive field must be applied to the film to align the domains to these directions.

Writing is accomplished by perpendicular magnetic fields applied to the films. One is a



Differential sense amplifier suitable for use with Burroughs' thin-film memory planes. Sense and information conductors of adjacent planes are interconnected in a noise-canceling manner by reversing sense-conductor connections.

CIRCLE 7 ON READER-SERVICE CARD



Sixteen plates are assembled into a 320-word, thin-film experimental memory. Word-drive lines connect to a diode matrix, and sense and information lines of corresponding bits are interconnected in series.

drive field, in the hard direction, and the other is an information field in the easy direction. The polarity of the information field determines whether a ONE or ZERO will be stored.

Then, when the domains are shifted to the hard direction by a current in word-drive conductors, a current is induced in sense lines. The direction of this current depends on whether the film was stored in a ONE or ZERO state.

Operating at 1 mc with a drive current of 1 amp, a sense output signal of 5 mv with 0.05- μ sec rise time is achieved. Information currents should be about 200 ma.

Connectors used with each plane are two SR-106's, for connecting to the word drive conductors, and two SR-107's for input and output connections to information and sense lines.

Some design precautions are necessary because of the low-level sense signals. Magnetic shielding, with soft iron for example, must be used around storage elements. The influence of the earth's magnetic field can be cancelled by use of magnets or Helmholtz coils.

Either a differential amplifier or a transformer can be used to reject the common-mode noise signal. A ferrite core with four turns primary and eight turns secondary is one possibility. ■ ■



Thin-film plane, center, has printed sense, information and drive conductors placed adjacent to it. Close spacing is used to get optimum flux linkage to the films when current passes through the conductors.

db,



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SINGLE SIDE BAND FILTERS—Band ripple held to $\pm 1/2$ db, both 1 and 3db points defined, over the temperature range 0° C to 85° C, and 300 to 2000cps

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vibration at 30G level. Part #117B-FC-22-4WU

DISCRIMINATOR—Center frequency held to within 10cps, frequencies equally spaced from center, held to 5.4v peak $\pm 5\%$. Part #186C-TN-22A-WD

BAND SUPPRESSION FILTERS—2kc wide band attenuated 60db, right next to it a pass band held flat to $\pm 1/4$ db for 150kc. Part #158-TF15-6R

If you're faced with tough filtering problems, need additional information or practical application assistance, contact Bulova for engineering specialists to assist in selection of filters best

CIRCLE 8 ON READER-SERVICE CARD

NEWS

NBS Advances Helping to Ease Mounting Measurement Crisis

Government Calibration Services Eliminating Costly Trial and Error; Two New Techniques for Gaging Temperatures Are Due by July

ADVANCES in precision measurement and calibration techniques are overcoming many of the limitations that have hampered important electronic programs in the past.

Among the new steps are plans to add by July two new services to the facilities of the National Bureau of Standards at Boulder, Colo. These services will provide calibration techniques for germanium resistance thermometers in the cryogenic region and for very-high-temperature thermocouples. Illustrated here are some of the other services already developed to fill voids in measurement techniques.

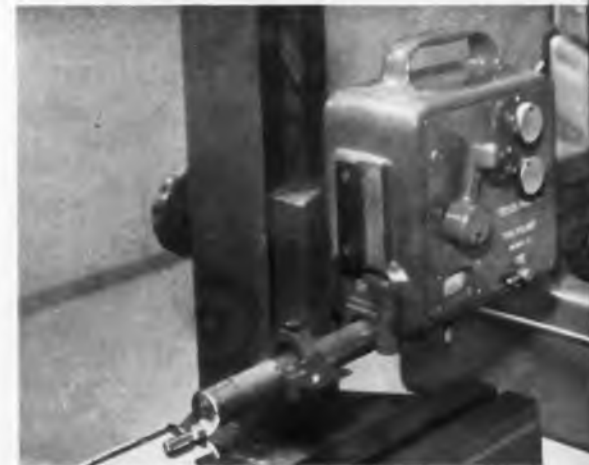
To learn of industry needs, NBS, in cooperation with the Aerospace Industries Association has held a series of conferences.

One result of these meetings is a new three-

volume handbook that gives designers complete information on various phases of measurement and calibration. The handbook, "Precision Measurement and Calibration," can be obtained by writing to the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

As an example of the problems discussed, an industry representative cited a million-dollar development of radomes that had to proceed more by trial and error than by test and analysis, because phase and amplitude could not be measured at the required frequencies.

Another participant cited over-designing of klystron tubes as another wasteful practice. The availability of techniques for accurate measurements of peak microwave power would eliminate this costly procedure. ■ ■



Experimental tantalum-tube, high-temperature furnace is assembled by NBS physicist. The furnace is used to calibrate refractory metal thermocouples at temperatures in excess of 2,000 C. A lack of standards for extremely high temperature measurements has proved a critical problem in space technology. Rocket design engineers are seriously handicapped in their efforts to improve the design of rocket motors, because standards and techniques for the measurement of exhaust gas temperatures have been essentially nonexistent.



Modulated subcarrier attenuation measurement system, developed at NBS, is adjusted by researcher. This is one of two recently developed techniques for measuring microwave attenuation. Improved techniques and standards in microwave attenuation and power were cited as areas of major importance at NBS-industry measurement research conferences.



Microwave setup, adjusted by physicist, was used to compare the microwave standards of Japan and the United States. Recent measurements have yielded agreement to within 1/4 of 1 per cent at X-band frequency. At left, just above physicist's hand, is the gold plated Japanese standard. The heart of this instrument is a tiny section of platinum wire.



More accurate inertial guidance systems should result from this new apparatus for calibrating surface finishes. This measurement is vital for inertial components, such as gyroscope parts. The standard, on the anvil at left, has regularly spaced grooves of uniform depth. Researcher monitors the procedure. Previous standards and techniques were not accurate enough for the measurement of surface characteristics to the tolerances required in some space programs.



Thirty-mc piston attenuator, developed by NBS scientists, uses the waveguide-below-cut-off principle. The instrument is used as the standard for calibration of attenuators at NBS's Electronic Calibration Center. Components are (left to right): lumped phase shifter; monitor-receiver and shielded box; piston attenuator with cooling jacket, and continuously variable phase shifter. The instrument is accurate to within 0.003 db per 10.

CIRCLE 9 ON READER-SERVICE CARD ▶

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Collector Voltage, V_{CE} -15 volts
Total Device Dissipation at 25°C 60 mw

ELECTRICAL CHARACTERISTICS (T=25°C)

	Min.	Typ.	Max.	
Static Characteristics				
Collector Cutoff Current, I_{CBO} ($V_{CB} = -5v$)		1.0	3	μA
DC Current Amplification Factor, h_{FE} ($V_{CE} = -0.5v, I_C = -10 ma$)	50	90	200	
Base Voltage, V_{BE} ($I_C = -10 ma, I_B = -0.5 ma$)	0.29	0.33	0.36	volt
Collector Saturation Voltage, $V_{CE}(SAT)$ ($I_C = -10 ma, I_B = -0.5 ma$)	.09	0.12	0.16	volt
High Frequency Characteristics				
Output Capacitance, C_{ob} ($V_{CB} = -3v, I_C = 0, f = 4 mc$)		1.9	2.5	$\mu\mu f$
Input Capacitance, C_{ib} ($V_{EB} = -1v, I_C = 0, f = 4 mc$)		6.0	10	$\mu\mu f$
Gain Bandwidth Product, f_T ($V_{CE} = -5v, I_C = 7 ma$)	320	450		mc
Switching Characteristics				
Rise Time, t_r ($\beta_C = 10$)		13	18	$m\mu sec$
Hold Storage Factor, K'_s		39	50	$m\mu sec$
Fall Time, t_f ($\beta_{CO} = 10$)		10	18	$m\mu sec$

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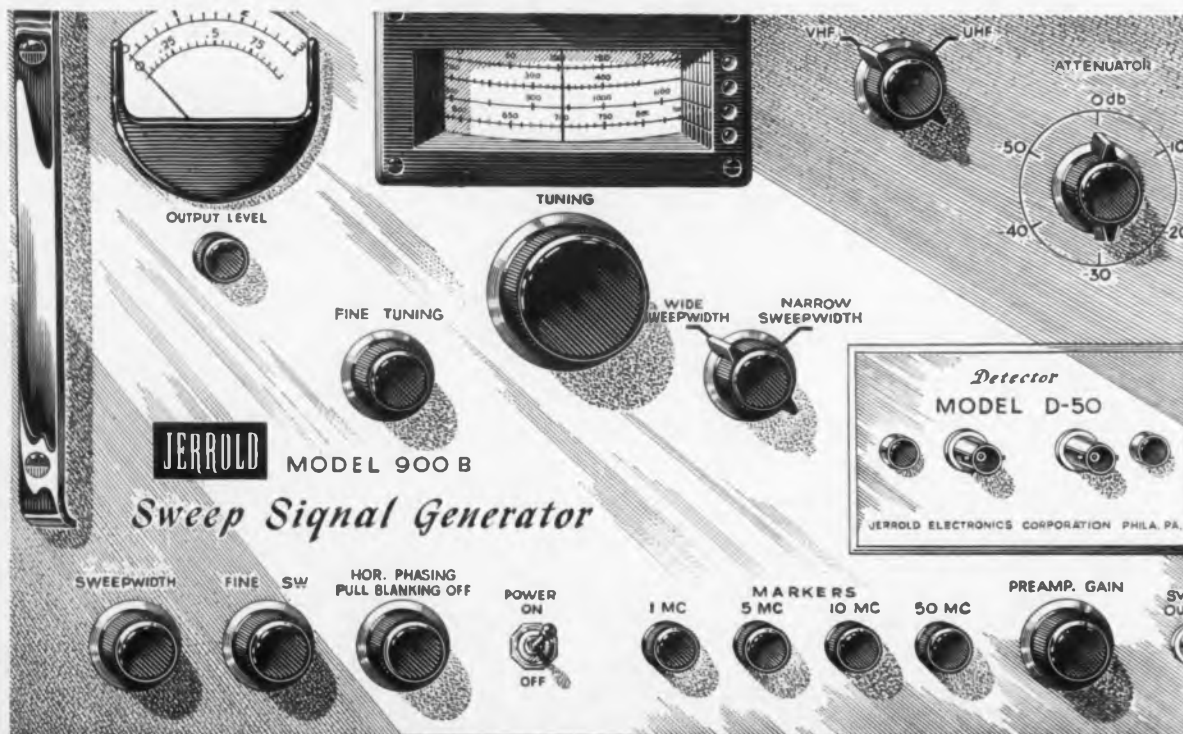
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NEWS

Tape-Recording Density Lifted by New Technique

*Anti-Skew System Clocks Every Bit,
Achieves Packing of 1,100 Bits/in.*

A NEW technique for recording information on magnetic tape can raise the density of tape records, at least theoretically, to a level of 2,000 bits per in.

One such system, delivered by Potter Instrument Co. of Plainview, N.Y., for use in a Bendix G-20 computer system, features a recording density of 1,100 bits per in. This compares with a high of about 300 to 400 bits per in. with conventional recording techniques and 556 bits per in. with International Business Machine Co.'s 729 tape system.

By having a clock pulse accompany each bit, the Potter system bypasses one of the major density limitations of digital tape transports—tape skew. In addition the Potter system requires no separate clock channel.

In conventional tape systems, where one sprocket or clock channel is used to synchronize all the data channels, if the tape does not pass the read heads at the same angle that it passed the write heads, the first bit in one channel may be read with the second or third bits in other channels. Bits in each channel must therefore be adequately spaced to avoid this problem in case of tape skew.

In the Potter system a clock pulse occurs at the beginning of each data "cell" on the tape. A "one" is recorded in the middle of a cell, between the cell boundaries. Hence, a cell with a "zero" has only one transition—that of the clock pulse. A cell with a recorded "one" has two transitions—one at the beginning, from the clock pulse, and one in the middle.

Since a clock pulse is used to gate every bit, whether it be a "zero" or "one," a data dropout can be discovered quickly, since the clock pulse would be lost as well as the data.

Following a preamble code that precedes each block of information, the bits read from each data channel are stored in a small flip-flop register called a de-skewing buffer.

This register has as many rows as there are data channels on the tape, and as many columns as necessary to compensate for the worst expected cases of tape skew. After the first column of the register is filled (and while subsequent columns are being filled), the character thus



High-density recording system undergoes test. Digital tape handler is at far right next to a computer simulator. A high-speed central control unit appears next to the oscilloscope.

formed can be read into a computer's memory.

The Potter tape system delivered to Bendix includes a six-column register. But Potter's senior engineer, Dr. Andrew Gabor, feels that this was overly conservative. A three-column register would have been adequate, he says.

According to Dr. Gabor, the new system assures a permanent error from tape of no more than one lost bit in 10 billion and a transient error of no more than one lost bit in a billion.

Potter's chief engineer, George Comstock 3d, reports that in 40 hours of running time, a Potter 906 Mark II tape handler using the new high-density recording system lost only 1 sec in re-reading a transient error. ■ ■

System Designers Warned Against Over-Protection

System design engineers, developing units for Mach 3 aircraft, have been cautioned that over-protected equipment may impair the plane's performance.

At a recent meeting of the Aircraft Electrical Society, B. F. Varney, group leader of electrical systems design at North American Aviation, Inc., said that over-protection might save the black box but abort the mission.

Mr. Varney cautioned that Mach 3 aircraft, such as the B-70, could not stand power interruptions or subnormal power characteristics for many milliseconds. If deprived of power, a gyro platform serving as a guidance component might take many minutes to re-erect itself. During this time a Mach 3 bomber may have traveled many miles under an impaired heading or a computer may have "forgotten" its calculated position, Mr. Varney noted.

New Nanosecond* Pulse Transformers for Ultra-miniature, Ultra-high Speed Applications



Digital circuit designers will find the new Sprague Type 43Z Nanosecond Pulse Transformers of considerable interest. These tiny transformers have been carefully designed for the all-important parameter of minimum rise time at high repetition rates up to 10 mc.

The new Type 43Z series is comprised of a broad line of 72 pulse transformers in 10 popular turns ratios. They are Sprague's latest addition to the most complete listing of pulse transformers offered by any manufacturer for use in digital computers and other low-level electronic circuitry.

Type 43Z Pulse Transformers are designed so that the product of leakage inductance and distributed capacitance is at a minimum. They are particularly well suited for transformer coupling in transistor circuits since transformers and transistors are very compatible low impedance devices. Nanosecond transformers are equally suitable for transmission line mode of operation, in twisted-pair transmission line coupling, and in regenerative circuits.

The epoxy-encapsulated "pancake" package is excellent for both etched wire board or conventional chassis mounting. To simplify etched-board design, these ultra-miniature pulse transformers are available with leads terminating at the side or the bottom of each unit.

For complete technical information on Type 43Z Nanosecond Pulse Transformers, write for Engineering Data Sheet 40235 to Technical Literature Section, Sprague Electric Co., 347 Marshall St., North Adams, Mass.

*millimicrosecond

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NEW! SPRAGUE LOGILINE* CIRCUITRY

for digital system design

LOGILINE circuitry features a series of 5 mc/s transistor switching circuits in building block form. Basically a pulse-level system, LOGILINE circuitry performs all of the digital functions required by computer designers, including combinational logic, temporary storage, pulse source, and pulse amplification.

Because LOGILINE "building blocks" are pre-designed to incorporate standardized switching circuits, you can save many hours of valuable design time. The basic plug-in feature, which has gained wide acceptance throughout the digital industry, is another note-worthy time saver.

LOGILINE offers designers the flexibility of encapsulated packages and the versatility of conventional wiring board construction for standard equipment assembly.

LOGIPAK* encapsulated packages

- Epoxy encapsulated for protection against severe environmental conditions
- Smaller in size than standard wiring board assemblies, in keeping with the modern trend toward miniaturization
- Priced lower than standard assemblies, due to simplified production techniques
- Transistors are accessible for test or replacement
- Pins have standard grid module spacing of 0.1 inch
- Standardized configuration—ideal for prototype design, equally suitable in final production.

Logipak series includes:

1100Z1	Inverter	2100Z5	Delay
1100Z2	Diode	3100Z1	Clock
1100Z3	Complementary Trigger	3100Z2	Pulse Generator
2100Z1	Flip-Flop	3100Z3	Pulse Amplifier
2100Z2	Trigger Network	3100Z4	Indicator Driver
2100Z4	Shift Register Flip-Flop		

LOGICARD* wiring board cards

- Epoxy glass etched wiring board and twenty-two pin connector in aluminum frame
- Designed for insertion into pre-wired rack mounted panel
- Completely interchangeable with comparable units.

Logicard series includes:

1000Z1	Inverter	2000Z4	3-Digit Shift Register
1000Z2	Diode	3000Z1	Clock
2000Z1	Flip-Flop	3000Z2	Pulse Amplifier
2000Z2	Dual Flip-Flop	3000Z3	Pulse Generator
2000Z3	Delay	3000Z4	Indicator Driver

*trademark



For complete data on LOGILINE circuitry, or application assistance on your digital design problems, write to Special Products Div., Sprague Electric Company, 347 Marshall St., North Adams, Mass.

SPRAGUE
THE MARK OF RELIABILITY

CIRCLE 12 ON READER-SERVICE CARD

EECO CIRCUIT APPLICATIONS UNLIMITED

Pulse Width Detection

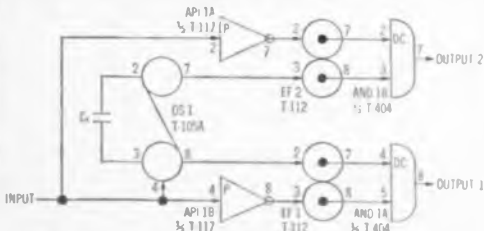
Pulse width detection circuits are normally required to perform only one of two functions: They produce an output signal when the input pulse (1) is wider than specified, or else (2) is narrower than specified. The EECO pulse width detection circuit described here performs both of these functions.

EECO T-SERIES MODULES

The circuit employs the following five T-Series germanium plug-in circuit modules:

- 1 only T-105A One-Shot Multivibrator (OS 1)
- 1 only T-117 Dual Pulse Inverter (API 1A and API 1B)
- 2 each T-112 Dual PNP Emitter Followers (EF 1 and EF 2)
- 1 only T-404 DC Logic (AND 1A and AND 1B).

The specified pulse width is established by the output pulse duration of the one shot OS 1. This is primarily determined by an external capacitor connected between pins 2 and 3 of OS 1.



CIRCUIT DESCRIPTION Input pulses are applied to both halves of pulse inverter API 1, and also to one shot OS 1. Capacitor C_x is selected so that the output pulse duration of OS 1 is longer than that of narrow input pulses to be detected, but shorter than that of wide input pulses to be detected. This selection is based on the following relation between capacity and duration:

$$C_x = 50(t-2)$$

where C_x is capacitance in μf and t is duration in microseconds. (The minimum pulse duration is 2 microseconds with no external capacitance, the maximum pulse duration is 1 second with $C_x = 50 \mu\text{f}$.)

DETECTING WIDE PULSES: The positive-going excursion of an input pulse triggers OS 1, but does not affect API 1B. As OS 1 is triggered, the output at pin 8 of OS 1 decreases to -11 volts. This voltage is coupled through EF 1 to inhibit AND 1A at pin 4 for the duration of the one-shot pulse. When the input pulse ends, the negative-going excursion triggers API 1B, which, in turn, couples an output through EF 1 to pin 5 of AND 1A.

If the input pulse is narrower than the established critical pulse width, AND 1 is still inhibited when a pulse is presented by API 1B. If, however, the input pulse is wider than the established critical pulse width, the output at pin 8 of OS 1 will have returned to -3 volts by the time a pulse is presented by API 1B, and AND 1A will be enabled. In this latter case, the pulse from API 1B causes an output from the circuit.

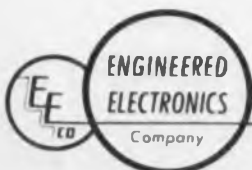
DETECTING NARROW PULSES: Input pulses trigger one-shot OS 1 as described above. In this case, the "0" (pin 7) output of OS 1 is coupled through EF 2 to enable AND 1B at pin 3 for the duration of the one-shot pulse. When the input pulse ends, the negative-going excursion triggers API 1A, which, in turn, couples an output through EF 2 to pin 2 of AND 1B.

If the input pulse is narrower than the established critical pulse width, AND 1B is still enabled when a pulse is presented by API 1A, and the circuit generates an output pulse. If, however, the input pulse is wider than the established critical pulse width, the output at pin 7 of OS 1 will have returned to -11 volts by the time a pulse is presented by API 1A and AND 1B will be inhibited, preventing any outputs.

This is typical of the many practical applications of EECO T-Series Germanium plug-in circuit modules. We stand ready to furnish circuit modules and application data to meet the needs of your specific problems. Write or wire today.

ENGINEERED ELECTRONICS COMPANY

1441 EAST CHESTNUT AVENUE • SANTA ANA, CALIFORNIA



Raster Display Handles 400 Data Channels

New System for Flight and Static ICBM Testing Permits Fast, Visual Monitoring of Multibar Graphs



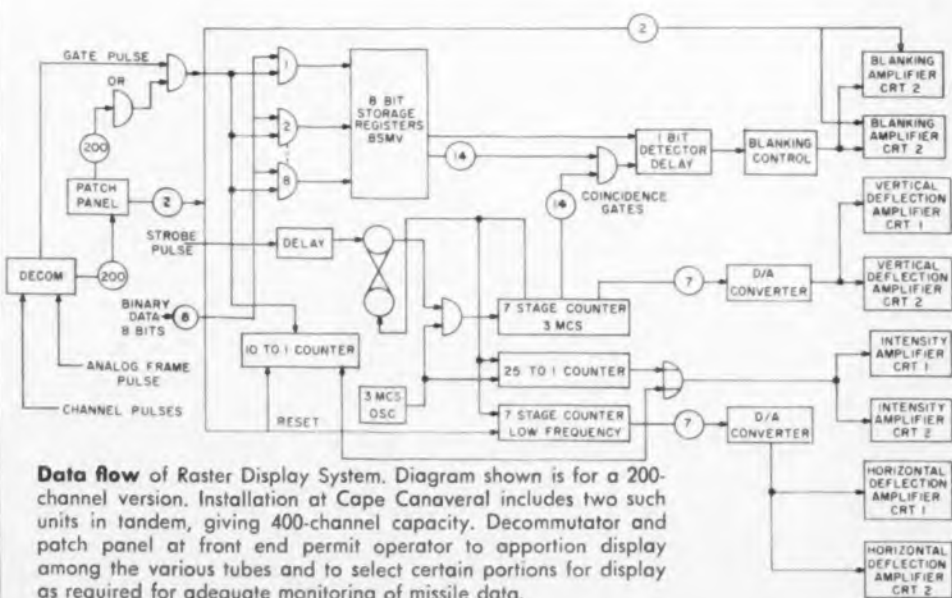
Raster Display System presents 100 channels of telemetered data in bar graph form on crt. Note bright calibration marks and intensification of every 10th channel. System was developed by Radiation, Inc., Melbourne, Fla., to monitor Minuteman tests at Cape Canaveral.

RAPID, visual monitoring of up to 400 data channels is possible with a new display system recently installed at Cape Canaveral for flight and static tests of the Minuteman ICBM. Developed by Radiation, Inc., Orlando, Fla., the Raster Display System presents data as a multibar graph on the face of a cathode-ray tube.

One hundred channels can be written on each of the four 17-in. crt's in the system. Each bar contains intensified calibration marks electronically superimposed at 10 per cent scale increments. In addition every 10th bar is intensified to facilitate channel identification. Accuracy of the system is ± 1 per cent of full scale.

Incoming pulse-code-modulated data in 8-bit broadside form are received at 12,800 measurements per sec. Each measurement is converted to a vertical bar of corresponding height. Data handling and conversion are accomplished by digital logic circuits operating at a 6-mc clock rate. The logic is fully transistorized, with 2N501 mesas predominating.

Data are written vertically on the tube face, channel by channel. Retrace time from one channel to the next (about 10 in.) is about 25 μ sec. This is made possible by a specially designed deflection yoke manufactured to careful tolerances and a push-pull retrace scheme. The beam is rapidly driven to the base line by a field of opposite



NEW SYLVANIA FLEXI-CORE TRANSFORMER

polarity rather than by the more gradual decay to zero of the scanning field.

Input format is such that new data are written on all channels of any one tube before display on the next tube begins. Thus there is ample time for the beam to retrace horizontally across the cathode-ray tube.

The analog output to be written on the tube is determined by Zener diode voltage shifters and dc amplifiers. Accuracy is not seriously impaired by amplifier drift, as the scale markers are written by a pulse counter. Thus they are frequency-dependent and vary in spacing according to the amount of drift.

The conversion of eight-bit binary data to analog form is accomplished digitally to the point of entry into the crt deflection circuits. Incoming binary data are stored in a set of bistable multi-vibrator registers. Simultaneously the output of a clock oscillator is gated into a comparison counter. The counter drives a digital-to-analog converter, thereby generating a sawtooth wave for the vertical deflection circuits. When the counter reaches the value equal to the stored data, the crt is blanked. The height of the bar written on the crt is therefore proportional to the incoming data.

When the counter reaches full scale, the system is reset to zero. This triggers a horizontal deflection counter and indexes the trace one position to the right for arrival of new data.

A decommutator and patch panel permit the Raster Display System to distribute incoming data among the four crt's as required. The operator can in addition select any group of 25, 50 or 75 bars for display.

Information displayed by the system includes temperature pressure, acceleration, and other data derived from all parts of the missile. The visual display permits the human link in the system to evaluate and act upon this data quickly, especially during the countdown phase.

Radiation, Inc., spokesmen indicate that the display concept may prove applicable in other situations where many items of telemetered data must be conveniently observed. Possible applications, apart from missile check-out and scientific testing, could include petroleum and chemical processing, power generation and distribution, and other continuous-flow industrial processes.

E. Telander, engineering unit head is project engineer for the Raster Display System. ■ ■



opens
up
new
worlds
of
design possibilities

No longer are design engineers restricted by standard E.I., C, U, or D transformer configurations! The radically new Sylvania Flexi-core transformer now creates almost unlimited new opportunities for designers to make innovations without increasing costs.

Further, no matter what the shape, Sylvania Flexi-core transformers are up to 30% smaller and lighter than conventional types now in use!

The heart of this new transformer is a formed core consisting of nests of lam-

inations of fabricated steel strips. The nests are fitted together to provide 100% interleaving, thus minimizing magnetic current. And since virtually any size core can now be produced from the steel strips — *no tools or dies are needed*. Now, the design engineer can dictate the physical configuration of a transformer depending on the electrical characteristics required!

For full details, consult your Sylvania Special Products representative. Or write Sylvania Electric Products Inc., Ipswich, Mass.

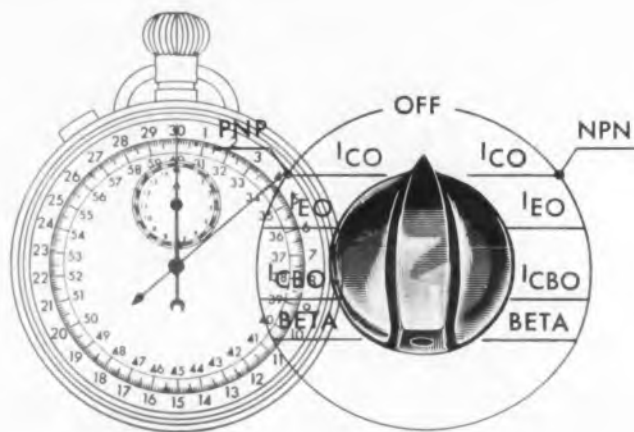


This illustration shows conformal Flexi-core transformers of current limiting design, which are scrap free and require no tooling.

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS** 

CIRCLE 14 ON READER-SERVICE CARD



IN SECONDS...

you can completely check out PNP and NPN transistors with one function selector switch!

For incoming inspection, component matching, production testing or trouble shooting . . . MRC's new T-340 Transistor Tester is unmatched in simplicity, accuracy and low price. It is designed to measure the four basic parameters that determine transistor acceptability—Beta, I_{CBO} , I_{EO} , and I_{CO} . For usual check out purposes, no other parameters are necessary. There is no need to pay three or four times more for test values that are not actually required.

Operation is extremely simple. Set in range values, plug in the transistor, position the function switch to the desired parameter . . . and read results directly from the meter. Since all four functions are sequentially selected from a single rotary selector switch, it takes only a few seconds to complete the entire check out operation. No special connections, time consuming adjustments, or calculations are required.

Additional features include parallel test receptacles so that a cable can be used to test transistors installed in circuits or environmental chambers. Within the 0-100 volt V_c span, a special 0-10 volt range facilitates the finite control needed for accurately examining the low collector voltage region—a necessary parameter when matching transistors for oscillator circuits.

All components operate well below their rated values, assuring reliable, trouble-free operation. An integral power supply furnishes 0-100 volts DC, and can be used externally if desired.

Special, high capacitance filtering circuits assure ripple-free test voltages. An accessory funnel adaptor that mounts in the panel binding posts is available for testing long lead transistors.



MODEL T-340 TRANSISTOR TESTER

Price \$295.00 F. O. B. Factory
Write today for demonstration or descriptive literature.



MAGNETIC RESEARCH CORPORATION

Armour Stalvolt Division

3160 WEST EL SEGUNDO BOULEVARD, HAWTHORNE, CALIFORNIA

CIRCLE 15 ON READER-SERVICE CARD

FEATURES

- Silicon and germanium transistors—either NPN or PNP types—can be accurately checked out in seconds.
- All test parameters are selected with a single, rotary 4-function selector switch.
- Transistors are simply plugged in—no special connections or complicated adjustments are required.
- Test values are read directly from the meter—no calculations are necessary.
- In-circuit transistors may be checked out easily with a parallel test cable.
- A special 0-10 VDC test range allows close scan of the low collector voltage region when matching transistors for oscillator circuits.
- High capacitance filter circuits assure ripple-free test voltages.

SPECIFICATIONS

I_{CO} , I_{EO} and I_{CBO} Ranges	0-50 μ a	0-1 ma	0-10 ma
	0-200 μ a	0-2 ma	0-20 ma
	0-500 μ a	0-5 ma	0-50 ma
Beta Ranges at 8 different Collector Current Levels	4-40	10-100	40-400
I_c Set Level Values	2.0 ma	20.0 ma	200.0 ma
	5.0 ma	50.0 ma	500.0 ma
	10.0 ma	100.0 ma	
V_c Ranges	0-10 volts	0-100 volts	
Inherent Accuracy	3%		
Power Requirement	115V, 60 Cycles		
Net Weight	22 lbs.		
Shipping Weight	30 lbs.		

NEWS

Passivation Gives Microdiodes Storage Temperature of 300 C

Microdiodes said to have storage temperature ratings of 300 C are being produced by a new surface passivation process. The diodes are being made by Microsemiconductors, Inc., of Culver City, Calif., and reportedly have peak inverse voltage ratings of 1,000 v.

According to Dr. Arthur Feldon, president of the five-month-old company, the efficiency and life suggested by theoretical models of the diode are now being approached with the passivation process.

At Microsemiconductors as little mechanical work as possible is done on the diodes. Material is etched instead of cut, and lapping is held to a minimum.

"Lapping," Dr. Feldon says, "leaves a residual damage at some depth below the surface—sometimes to a depth equivalent to 10 times the size of the grit particles used for lapping. A depth of damage of 25 microns is common. We etch past any damaged area."

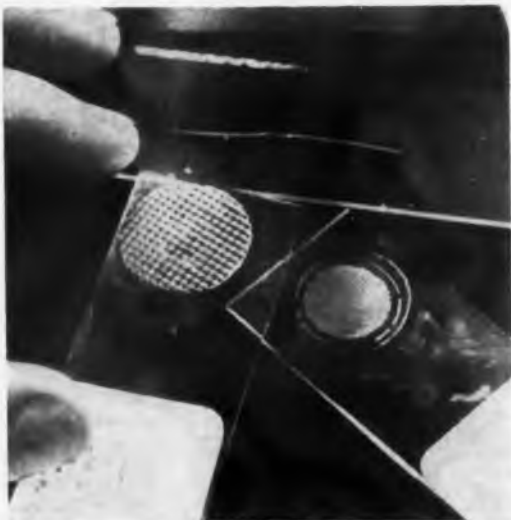
Matrix of Mesa Diodes Prepared for Passivation

N-type silicon wafers with a 2-to-3-mil-deep boron-diffused p-layer, 25-mil-thick and about 1 in. in diameter, are prepared for mesa-diode treatment by masking the wafer with a mixture of asphalt and beeswax dissolved in toluene. After 10 min. during which the masks dry, the wafer is scribed with two sets of lines, one at right angles to the other, to produce a square pattern. The wafer is then drawn under the point of a weighted needle by a ruling machine.

A matrix of mesa diodes is prepared by etching exposed silicon with a 1:1:1 HF, HNO₃, glacial CH₃COOH etch mixture. The mix penetrates to a depth just below the junction but not through the wafer.

After being given a conventional etch, the mesa-diode ensembles are rinsed in deionized water and then carefully oxidized. Before the final passivation treatment, the oxide is removed locally by lapping the tops of the mesas and the bottom of the whole wafer to allow contact to be made during electrical test. Oxide is removed by first masking, then removing the mask on the mesa top, and finally by treating with hydrofluoric acid to remove the locally exposed oxide.

The oxide, subsequently to be passivated,



Two matrices of microdiodes in production appear in front of assembled microdiode. Units in matrix at right are 7 mils in diameter. Both matrices were made by surface-passivation process.

exists then only over the region in which the junction intersects the surface.

In the final passivation treatment, an organopolysiloxane is generated on and chemically bonded to the silicon surface.

The manufacturing process and passivation technique permits control of the surface properties and results in high, controllable surface-breakdown voltage, says Vice President Thomas Hall.

Record Sales of Transistors Reach \$301.4 Million in 1960

Nearly 128 million transistors valued at \$301.4 million—a record high—were sold at factories in 1960, the Electronic Industries Association reports.

The corresponding figures for 1959 were \$2.3 million units valued at \$222 million.

Following are the figures for 1960:

	Factory Sales Units	Factory Sales Dollars
December	13,347,525	\$27,915,649
November	12,149,077	25,372,480
October	12,168,632	25,945,195
September	12,973,792	28,442,229
August	9,732,993	22,739,969
July	7,070,884	18,083,802
June	10,392,412	27,341,733
May	9,046,237	24,146,373
April	9,891,236	23,198,576
March	12,021,506	28,700,129
February	9,527,662	24,831,570
January	9,606,630	24,714,580
	127,928,586	301,432,285

ELECTRONIC DESIGN • March 15, 1961



IT'S NO SECRET...

IT'S THE CRIMP THAT COUNTS! Line 'em up! Look 'em over! They're as much alike as midnight sheep jumping for a sleep-searching count and . . . with good reason! Most of them have a great deal in common — materials, design and construction.

It's this look-alike, act-alike quality about connectors that makes AMPin-cert connectors stand out. Only AMPin-cert gives you the one very important difference in connectors — AMP's industry-accepted solderless termination technique . . . a controlled-pressure, compression-crimp whose reliability is backed by twenty years of research, development and production.

Does the difference stop here? Definitely not! AMPin-cert not only gives you extreme reliability but also . . . high-level production of terminations, up to 1,500 per hour on the AMP-O-LECTRIC automatic machine . . . quick "snap-in" assembly of contacts in the block with finger-touch ease and an extraction tool that makes routine checks, maintenance and circuit rearrangement "snap-out" easy.

Want to base your connector choice on something more than blind-fold logic? Then . . . get the whole story on AMPin-cert connectors. Write today for the catalog — "AMPin-cert CONNECTORS (Pin and Socket Type)".



FEATURE PRODUCT
1961 I R E SHOW
Booths 2527-2531

ENLARGEMENT OF
CRIMP CROSS SECTION

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • Mexico • West Germany

CIRCLE 16 ON READER-SERVICE CARD

What's New in Japanese Tunnel-Diode Circuits

Circuits for Computer Logic and Memory

Described at Solid-State Conference

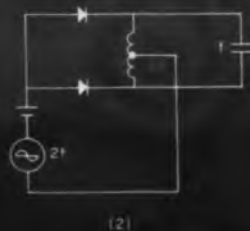
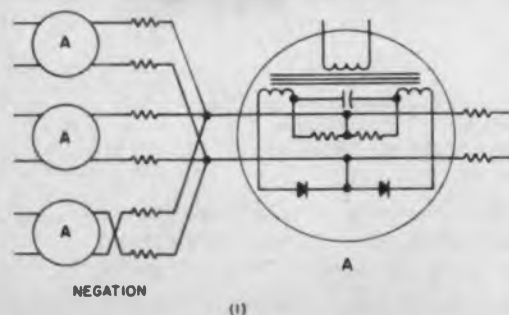


Fig. 1. Diode-pair logic circuit features separate power supply for each diode pair. This is to eliminate common ground and give better negation than original diode-pair circuit developed by Dr. E. Goto of Tokyo University, who described the circuits shown here at the Solid-State Circuits Conference, Philadelphia. (Circles marked A contain same circuit.) In improved circuit developed by S. Oshima and K. Amano of Japan Overseas Telegraph and Telephone Co., negation is accomplished by reversing polarity of coupling. Use of floating power supply reduces previous requirements for tunnel diodes by half. A dc autobias is generated at the RC network of each pair. Circuit is designed for low-frequency operation and has a 5-mc clock.

Fig. 2. Half-subharmonic oscillator resembles parametron. Oscillation of frequency (f) in this circuit, developed by T. Yamamoto and K. Fushimi of the Japanese Defense Agency is energized by negative conductance of the tunnel diodes. In parametron, energizing results from varying circuit parameters. Frequency and phase are locked into half subharmonic by non-linearity of diodes.

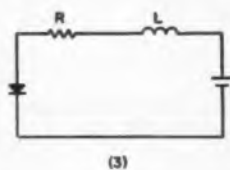
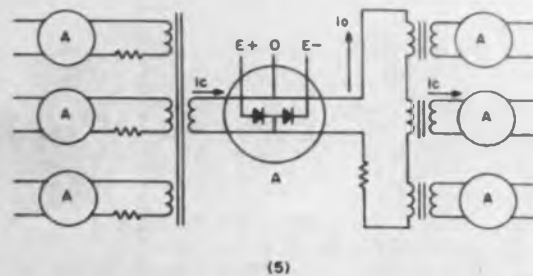


Fig. 3. Hard oscillator for asynchronous systems was developed by Y. Komamiya, Electrotechnical Laboratory of the University of Japan, for use as either logic or storage element. Oscillator, which is not self-starting, is triggered by either a pulse or by other oscillators. Its two states, either oscillating or not, represent binary digits. Circuit shown is simplest form, and other variations are possible. It has been used at a 500-mc oscillation frequency and is expected to make possible OR-gate operation of 0.5 μ sec and negation of 4 μ sec.

Fig. 5. Transformer coupling applied to tunnel-diode pair logic in circuit being developed by Dr. Goto. (Circles marked A contain same circuits). Coupling the pairs with transformers eases impedance matching, permits larger control currents, and gives insulation from common ground signals. Disadvantage is impossibility of transmitting dc components, which requires that system operate with special dc-free logic configuration. This provides dc-free signals without addition of hardware. While system is in dc-free mode, information rate is half the clock rate.



Fig. 4. Memory cell is part of matrix for tunnel-diode memory being designed for Tokyo University's ETL Mark VI computer. Memory cycle for this high-speed system is expected to be less than 100 μ sec. Writing is by coincidence. Nondestructive readout results from sending a read pulse to WY and sensing at RX. Buffer diode for each tunnel diode and resistor binary cell reduces attenuation of readout signal. Circuit is being developed by S. Takahashi of the University of Tokyo's Electrotechnical Laboratory.



Commercial Field-Effect Transistors Offer High Input Impedance Levels

Field-effect transistors, now commercially available, offer high input impedances for use in input stages, or in operational amplifiers.

Development engineers who have sampled the new transistors told *ELECTRONIC DESIGN* that the devices offer practical gain values and are considerably better than developmental field-effect units they have checked in the past. Because of interelectrode capacitance, primary uses will probably be in low frequency circuits, they commented. Input stages can use the high impedance, although gain is not competitive with conventional transistors for regular amplifier stages. In operational amplifiers, the devices should permit long time constants with reasonably-sized capacitors.

Main conduction path in the field-effect transistor is through a bar of n-type silicon. Control is achieved with a p-type junction on the side of the bar. Reverse biasing of the control junction gives the high input impedance. Typical g_m for the devices is 1,000, according to William Frusztajer, president of Crystalonics. Because action takes place within the material, there should be no surface effect problems, he said.

Greatly improved properties, including a ten times increase in transconductance, were found at liquid nitrogen temperatures by John Klein, an engineer with Radio Corp. of America's Missile Electronics and Controls Div., Burlington, Mass. He plans to package the field-effect unit with a germanium ir cell to step the cell's 10 megohm level down to 100K for further transistor stages.

Prices for the new field-effect transistors range from \$35 to \$72 each.

Optical Radar Uses 3-msec Pulse Of Red Light in 0.02-deg Beam

An experimental optical radar uses red light, from a ruby-crystal maser, collimated by lenses into a pulsed beam of about 0.02 deg, it was learned at the Spring Meeting of the Optical Society of America in Pittsburgh. The Colidar radar was developed for space use by Hughes Aircraft Co., Culver City, Calif.

The 3-msec pulse radar has a range of up to about 30,000 feet in atmosphere. A telescope and phototube are used in its receiver.

At the meeting 15 papers related to optical masers attracted nearly twice the registrants of previous spring meetings of the OSA.

From floor discussions it was apparent that problems of modulation, continuous operation and materials are still holding back application of optical masers.

VITRAMON, INC. Develops Dramatically Improved Dielectric Material

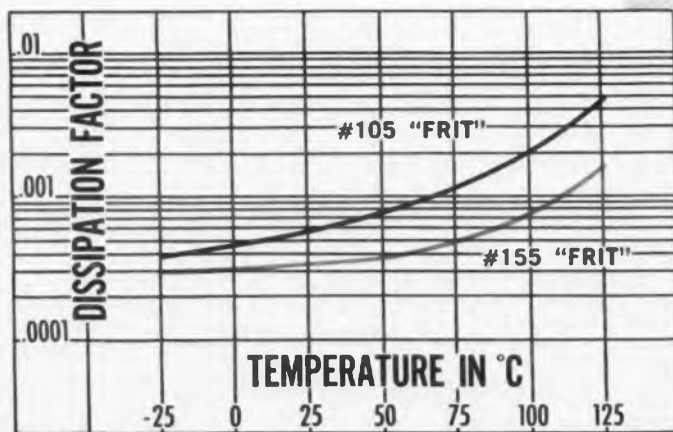


**SOLID STATE
PORCELAIN
CAPACITORS**

with NEW #155 "FRIT"

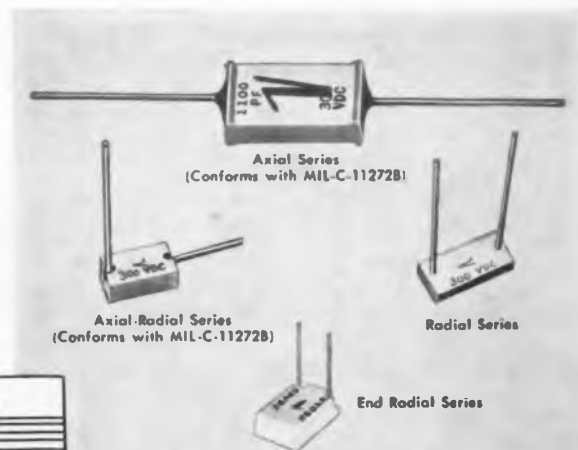
ASSURE 10 TIMES BETTER PERFORMANCE AFTER A LIFE TEST 10 TIMES MORE DEMANDING!

Three years of intensive product research, and the desire to impose a more exacting quality control during production, have resulted in the development of a new porcelain "frit." Completely formulated and produced within our own plant, this high quality dielectric material, utilized throughout the entire "VY" Porcelain Capacitor line, has produced dramatic results. After a Life Test, which has been made 10 times more stringent, both Dissipation Factor and Insulation Resistance have been improved by a factor of 10!



NOTE: Offered Exclusively For MIL-C-11272B Requirements.

© Vitraron, Inc.



The exceptional performance of the new #155 "frit" is sharply drawn by this Comparison Curve. Low losses, particularly at high temperatures, do not increase significantly with life.

Vitraron
INCORPORATED
Box 544, Bridgeport 1, Conn.

NEW FROM FAIRCHILD

TRANSISTOR/DIODE MULTIPLE ASSEMBLIES PACKAGED IN STANDARD-SIZE TRANSISTOR ENCLOSURES



MADE POSSIBLE BY FAIRCHILD'S EXCLUSIVE PLANAR PROCESS

● **REDUCE CIRCUIT COSTS**

By replacing several individual components, functional transistor/diode multiples reduce external soldered connections and effect great savings in circuit assembly time and cost.

● **CUT SPACE UP TO 80%**

Fairchild multiples with two to five components occupy the same TO-5 and TO-18 sized enclosures as single transistors. Because they are in familiar packaging, no special physical or electrical handling methods are required.

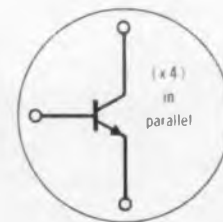
● **OFFER MATCHED PERFORMANCE**

Electrical matching is now available in transistor and/or diode twins, triplets, quads or more. Single enclosure assures thermal matching. PLANAR protective oxide makes parameters impervious to change with age or environment.

● **PROMISE UNLIMITED COMBINATIONS**

Fairchild's new multiples are production-line assembled from STANDARD PLANAR dice. The multiples described here are given as examples, but any multiple arrangement of any of the devices in the Fairchild line can be assembled to order.

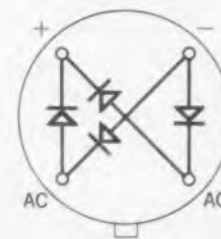
**FOR MORE INFORMATION, OR ASSISTANCE WITH MULTIPLES FOR YOUR
SPECIFIC APPLICATION, CONTACT THE SPECIAL PRODUCTS GROUP**



TOP VIEW

RF POWER

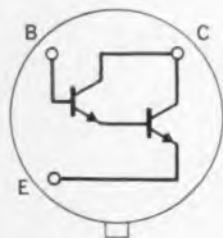
Four high-voltage PLANAR transistors in parallel within a single power transistor enclosure. Applications: RF amplifiers and oscillators.



BOTTOM VIEW

DIODE BRIDGE

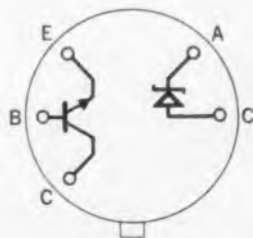
Four PLANAR diodes within TO-18 enclosure connected in bridge configuration.



BOTTOM VIEW

DARLINGTON

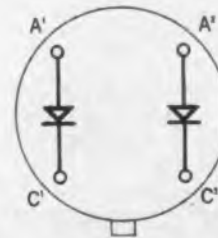
Two high-gain PLANAR transistors connected internally in a Darlington configuration. In TO-18 enclosure. For use in analog and servo amplifiers.



BOTTOM VIEW

REF-MODULE

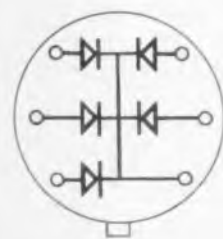
A Zener diode and a high-gain PLANAR transistor in TO-5 enclosure. Good thermal proximity makes this excellent for use in ultra-low-drift power supplies.



BOTTOM VIEW

DIODE PAIR

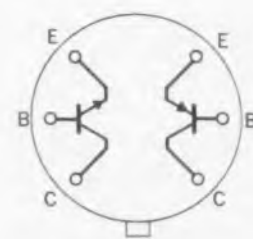
Two PLANAR diodes in TO-5 enclosure. Electrically isolated, their forward voltage drops at given current value are matched within two millivolts.



BOTTOM VIEW

DIODE LOGIC

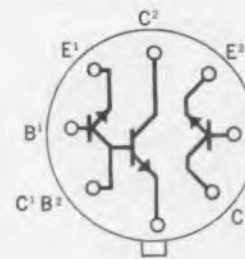
Five PLANAR diodes within a TO-5 enclosure and connected with common cathodes. Applications: diode logic in digital computers.



BOTTOM VIEW

COMPLEMENTARY PAIR

A PLANAR PNP and PLANAR NPN transistor, electrically isolated, within a TO-5 case. Special parameter matching may be specified for amplifier circuitry use.



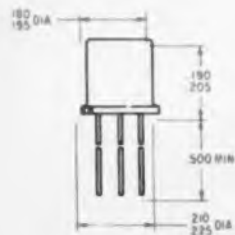
BOTTOM VIEW

AMPLIFIER MODULE

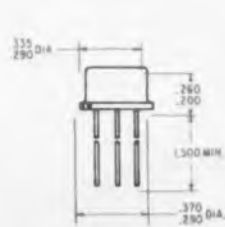
Three PLANAR transistors within a TO-5 enclosure. Its small size makes it particularly useful for miniaturized amplifier circuitry.

The above are examples from a very large number of functional multiples available from Fairchild's Special Products Groups

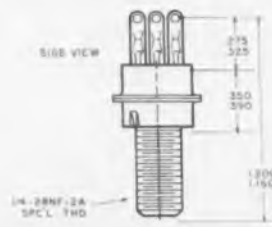
TO-18 Type



TO-5 Type



Power enclosure



Number of pins and spacing dependent on individual device

NOTE: All dimensions in inches

SEE US AT THE IRE, BOOTHS 2705, 2707.



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a big boost for missile reliability

Vital but vulnerable missile components must "live" in severe aerospace environments. This requirement is being met with protection afforded by Lord-engineered mounting systems.

Vibration/shock/noise control, now employed on the missiles shown here, is a proved route to increased reliability. Lord suspensions have been an essential factor in reaching a high plateau of performance for several critical programs.

Many types of advanced "soft mounting" systems, both elastomeric and non-elastomeric, have been custom designed. As a result, guidance systems perform with exacting precision. Sensitive GSE units are transported safely. Electronic equipment operates reliably on low-response, damped chassis.

Alert missile designers have come to rely on Lord to help them reach higher reliability levels. A call to the nearest Lord Field Engineering Office or the Home Office, Erie, Pa., will put you in touch with those responsible for the important advances in vibration/shock/noise control.

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 NEW YORK, N. Y. (Paramus, N. J.)
 New York City - Bryant 9-8042
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Lord contributions to missile reliability include:

- Inertial Guidance System Suspensions**
... for both stabilized and strapdown types
- Shipping Container Mounting Systems**
... for complete missiles, nose cones, warheads, engines
- Launcher Mountings**
... for soft and semi-hard site installations
- Integral Skid Mountings**
... for ground control, communications, maintenance huts
- Tylastic Tie-downs**
... for fragile railroad lading
- Elastomeric Mountings**
... for missile carriers, trailers, ICBM transporters
- Special Mounting Systems**
... for controls, instrumentation, computers
- Dyna-damp Structural Panels**
- Acoustical Enclosures**
- Elastomeric Antenna Snubbers**

NEWS

Automation to Be Added To 1961 IRE Convention

Data-Processing System to Analyze Booth and Session Attendance

AUTOMATION of show activities will be a key feature of the 1961 IRE International Convention and Show opening Monday, March 20, at New York's Coliseum.

Well over 70,000 engineers and businessmen are expected to converge on the Coliseum for the year's biggest industry show. More than 850 exhibits and 54 technical sessions are planned for the four-day event.

For those who can't attend in person, television broadcasts, entitled "Today at the IRE," will be beamed from the Coliseum to New York, Philadelphia and Los Angeles stations. The telecasts will again be sponsored by the International Resistance Co. of Philadelphia.

To increase booth-shopping efficiency for both show visitors and exhibitors, a new approach to automation will be applied at this year's show. At the time of registration each show visitor will receive a coded card with a series of numbers on the back. Each booth will have a number, or a series of numbers if several product lines are shown at the booth. If the booth visitor wants information on the products shown, he checks this number on the back of his card.

As he leaves the show, he drops off his card, or it can be mailed to show officials later. When the show is over, the numbers checked off on each card will be entered into a Burroughs 220 data-processing system. The code number on the card will be used to match it with registration information about the visitor already stored in the computer's memory.



Shuttle-bus service between New York's Coliseum and the Waldorf-Astoria Hotel will be provided by International Rectifier Corp. during the IRE Show.



Tabulation of session attendance and booth visitors will be handled on this 1,500 line-per-min printer by Data Patterns, Inc., after this year's show.

The result will be a detailed list of all visitors to each booth, and mailing labels will be printed automatically, so that the proper literature can be mailed to the interested individuals.

The tabulation procedure will be handled by Data Patterns, Inc., New York.

The procedure will also be used to analyze attendance at technical sessions during the convention. At the beginning of each session everyone in the audience at the session will be asked to check off a number representing that session on the back of the coded card. This will permit a list of all attendees to be sent to the IRE group involved in each session.

Energy Sources, Biomedical Electronics Featured in Technical Panel Sessions

Panel sessions at the convention will cover energy-sources progress and the latest trends in biomedical electronics. The energy-sources panel will include discussions of the Russian thermo-electricity program and progress in Western Europe, as well as developments in this country. Dr. Jerome B. Wiesner, President Kennedy's science advisor, is scheduled to participate in the biomedical discussion.

Frontier areas in component developments will be covered in a session on "Broadening Device Horizons." Subjects scheduled include electron devices for the infrared and millimeter gap, optical masers and solid-state developments. ■ ■

TV Schedule For "Today at the IRE"

Los Angeles KTLA-TV (5) 11 pm, Mar. 21, 22, 23
New York WPIX-TV (11) 11:20 pm, Mar. 20, 21, 22
Philadelphia WRCV-TV (3) 6:15 pm, Mar. 21, 22, 23

ELECTRONIC DESIGN • March 15, 1961



Bendix Craftsmanship at work for you

TYPICAL SPECIFICATIONS

	Phase Shifter	Y Circulator	Attenuator
Frequency Range	5200 to 5800 mc	4700 to 5700 mc	4900 to 5800 mc
Insertion Loss	1 db max.	0.4 db max.	1 db max.
Impedance	50 ohms	50 ohms	50 ohms
VSWR	1.30 max.	1.20 max.	1.25 max.
Power Handling Capacity Average Pulse	5 watts 5 kilowatts	10 watts 10 kilowatts	5 watts 5 kilowatts
Temperature Range	-55° C. to +85° C.	-55° C. to +85° C.	-55° C. to +85° C.
Diameter	1.12"	2.375"	1.12"
Weight	6 oz.	11 oz.	6 oz.

NEW BENDIX MICROWAVE FERRITE DEVICES.* **1** The Electrically Variable Phase Shifter, TFP-1, can produce phase shifts in excess of 90° over a minimum bandwidth of 10%. Chief uses are as phase modulator, fast shift, and in a wide variety of r-f direction finding devices. **2** The Y-Circulator, TFC-1, offers at least 20 db isolation with less than 0.4 db insertion over bandwidth exceeding 20%. Ideal for use with masers, and parametric amplifiers. **3** The Electrically Variable Attenuator, TFA-1, has a range exceeding 25 db over a minimum bandwidth of 15%. Useful in fast AGC circuits and remote level control applications. Write today.

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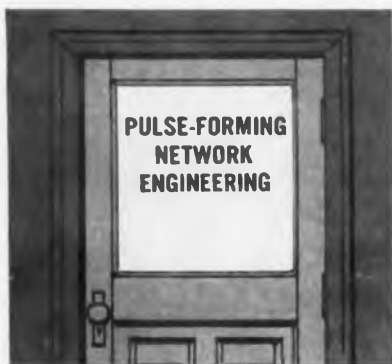
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CIRCLE 20 ON READER-SERVICE CARD

Special Engineering Section Maintained for Design and Development of Pulse-forming Networks



BEHIND this door, the Sprague Electric Company, North Adams, Massachusetts, maintains a highly-technical special engineering section devoted exclusively to the design, development, and manufacture of pulse capacitors and pulse-forming networks. The many complexities of these highly-specialized units demand that they be handled by a highly-specialized organization. For this reason, Sprague has been, from the very beginning, a major supplier of pulse capacitors and networks for radar equipment (ground, marine, aircraft, missile), tube testing, and similar pulse circuit applications.

This special engineering section performs four important functions: One group *designs* custom units in accordance with required parameters. Another group *builds* pulse capacitors and networks to these precise specifications. In another area, a group of specially-trained field engineers *provides application assistance* wherever needed. And yet another independent group *works toward the future* developing new materials, new design concepts, and new techniques for manufacture, enabling Sprague to introduce product improvements such as heliarc sealing of cases, rugged alumina bushing assemblies, Fabmika[®] dielectric, and improved hermetic sealing of closures.

Save time and money by working with Sprague from the start. Application engineering services are available to you without obligation.

Write for Engineering Bulletin No. 10,001 to Technical Literature Section, Sprague Electric Co., 347 Marshall Street, North Adams, Massachusetts.

New Capacitors for Computer Power Supplies Now Designed for 85 C Operation



New Compulytic[®] Capacitors, recently announced by Sprague Electric Company, now permit digital computer power supply filtering at operating temperatures to 85 C. By extending the temperature range a full 20 C higher than capacitors offered by other sources, Compulytics will reduce design headaches by cutting down cooling and ventilating problems.

Under normal 85 C operating conditions, Type 32D Compulytic Capacitors display extremely low leakage current, low equivalent series resistance, and have higher permissible ripple current values. Extended shelf life of 3 years and more is another outstanding feature.

Ratings up to 130,000 μF at 2.5 volts or 630 μF at 450 volts are skillfully packed into the largest standard case size of 3" diameter by 4 $\frac{1}{8}$ " high. Capacitor banks as large as 1 farad have been constructed, in relatively small space, using Compulytic Capacitors.

Because of their extremely high stability, Compulytics are ideally suited for use in continuously adjustable voltage power supplies since they will not "deform" when operated for long periods at lower than rated voltages.

For complete technical data, write for Engineering Bulletin 3441B to Technical Literature Section, Sprague Electric Company, 347 Marshall Street, North Adams, Massachusetts.

See us at the IRE Show—Booths 2416-2424

CIRCLE 241 ON READER-SERVICE CARD

CIRCLE 242 ON READER-SERVICE CARD

WASHINGTON REPORT



John J. Christie

THE NIKE-ZEUS PROGRAM gets a higher priority with each successive re-evaluation of the nation's defense posture. Richard S. Morse, Army director of R&D, expressed the opinion at a recent hearing before the House Science and Aeronautics Committee that it was the only possible anti-missile defense system that "can be produced and deployed within the next decade."

Defense Secretary Robert S. McNamara has implied that Administration revisions to the Eisenhower fiscal 1962 military budget, due to be submitted to Congress by April 1, will propose acceleration of the Nike-Zeus program and ask for initial production funds.

A redesign of the Zeus rocket, based on elimination of its delta wings, has not only resulted in a substantial weight saving and about a 30 per cent increase in velocity but also a major simplification of the rocket's control system. A single control unit packaged in the third stage of the rocket has replaced second and third-stage interconnected servo units. The change has greatly enhanced maintainability of the electronics and hydraulics and eliminated the worrisome interconnection feature.

RELIABILITY REQUIREMENTS for Nike-Zeus rival the ultra-high standards set for the Minuteman missile. A \$22 million program is underway to prove out manufacturing techniques and to develop pilot machines for making several components of ultra-high reliability, including resistors and transistors, and a number of high-density packages. One requirement is to develop equipment for a new technique of manufacturing aluminum strip delay line packages. Funds also have been earmarked for efforts to lower costs and rejection rates on high-power klystrons.

The wingless version of the Zeus rocket is now in the advanced development stage, three R&D models having been flown to date. Development work on ground installations is essentially complete.

DESIGN FOR LOW-COST BOOSTERS has become a major objective of the Navy space program. The Transit satellite navigation system, due to become operational late next year, will set the precedent. Cost of launching four 100-lb Transit operational satellites is projected at less than \$1 million apiece, compared with the \$5 million it costs to put up one of the current experimental models, weighing 250 to 265 lb, with a Thor-Able-Star vehicle.

"The Navy believes that for an early payoff, satellites operating close to the terrestrial sphere, say up to 700 miles, can effectively and economically use relatively small boosters for relatively small but completely adequate payloads," declared Rear Admiral Thomas F. Connolly in recent House committee testimony. "We feel," he said, "that this approach can be applied to

satellites for geodesy, communications, weather, surveillance and later many others."

A LIGHTER TRANSIT PAYLOAD will automatically result from elimination of duplicate components and special devices employed in the experimental stage. For example, experimental Transit satellites have been transmitting four doppler frequencies in connection with studies of ionosphere refraction effect and other environmental conditions, whereas the operational satellites will transmit only two frequencies. Aside from eliminating duplication, such as back-up batteries and extra telemetry gear, microminiaturization and improved component packaging will be employed to reduce the weight of the operational payload to 100 lb.

The Navy is specifying redundancy techniques for self-healing and reliability that are calculated to give its initial operational satellites a five-year lifetime, an admittedly optimistic goal.

By orbiting four of the passive satellites, which will require no shipboard interrogation or transmission to fix a position, the Navy feels that it will provide both reasonable coverage and frequency of reception for any spot on the earth, land or sea. Plans call for putting the satellites into a circular orbit at an altitude of 500 nautical miles, which would keep them clear of the layer of radiation above that and the region of drag and gravity below.

INTEGRATED GROUND SUPPORT FACILITIES that would serve all military space activities have been proposed by Lt. Gen. Arthur G. Trudeau, Army Chief of R&D. The proposed global network of installations would come under a joint military space agency, similar to the recently organized Defense Communications Agency. It would also serve the requirements of the National Aeronautics and Space Administration and eventually commercial services.

The proposal is offered as a means of preventing unnecessary duplication of ground support facilities, whose complexity and cost are steadily increasing. It is based on the premise that common usage of a substantial portion of ground support systems and equipment is feasible, particularly in computing and communications. Moreover, the plan could serve to spur efforts to develop general-purpose ground-support equipment.

Operational requirements as well as economics favor geographical standardization. Pin-pointed ground stations in all parts of the globe will become increasingly important for effectively tracking, monitoring, logging, etc., required by upcoming satellite and space vehicle projects. A coordinated Defense Dept. plan, backed up by firm international agreements, might provide a stronger guarantee that the most advantageous locations will be available.

A belt of stations stretching from the East Coast of the U. S. around the world to the West Coast will participate in tracking the Army's ADVENT communication satellite and its booster rockets to the required 22,000-mile altitude. Final determination of ADVENT's orbit and thus the exact line of required stations is now in progress. To the fullest extent possible, station requirements will be dovetailed with the network to be used for Project MERCURY. Thus the framework of General Trudeau's proposal is rapidly reaching the point where over-all DOD control and coordination with NASA is ripe for consideration.

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CIRCLE 243 ON READER-SERVICE CARD

NEWS

Data-Access Console Gives Simple Computer Control

An advanced display and analysis console will permit unskilled operators rather than highly trained programmers to communicate with a computer in a new Air Force data-reduction system.

The system, called MIPE (Modular Information Processing Equipment), is being completed by the Ramo-Wooldridge Div. of Thompson Ramo Wooldridge Corp. for the Rome (N.Y.) Air Development Center. An AN/FSQ-27 "polymorphic" computer, built under the same concept as the company's commercial RW-400 computer is also part of the system.

MIPE will be used to reduce military reconnaissance data.

The display console consists of three crt displays, a series of process step buttons, and numerical input keys and buttons. It also includes a photoelectric light gun, which is aimed at a point on a graphical display to single out that point for computer analysis or action. A "joystick," which controls cross-hairs, can single out an area rather than a point.

Plastic overlays which fit over the process step keyboard, and plain language labels for the keys, are used by the operator to draw information from the computer.

Three basic modes of operation are being used with the system. In logistics, for example, the operator could call for displays of plots showing cost versus transportation.

In another mode of operation the computer and operator become "equal components." In intelligence indexing of photographic data, the computer might show the operator a photo and ask "Does this area contain a new launching pad?"

The operator would answer by pressing a "yes" or a "no" button.

The display system could also be used as a flexible file access and data entry system, enabling an operator to extract file information in any useful combination.

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PT600
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- Broadest h_{FE} vs. V_{CE} linearity ever offered

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NEWEST HIGH VOLTAGE POWER AMPLIFIER!

- 300 mW power output at 100 mc, 10 db power gain
- $V_{CE} = 150V$ Min, $V_{CE} = 125V$ Min

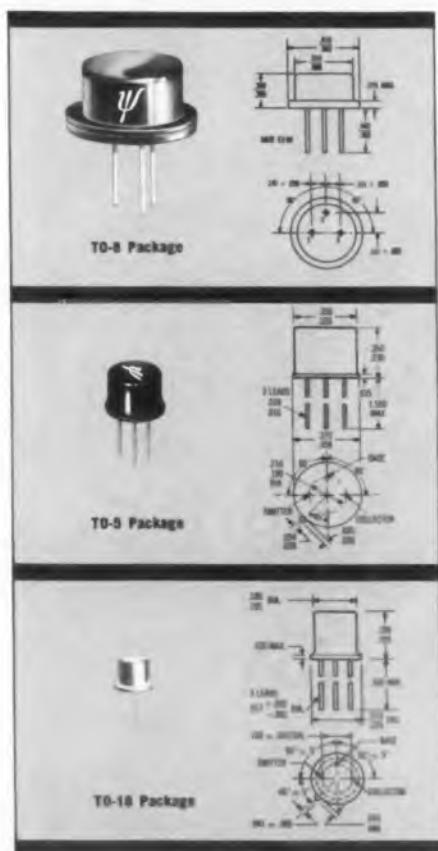


See inside for the most extensive line of high performance silicon transistors available today! ▶

SWITCHING TRANSISTORS

NPN TRIPLE DIFFUSED SILICON MESA

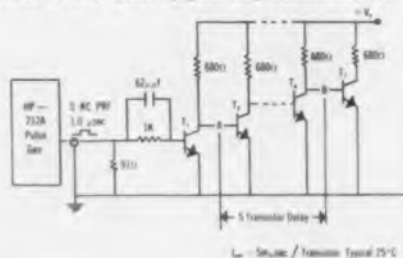
Wide Range of Types μA to 10 Amps .2V to 140V



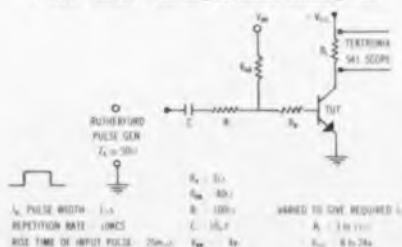
DIMENSIONAL DRAWINGS

All dimensions shown in inches

2N706 - PT706 DCTL Propagation Delay Measurement Circuit



PT600 - PT601 Switching Circuit and Switching Time



**TO-18
PACKAGE**
HIGH SPEED TRANSISTORS

TYPE	TOTAL POWER AT 25 C CASE Watts	V _{CE} Min	V _{BE} Min	V _{ES} Min	f _t mc TYP	h _{FE}	V _{CE} Sat* Max
2N706	1.0	25	20	3	350	20 min	60
2N706A	1.0	25	20	5	350	20-60	60
2N706B	1.0	25	20	5	350	20-60	40
2N753	1.0	25	20	5	350	40-120	60
PT706	1.0	25	20	5	350	35-125	20

**TO-4
PACKAGE**
PREMIUM TRANSISTORS

2N1837	2.0	80	50	8	210	40-120	80
2N1837A	2.8	80	50	8	210	40-120	80
2N1409	2.0	30	25	4	230	15-45	80
2N1403A	2.8	30	25	4	230	15-45	80
2N1410	2.0	45	30	4	230	30-90	80
2N1410A	2.8	45	30	4	230	30-90	80
PT850	2.0	120	80	5	200	40-120	20
PT850A	2.8	120	30	5	200	40-120	20

STANDARD TRANSISTORS

TYPE	TOTAL POWER AT 25 C CASE Watts	V _{CE} Min	V _{BE} Min	V _{ES} Min	f _t mc TYP	h _{FE}	V _{CE} Sat* Max	PKG
2N696	2.0	60	40	5	200	20-60	1.5	TO-5
2N637	2.0	60	40	5	200	40-120	1.5	TO-5
2N698	2.0	120	80	5	190	20 min	5.0	TO-5
2N699	2.0	120	80	5	190	40-120	5.0	TO-5
2N717	1.5	60	40	5	200	20 min	1.5	TO-18
2N718	1.5	60	40	5	200	40-120	1.5	TO-18
2N719	1.5	120	80	5	190	20 min	5.0	TO-18
2N720	1.5	120	80	5	190	40-120	5.0	TO-18
2N1420	2.0	60	30	5	170	100-300	1.5	TO-5

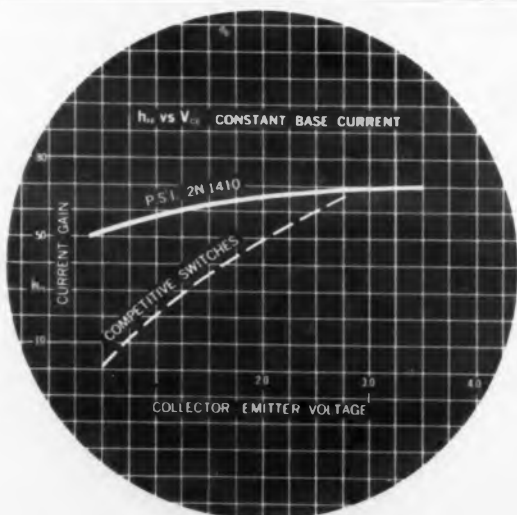
**TO-4
PACKAGE**
GENERAL PURPOSE TRANSISTORS

2N1336	2.8	40	25	3	190			
2N1838	2.0	45	30	4.5	190	40-150	1.4	
2N1839	2.0	45	30	4.5	170	17-50	1.4	
2N1840	2.0	25	20	5	150	10 min	1.4	

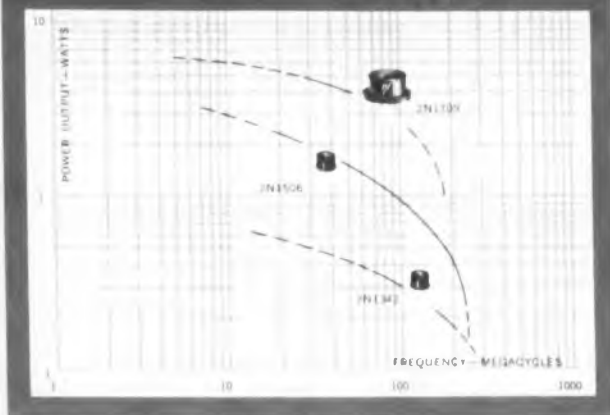
SPECIAL PURPOSE TRANSISTORS

TYPE	TOTAL POWER AT 25 C CASE Watts	V _{CE} Min	V _{BE} Min	V _{ES} Min	f _t mc TYP	h _{FE}	V _{CE} Sat* Max	PKG
2N1340	2.8	150	100	5	220	5 min	0.7	TO-5
PT601	13.0	60	45	4	210	30-90	1.0	TO-8
PT600	13.0	60	45	4	210	15-45	1.0	TO-8
2N1900	125.0	140	100	5	50 min	10-20	2.0	POWER
2N1901	125.0	140	100	5	50 min	15-40	2.0	POWER

*SEE DATA SHEETS FOR CONDITIONS

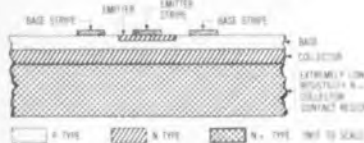


Extremely flat Beta vs. Collector Voltage is one of the many advantages made possible by the PSI Triple Diffusion Process.



FREQUENCY-POWER OUTPUT RANGE
OF PSI COMMUNICATIONS TRANSISTORS

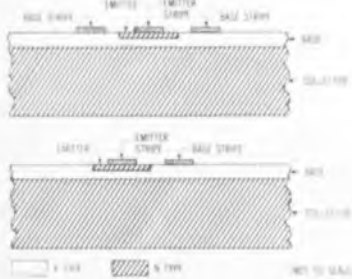
PSI TRIPLE DIFFUSED PROCESS



PSI triple diffusion makes possible these outstanding performance characteristics: Low V_{CE} saturation, faster switching, excellent high current beta, high small signal beta and broad VHF versatility.

The triple diffusion process, above, provides manufacturing control unmatched by any other process.

OTHER MESA PROCESSES

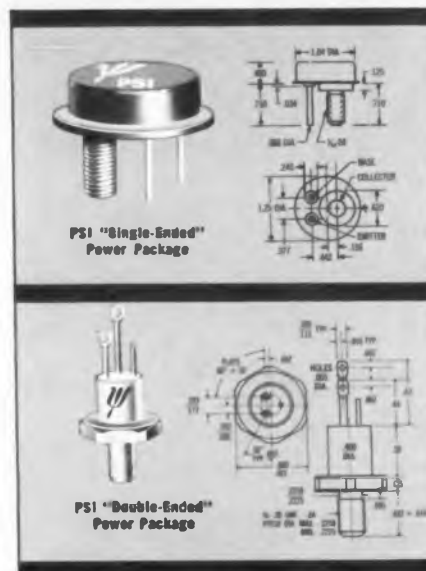


COMMUNICATION TRANSISTORS

NPN TRIPLE DIFFUSED SILICON MESA

Wide Range of Types

mW to Watts 10 to 100 + Source Voltages



DIMENSIONAL DRAWINGS
All dimensions shown in inches

HF HIGH POWER TRANSISTORS

NPN TRIPLE DIFFUSED SILICON MESA

Wide Range of Types ... for many new applications.

TYPE	V _{Min.}	V _{Min.}	V _{Min.}	h_{FE}	10mc h_{FE}	f- mc	5 mc Class C AMPLIFIER Power Out	Power Gain	PACKAGE
2N1899 formerly PT901	140	100	5	10 min	3	50 min	125W	10db	Single End
2N1900	140	100	5	10-20	3	50 min	125W	10db	Single End
2N1901	140	100	5	15-40	3	50 min	125W	10db	Single End
2N1902	140	100	5	10 min	3	50 min	125W	10db	Double End
2N1903	140	100	5	10-20	3	50 min	125W	10db	Double End
2N1904	140	100	5	15-40	3	50 min	125W	10db	Double End
PT900	80	50	4	7 min	3	50 min	125W	10db	Single End

KILOWATT MEGACYCLES AMPERES NANoseconds Now possible with PSI Load Tested Silicon Mesa Power Transistors. In a typical switching application the rate of current rise can be as high as 100 million Amperes per second. Selected Beta ranges now available.

Power Switching at higher speeds and RF Power Generation at higher levels than previously attainable are now possible.

Availability: Single Ended packages are available in production quantities. Double Ended in Engineering quantities.

VERY HIGH FREQUENCY

TYPE	TOTAL POWER AT 25 C CASE	V _{Min.}	V _{Min.}	V _{Min.}	POWER GAIN AT f = 30mc TYPE	POWER GAIN AT f = 70mc TYPE	POWER GAIN AT f = 100 mc TYPE	PKG
2N1338	2.8	80	50	1	18 db P - 0.35W	10.5db P - 0.15W	7db P - 0.35W	TO-5
2N1342	2.8	150	125	5	13db P - 0.4W	10db P - 0.3W	TO-5	
2N1505	1.0	50	40	1	10db P - 1.8W	8db P - 1.2W	6db P - 1W	TO-5
2N1506	1.5	60	40	4	12db P - 1.8W	10db P - 1.2W	8.5db P - 1W	TO-5
2N1710	1.0	60	45	1	10db P - 5W	6db P - 3.5W	5db P - 3W	TO-8
2N1709	1.0	75	60	4	12db P - 5W	8db P - 3.5W	6db P - 3.5W	TO-8

THESE TRANSISTORS OFFER THE DESIGNER A WIDE SELECTION OF CHARACTERISTICS

SUPPLY VOLTAGE 10 VOLTS TO 125 VOLTS

OPERATING CURRENT 1 mA TO SEVERAL Amps

OPERATING FREQUENCY UP TO SEVERAL HUNDRED Mc HIGHER WITH VARICAP DOUBLING CIRCUITS

POWER OUTPUT MILLIWATTS TO NEARLY 10 WATTS

The 2N1338, 2N1342, 2N1505, 2N1506 are available in production quantities.

The 2N1709 and 2N1710 are available in prototyping quantities.

PICO-TRANSISTORS and MICRO-TRANSISTORS

PSI Pico and Micro transistors are ultra miniature triple diffused silicon mesa devices. They are designed for low level amplification and for low power, high speed switching applications. These unique transistors are extremely valuable where weight and size are prime design and operational factors.

The remarkable high reliability standards of PSI Micro-Diodes are the result of simplified construction and advanced surface passivation techniques. These same techniques are employed in the manufacture of PSI and Micro Transistors.

The surface passivation process and coating materials provide protection from extreme environmental conditions of heat, moisture, thermal shock, mechanical stresses and electrical load.

After manufacture all devices are subjected to environmental testing to assure reliability and device parameters.

- Meet MIL-S-19500B and MIL-STD-202A
- -65°C to 200°C temperature range
- 200 hr. 200°C "Burn-in"
- 100 mW power dissipation
- Pico size 1/10000 of TO-5 package
- Micro size 1/100 of TO-5 package
- Companion components to PSI Micro-Diode

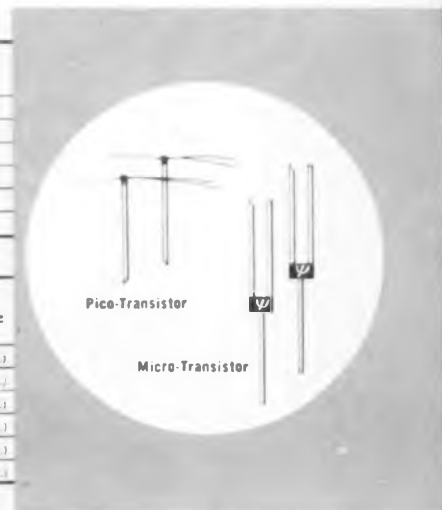
ABSOLUTE MAXIMUM RATINGS (25°C)

Micro Types	Pico Types	Equivalent EIA Type	Collector to Emitter Voltage V_{CE0}	Collector to Base Voltage V_{CB0}	Emitter to Base Voltage V_{EB0}	Junction Temperature T_j	Power Dissip.
PMT 111	PMT 011	2N1409	25V	30V	4V	150°C	100 mW
PMT 112	PMT 012	2N1410	25V	30V	4V	150°C	100 mW
PMT 113	PMT 013	2N696	40V	60V	5V	150°C	100 mW
PMT 114	PMT 014	2N697	40V	60V	5V	150°C	100 mW
PMT 118	PMT 018	—	30V	40V	5V	150°C	100 mW
PMT 119	PMT 019	—	30V	40V	5V	150°C	100 mW

ELECTRICAL CHARACTERISTICS

Micro Types	Pico Types	Collector Cut-off Current I_{CO}	Base Saturation Voltage $V_{BE SAT}$	Collector Saturation Voltage $V_{CE SAT}$	Collector Capacitance C_{CE} (Typ.) $V_{CB} = 10V$	f_{Tc} (min.)	f_{Tc} (Typ.) $f = 20mc$
PMT 111	PMT 011	10 μ A (20V)	1.2V (Max.) 1	1.1V (Max.) 1	20 μ f	15 (150mA, 10V)	3.1 (Typ.)
PMT 112	PMT 012	10 μ A (20V)	1.2V (Max.) 1	1.1V (Max.) 1	20 μ f	30 (150mA, 10V)	3.5 (Typ.)
PMT 113	PMT 013	1 μ A (30V)	1.2V (Max.) 1	1.1V (Max.) 1	20 μ f	20 (150mA, 10V)	2.0 (Typ.)
PMT 114	PMT 014	1 μ A (30V)	1.2V (Max.) 1	1.1V (Max.) 1	20 μ f	40 (150mA, 10V)	2.5 (Typ.)
PMT 118	PMT 018	1 μ A (10V)	.9V (Max.) 2	.4V (Max.) 2	20 μ f	10 (5mA, 5V)	2.0 (Typ.)
PMT 119	PMT 019	1 μ A (10V)	.9V (Max.) 2	.4V (Max.) 2	20 μ f	30 (5mA, 5V)	2.5 (Typ.)

NOTES: Test Conditions 1. $I_C = 50mA$, $I_B = 5mA$ 2. $I_C = 5mA$, $I_B = 5mA$



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Experimental Traveling-Wave Tube Makes Use of Liquid-Cooled Helix

An experimental liquid-cooled helix traveling-wave tube has been built by Sperry Gyroscope Corp., Great Neck, N.Y. Use of a coolant pumped through a hollow, thin-wall helix, is said to give high heat dissipation, permitting the tube to be used at power levels higher than usual for helix twt's.

The tube is designed for airborne radar countermeasure systems. It weighs about 20 lb and has a magnet weighing approximately 300 lb. A production version is expected to weigh about 10 lb and have a magnet weighing less than 100 lb.

Sperry reports that substitution of a hollow, liquid-cooled helix for the conventional solid-wire helix conductor increases power capability in the case of a broadband X-band tube from 50 w to 3 kw.

This can be done, the company says, without affecting the helix tube's ability to amplify microwave signals without electrical or mechanical tuning over a very wide frequency range, or its ability to simultaneously amplify many signals at different frequencies.

Sperry has experimented with copper-plated, stainless-steel helices with inside diameters of 0.019 in. Helix walls are 0.006 in. In some thermal tests, the company reports, 3 kw was dissipated in a piece of helix 0.5 in. long, through which a special fluorocarbon coolant flowed at 0.03 gal per min.

Two prototypes of the production version are expected to be produced this year.



Tubular helix conductor is similar to one used in tests of helix traveling-wave tubes for airborne countermeasures equipment. In tests, liquid coolant pumped through thin-walled helix dissipated enough heat to suggest that tube's output power could reach 3 kw over a broad frequency range. Sperry reports that previous X-band helix tubes were limited to 50 w output power. Helix is stainless steel with ID of 0.019 in. and walls of 0.006 in.

◀ CIRCLE 22 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

Electronic Products **NEWS**

by **CARBORUNDUM®**

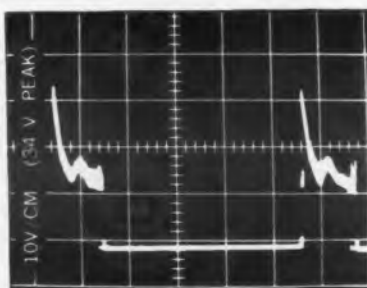
Arc suppression in CLARE Stepping Switches Improved with GLOBAR® Varistors

Laboratory report shows up to 4 to 1 reduction in peak voltage compared with standard condenser-resistor networks

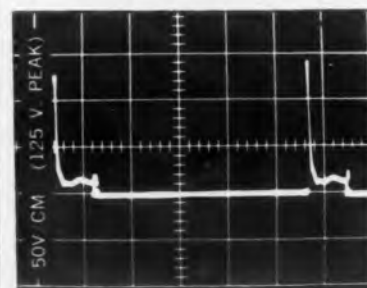
C. P. Clare & Co., Chicago, Ill., manufacture a line of precision stepping switches, offering as many as 480 contact points in a single unit. Arc suppression at the relay contact in these switches is vital to long life and dependable operation.

An extensive series of laboratory tests by Clare has established the

superior arc suppression capabilities of GLOBAR varistors. Tests were made in comparison with standard resistor-capacitor networks, using various stepping switches having coil ratings of 6 volts up to 110 volts. Results were based on visual observation of arc suppression, peak voltage and speed as shown on 'scope and heating of the body of the varistor, as recorded by a pyrometer. In some cases, tests with the varistor showed a 4 to 1 reduction in peak



5MS/CM (39 S.P.S.)



5MS/CM (39 S.P.S.)

Reduction of peak voltage is shown in these comparative oscilloscope traces. Upper trace, showing 34 v. peak, was obtained with varistor across coil. Lower trace shows 125 v. peak with .5 mfd. capacitor and 10 ohm resistor across contacts.



Disc and rod type GLOBAR varistors are shown above. Wide variation in voltage coefficients may be obtained through changes in length-diameter ratios.

voltage. Temperature readings revealed more than adequate safety factors under all anticipated voltages and duty cycles.

GLOBAR Type BNR varistors are non-linear, voltage-sensitive resistors made from electrical grade silicon carbide. Their negative voltage coefficient of resistance (resistance decreasing with an increase of voltage) offers wide possibilities for



Typical CLARE stepping switch, Type 20, is shown above. This switch offers up to 480 contact points in twelve 40-point levels, or 320 in sixteen 20-point levels.

application in contact arc suppression, protection against voltage surges and similar problems. Response to short duration impulses is instantaneous.

All GLOBAR varistors are made to individual customer specifications. Inquiries concerning specific applications are welcomed. If your interest is in experimenting with possible uses, it is suggested that you investigate the GLOBAR Varistor Test Kit. Write to Globar Plant, Refractories Division, Dept. EDV-31, The Carborundum Company, Niagara Falls, New York.

CIRCLE 804 ON READER-SERVICE CARD

BOOKLET AVAILABLE ON GLOBAR Type BNR VARISTORS



Full information on the physical and electrical characteristics of GLOBAR Type BNR varistors is contained in Technical Bulletin GR-2, which will be mailed on request. For your copy, write


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Cw infrared maser, developed by Ali Javan of Bell Telephone Laboratories, highlights design potential of quantum electronics.

an ELECTRONIC DESIGN staff report

Quantum Electronics: A Key to Future Design



Advances Appear Imminent for Optical Masers, Amplifiers, Modulators, Detectors and Oscillators

Manfred W. Meisels
Technical Editor

QUANTUM electronics, once the exclusive preserve of the research physicist, is today a significant factor in design. Electronic designers, crowded by the state of the art of classical electronic concepts, are turning increasingly to quantum electronics to extend the limits of attainable power, frequency, sensitivity and accuracy of equipment.

In a certain sense, quantum electronics has been employed by designers for decades. Klystrons, photocells, semiconductors and parametric amplifiers, while understandable in classical terms, are in fact quantum systems.

Other devices, however, including masers in all their variety, ferrite, antiferromagnetic and paramagnetic components, can be understood and designed only by quantum-electronic methods. This class of devices, in which bold design advances are most imminent, is surveyed in this report.

Quantum-electronic areas in which advances are anticipated include:

- Optical and infrared masers for high-power,

continuous operation.

- Advanced modulators for optical communications and radar systems.
- Quantum counters for noiseless detection of radiation over a wide range of frequencies.
- Quantum oscillators to fill the spectrum gap between K band and the far infrared.
- Broadly tunable, high-gain masers covering the L to K bands and engineered for everyday use in field and airborne equipment.

Armed Forces Supporting Variety of R&D Projects

The armed services are well aware of the design possibilities inherent in quantum electronics and are supporting much research and development in this area. Dollars are being spent for such projects as a sun-powered optical-maser communications system, optical-maser "death rays," millimeter-wave airborne masers, quantum counters and modulators. Basic research into improved materials, the principal need in quantum electronics, is also being financed by the military.

Altogether some 50 different quantum-electronic projects, most of them classified, are under way with Government support at perhaps 20 universities and industrial concerns. The bulk of these military research contracts are administered by the Army Signal Corps, the Office of Naval Research and the Air Force's Wright Air Development Division.

The potential importance of quantum electronics in military systems is clearly defined in the following statement by a Wright division spokesman:

"Although optical masers are in their infancy, the potentialities of using such devices for space-to-space communications seem almost unlimited. The successful exploitation of the optical maser should provide the long-sought coherent light source with an extremely narrow beam of very high power density. Utilization of such a system should provide communications over millions of miles in space.

"The very high data rates requiring large bandwidths will be prohibitive in the radio portion of the electromagnetic spectrum. However, frequencies in the near optical band and higher lend

themselves to data rates and bandwidths orders of magnitude greater than possible with Hertzian waves."

Small Industrial Teams Pressing Materials Research

In many instances, industry is paying its own bills for quantum-electronic research. Examples include Raytheon, International Business Machines, International Telephone and Telegraph, General Motors, and to a large extent, Bell Telephone Laboratories. Research groups tend to be quite small—generally less than five men.

This does not, however, reflect a lack of corporate interest. Most of these studies consist primarily of materials research, which does not always lend itself to crash-program techniques. Rather it can be shown that most of the significant developments in quantum devices, have come from small research teams that only subsequently received Government support.

Quantum-electronic devices are already beginning to reflect the emphasis on systems application underlying such military and commercial interest. Basic research is, of course, being expanded, but the resultant devices are being engineered with reliability, ease of operation and servicing in mind.

Low-temperature operation, for example, may prove to be less of a dilemma in quantum-system design than heretofore. Improved cryostats of reasonable size and power drain are becoming available. A recently announced unit from Hughes Aircraft Co. weighs less than 25 lb and draws 1 kw. The company has also developed a nonspilling Dewar that can be used in any position. Such components should greatly facilitate maser application in airborne and mobile-ground equipment. While some quantum devices, particularly in the optical region, may operate successfully at room temperature, cooling will remain necessary for low-noise amplifiers, antiferromagnetics and other components.

Intense magnetic fields, required by many quantum-electronic systems, are likewise becoming available with reasonably compact magnets. A method of fabricating niobium-three-tin, developed by Bell Laboratories, is said to enable design of comparatively lightweight 100,000-gauss superconducting magnets. The Lincoln Laboratory of the Massachusetts Institute of Technology is employing a 2-lb, 5,500-gauss superconducting magnet in one of its masers and is developing small 100,000-gauss units of an undisclosed type.

Maser Amplifiers Are Due For Major Improvements

Design and performance upgrading is due for maser amplifiers. These low-noise devices have

The A-B-C of Quantum Electronics: Energy at Different Level

Quantum electronics begins with the fact that energy is "digital." That is, energy increases or decreases in steps rather than continuously. The digit of energy is the quantum, which is a multiple of Planck's Constant ($h = 6.625 \times 10^{-27}$ erg-sec). The energy of light is therefore also quantized and equal to $h\nu$ (where ν is its frequency).

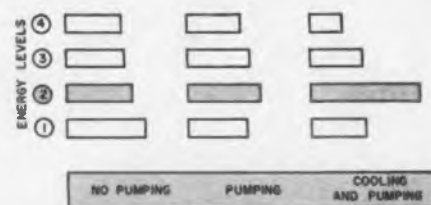
Quantum devices are possible because an atom can have any one of many possible levels of internal energy. This energy is embodied in the orbits of the atom's electrons, the spin of its electrons, and the spin of its nucleus.

Electromagnetic radiation can raise the energy of an atom by altering these characteristics. For example, an electron can be shifted to a new orbit more distant from the nucleus, or the direction of an electron's spin can be reversed.

The possible changes in energy, however, correspond to certain multiples of h and can be induced only by those precise quantities of energy. Thus an atom can be raised (or excited) from one energy level to a higher one only by light whose frequency corresponds to the energy difference between the two levels ($E = h\nu$). The light is absorbed by the atom in the process.

Once excited, the atom can return to a lower energy level (or relax) by emitting light whose frequency is equivalent to the energy surrendered by the atom. The atom can thus be considered as a sharply tuned oscillator that absorbs and radiates energy of discrete frequencies. Each element has its own characteristic energy levels and resonant frequencies.

At any given temperature, a body of atoms will have its population distributed among many of the possible energy levels. The probability, however, is that the lower levels will be more heavily populated than the upper. Such a system can readily accept more energy, and may be "pumped" by radiation of the correct frequency.



Population of energy levels is inverted by pumping. Normal population is shown at left; in center, population of second level is increased at expense of other levels. Cooling, at right, further enhances effect.

When pumping achieves a surplus of atoms at a given level, the population is said to be "inverted." The system then relaxes to the normal population by radiating energy at a particular frequency.

An excited atom need not surrender all its energy in a single relaxation. It can relax to successive intermediate levels in returning to its original level. The energy lost at each transition is, of course, less than the pumping energy and can be in the form of heat and vibration as well as microwave or light radiation. The various levels can be used to establish a continuous pumping and radiation scheme, as is the case in cw masers.

Magnetic and electric fields, either externally applied or due to the neighboring atoms in a crystal lattice, can alter the possible energy levels. In addition cooling the material depopulates certain energy levels. These levels are then available to receive atoms relaxing from higher levels.

These and other techniques are useful in the design of quantum devices. They enable the engineer to circumvent nature by using the material to absorb and radiate energy at frequencies other than nature intended. By thus selecting the material and manipulating the environment, the designer will ultimately develop quantum systems having useful characteristics in all regions of the frequency spectrum.



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been the mainstay of radar and radio astronomy, but low noise alone may not impress system designers. In many cases they can turn to the parametric amplifier as a very close second choice. Tunability, bandwidth, stability, gain bandwidth product and high-frequency operation—all in full measure—are being demanded by potential users of maser amplifiers.

The first design departure from the original cavity-type maser was the traveling-wave maser. Twm's are today overwhelmingly preferred in system design by such organizations as Hughes Aircraft Co., Airborne Instruments Laboratory and Bell.

Nevertheless more subtle concepts are being explored to improve maser performance. Multiple-cavity masers at MIT and twm's without discrete slow-wave structures at Radio Corp. of America are examples of such research. Emphasis here is on improving bandwidth tuning range beyond that of the now conventional twm's.

X band represents the upper frequency limit of masers being considered for system use. These units are generally pumped at K band, the limit of conventional pumping sources.

The need for higher frequency operation has thus given rise to several unconventional pumping schemes dedicated to the principle that somehow one can get more frequency out than is put in. Such methods include cross-relaxation pumping, under study at Johns Hopkins University and the Westinghouse Air Armament Div.; harmonic pumping, at Airborne Instruments; and pulsed field and adiabatic fast-passage methods, being considered by Lincoln Laboratory.

Some success has been achieved. An 8-mm pulsed maser has been operated by Lincoln and a 115-kmc, cross-relaxation unit was demonstrated at Johns Hopkins. Not all the above schemes, however, lend themselves to cw operation, and there are many problems inherent in each method. Materials for optically pumped microwave masers, an obvious solution, are thus a common research goal.

Millimeter-Wave Oscillators Of High Power Seem Likely

High-power millimeter-wave oscillators also appear possible through quantum-electronic methods. Ferrite oscillators in development at

ELECTRONIC DESIGN • March 15, 1961

Stanford University appear promising. A Cerenkov radiation approach at the University of Illinois may enable power in the tens of watts at submillimeter wavelengths. Both these projects are being supported by the armed services.

Optical and infrared masers are still very much in the laboratory stage, and one can hardly predict which of the many competing types and concepts will prove most useful. More likely, as one physicist put it, "We can look forward to a complete family of such devices covering the entire optical and IR spectrum, with each member having its own particularly desirable characteristics for a given type of operation."

Research projects underway in this area are strongly biased toward development of working systems. Apart from the prestige factor, the organization that first develops a high-power cw optical or infrared maser for system applications will have the inside track in a potentially enormous segment of the electronics industry.

While the contest for such devices continues, other groups are tackling the problem of how to modulate and detect coherent light, so as to make fullest use of the high available bandwidth. Electro-Optical Systems, ITT, Bell Laboratories, Harvard University and Ohio State University are among the groups active here. Methods include Kerr cells, plasmas, semiconductor light valves, and a number of possibilities employing the Faraday effect in paramagnetic substances. Many of these proposed devices as well as the maser itself, could be reversed for detection at the receiving end. In addition heterodyning of light and quantum counters are also being actively considered for detection of coherent light.

Frequency Standards, Magnetometers Among More Fundamental Devices

Quantum electronics also includes more workaday devices, such as frequency standards and magnetometers. Good design in these units has evolved from repetitive manufacture and has been confirmed by field use. Units have been flown successfully aboard airplanes and missiles. Plans for including magnetometers and frequency standards in space vehicles are being confidently pursued by such organizations as Texas Instruments, Varian, National Co., Space Technology Laboratories, and the National Bureau of Standards.

In all areas of quantum electronics the accent is on engineering development—and quite often with a short-range objective. Many of the physicists working in this field are almost akin to engineers, in that they view the evolution from basic concepts to operating equipment as a personal challenge. In retrospect, and considering the newness of the art, they have been remarkably successful. ■ ■



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Rapid Strides Made in Optical and Infrared Masers



Calcium-fluoride optical maser is adjusted by IBM scientist Peter Sorokin. The device comes in two versions. Samarium doping gives red light output uranium doping results in infrared beam. Both types operate at liquid helium temperature.

RESearch into optical and infrared masers has begun to pay off at an accelerated rate since the initial breakthrough in this field last July by Theodore H. Maiman of Hughes Research Laboratories. Six different types of masers are now operating; three companies have ruby masers for sale; maser materials, both proven and speculative, are readily available on the market; and the Air Force is about to announce award of a contract for a sun-powered optical maser to be used in a space communications system.

Dr. Maiman's demonstration that "it can be done" has motivated considerable new research. Skeptics hastened to duplicate his findings, competing approaches were re-examined, and much original work was begun. The results to date:

- Ruby masers at Hughes, Bell Telephone Laboratories, Raytheon and elsewhere.
 - Samarium-doped calcium-fluoride maser at IBM.
 - Uranium-doped calcium-fluoride infrared maser at IBM.
 - Mercury-zinc gas-discharge maser at the Lebedev Institute in Russia.
 - Helium-neon gas-discharge cw infrared maser at Bell Telephone Laboratories.
 - Satellite-line ruby maser simultaneously announced by Bell Laboratories and Varian Associates.
- Other types, still short of successful operation, include:
- Alkali-vapor infrared masers at Columbia University.
 - Semiconductor infrared maser at Lincoln Laboratory.
 - Fiber-optic maser of rare earth-doped glass at American Optical Co.

Individuals and Groups Press Search for New Materials

In addition every scientist in the field is investigating his own private blend of rare earths, crystals, semiconductors, gases and what-have-you. These, of course, "cannot be divulged at this time." Organizations thus engaged in studying materials include all the ones mentioned above, as well as ITT Federal Laboratories,

Technical Research Group, Westinghouse, MIT, General Motors, General Electric and RCA. Given enough time and test tubes, one can expect considerable improvement in optical and infrared masers.

The materials that will ultimately prove to be most useful will enable design of masers combining the following desirable characteristics:

- High power.
- Continuous operation.
- Spatial coherence.
- Narrow output frequency.
- Highly directional output.
- Room-temperature operation.

Apart from the choice of material, the same basic configuration and operating scheme have been employed in all the optical masers built to date, and no significant departures are proposed.

Fabry-Perot Interferometer Is Tuned to Desired Frequency

The basic principle, suggested by Arthur Schawlow of Bell Laboratories and Charles Townes, formerly at Columbia University and now at the Institute for Defense Analysis in Washington, uses a Fabry-Perot interferometer tuned to the desired output frequency. The active material (whether gas or solid) is contained in a slender cylinder with parallel reflecting plates at each end. Solids are commonly machined as cylinders with reflective coatings deposited on each flat.

Pumping light from a high-intensity flash lamp excites atoms in the material to a higher energy level. Intermediate energy levels are so arranged that the excited atoms surrender their energy as light of a desired frequency in returning to their original level.

Maser action, as distinguished from the ordinary fluorescence of these materials, is due to inversion of the atomic population at the higher energy level and the action of the interferometer.

Fluorescence is the result of spontaneous random emission by excited atoms and radiates light in all directions. Maser action is a controlled emission of light along the axis of the cylinder.

A single photon of the proper frequency triggers emission of the excited atoms. Successive



Elliptical reflector in Raytheon's ruby maser is said to reduce power consumption by a factor of ten. Unit will be marketed by company in competition with masers available from Technical Research Group and Trianon Instrument Co.

reflections at the end plates, with light reinforced by further emissions during each trip through the interferometer. intensifies output in the axial direction.

Light emitted in other directions is absorbed by the material or escapes through the side walls. The maser beam itself is coupled out of the material by a small, semitransparent area at one of the reflectors.

Highly Directive Beam, Narrow Frequency Assured

The interferometer assures a highly directive beam, as nonaxial modes are not readily propagated in the material. Beams less than 1 min of arc wide have been emitted by optical masers.

Frequency narrowness of optical masers also tends to be quite good. Output lines only 10 kc wide have been observed in the helium-neon infrared maser. The width is on the order of one part in 10^{-10} of the output frequency. Solid-state optical masers have rather broader lines—about one part in 10^{-5} —but still excellent compared with conventional microwave oscillators. In addition cooling would reduce the line width of solids to some extent.

High power and cw operation appear somewhat incompatible with present materials. The ruby maser can deliver about a megawatt, but only for a few microseconds at a time. The material is a very inefficient energy converter, as is the flash lamp used to pump it.

The calcium-fluoride masers developed at IBM research laboratories, while also high-power devices, may prove somewhat more adaptable to cw operation. The inherent conversion efficiency of the material is reportedly several hundred times better than that of ruby. In the first calcium-fluoride masers only a small fraction of the crystal was illuminated by the pumping light; ruby is generally placed inside a spiral flash tube

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Heater Negative With Respect to Cathode		
Total DC and Peak	200	Volts
Heater Positive With Respect to Cathode		
DC	100	Volts
Total DC and Peak	200	Volts
Maximum Bulb Temperature	175	°C



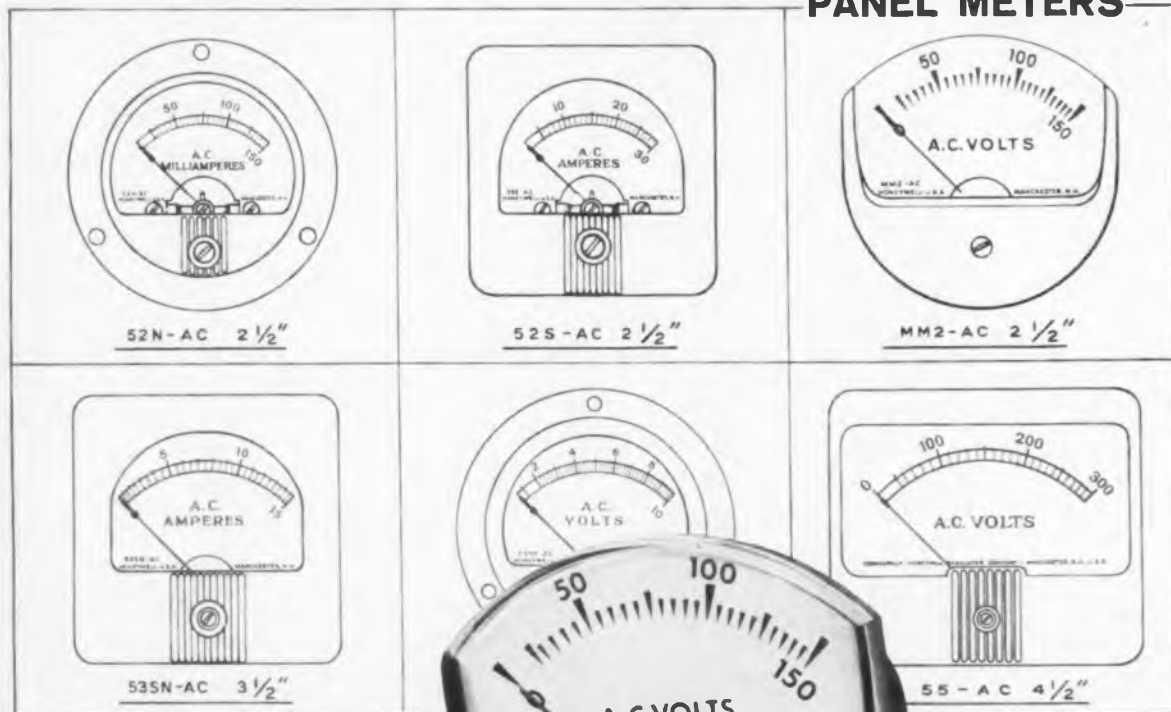
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Peter Sorokin and Mirek Stevenson, inventors of the calcium-fluoride maser, hope to achieve cw output by more complete illumination of the materials and by improving reflectivity of the end plates.

Since the maser beam is reflected at the ends millions of times while inside the interferometer, a small increase in reflectivity can mean the difference between pulsed and cw operation. (The success of the cw gas maser is largely due to the 13-layer dielectric reflectors used in the device).

Power output of gas masers is inherently limited by the low density of the materials, as it is the number of radiating atoms that determines the output level. At Bell Laboratories, Ali Javan's gas-discharge cw maser employs neon at a pressure of only 0.1 mm. The power obtained from a volume of about 150 cc is about 15 mw. Even a small amount of lightly doped solid (dilute ruby contains less than 1 per cent of the active chromium ion) brings a far larger number of atoms into play.

Coherence of optical maser output has been repeatedly demonstrated by interference fringe experiments and by beat notes from masers oscillating at more than one frequency simultaneously. So far, however, no one has attempted to obtain these effects from two separate masers.

Full-Crystal Action Sought To Lift Maser Performance

A potentially important observation is that maser action occurs only within certain areas of the crystal rather than through the entire volume. This is attributed to inhomogeneities in the material that establish certain preferred areas for maser action.

The newly developed cw gas maser embodies an unusual excitation mechanism that may prove applicable to other gas mixtures (such as the Russian mercury-zinc discharge maser). The Bell Laboratories device employs a mixture of helium and neon, pumped by electrodeless rf discharge at 28 mc.

This discharge excites the helium atoms, which then transfer their energy to the neon atoms by a collision process.

Neon atoms can return to the ground level by a number of different energy paths, each emitting radiation of a different frequency. Up to 30 outputs between 1.118 and 1.207 microns are possible.

Output frequencies of present masers are in the red and infrared regions as follows:

- Mercury-zinc gas discharge—6,263 A.
- Samarium-doped calcium fluoride—6,902 A.
- Dilute ruby (Hughes type)—6,943 A.
- Dark ruby (satellite-line type)—7,009 and 7,041 A.
- Helium-neon gas discharge—11,530 A.
- Uranium-doped calcium fluoride—20,490 A.

Studies Seek to Conquer Higher Frequency Barriers

A pair of energy levels in dark ruby make possible radiation in the far infrared (1/3-mm) region, according to Dr. Irwin Wieder of Varian.

Materials are also being studied for maser action in other portions of the visible spectrum, but the normal distribution of energy levels reduces the probability of success at the higher frequencies. Nevertheless the Navy would like to acquire a "green" maser to explore the 5,200 A transmission window in sea water for possible anti-submarine warfare applications.

The fiber-optic maser and the semiconductor cyclotron-resonance maser represent considerable departures from already successful methods.

The fiber-optic maser would not operate in the interferometer mode. Instead light travels only once along the fiber and exits at the ends. The fiber acts as an optical waveguide to quench non-axial modes and should permit the same order of directivity available with interferometer masers.

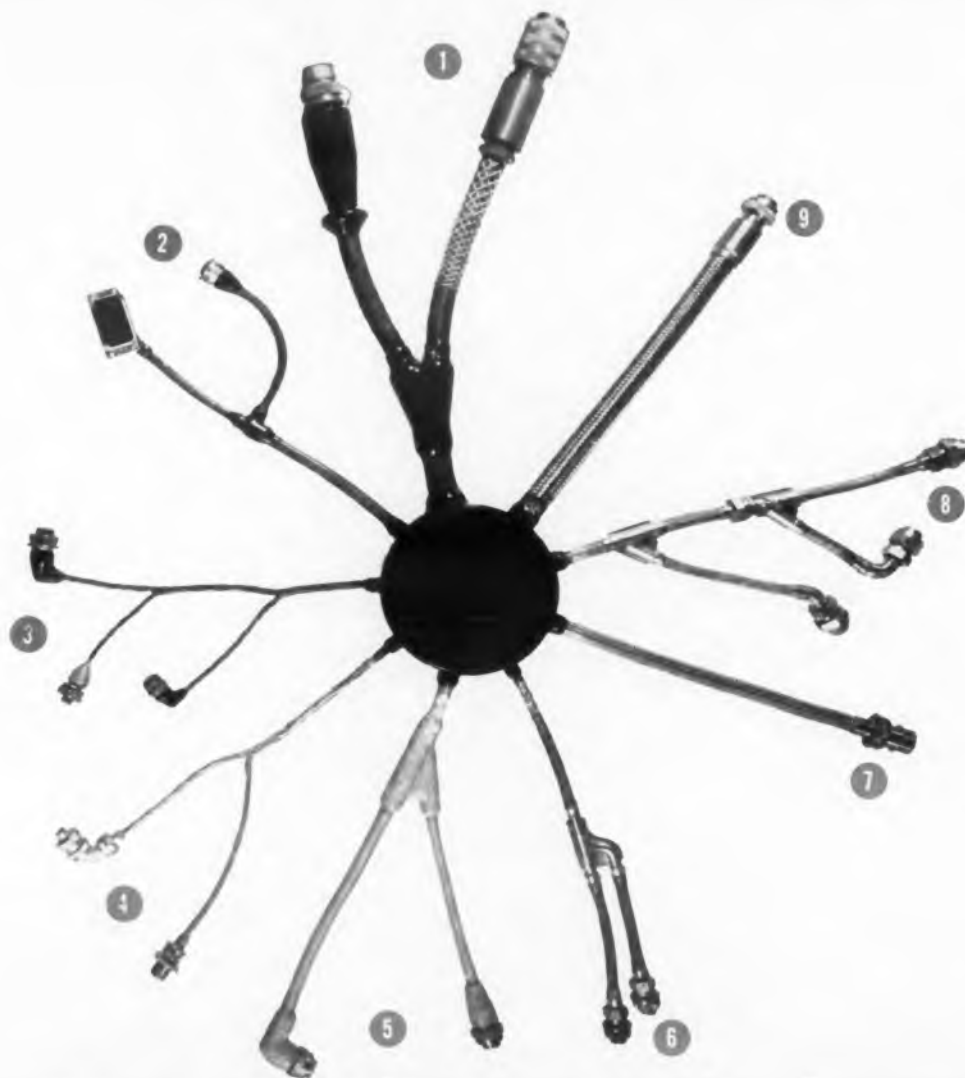
High power would be achieved by using fibers, up to several hundred meters long, to provide a sufficient volume of active material.

Rare, Earth-Doped Glasses May Permit Fiber Masers

Dr. Elias Snitzer of the American Optical Co., Southbridge, Mass., has done considerable work with ruby fibers. This work has been abandoned, however, since ruby cannot be drawn into fibers less than 200 microns in diameter.

The cyclotron-resonance maser being developed by Dr. Benjamin Lax of the Lincoln Laboratory employs indium antimonide and other semiconductors in which Landau energy levels are established by a resonant magnetic field. Electrons are raised into these levels by optical pumping. Subsequent relaxation emits infrared radiation.

Dr. Lax plans to use a ruby maser to pump the device, as up to 100 w of narrow-frequency light is thought necessary to pump the electrons. The magnetic field would be on the order of 100,000 gauss, but Dr. Lax is reported to be completing a magnet that will permit such fields with relatively compact size. ■ ■



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The Modulation-Detection Lag

EFFICIENT modulation and detection methods are required for system application of optical masers. The designer, presented at last with ample bandwidth, is now challenged to use it to the fullest advantage. Conventional choppers and Kerr cells seem primitive when kilomegacycle bandwidths are available. For detection, conventional photocell systems appear equally inefficient.

Internal modulation schemes (somehow con-

trolling the amplitude or frequency of the optical maser) are not being considered seriously for the transmitting end of optical communications systems. Magnetic fields can shift output frequencies, but only over a very narrow range. Amplitude or pulse modulation is theoretically possible, but known optical pumping sources cannot be modulated at nanosecond rates, and there is a limiting response lag of the maser itself.

Use of Two Masers in Series Among Modulation Schemes

One suggested amplitude-modulation technique would employ two optical masers in series. The first maser would be frequency modulated over a very narrow range by a magnetic field and its output used to pump the second maser. Small deviations of pump frequency may then amplitude-modulate the second maser.

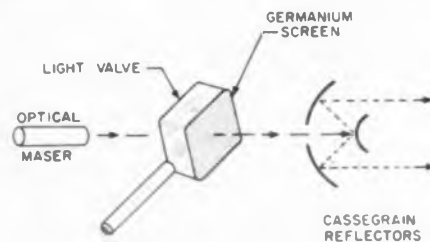
Most of the proposed modulation schemes, however, would involve external modulation of a cw maser beam. Many workers in this field are studying variations of the Kerr cell. Ruby, neodymium-ethyl-sulfate and other paramagnetic crystals exhibit the Faraday effect in which transmitted light is rotated in polarization by a magnetic or microwave field.

In one such method, proposed by Dr. Nicolaas Bloembergen at Harvard University, cross-relaxation in liquid-helium-cooled ruby should enable response to a modulating signal at high megacycle rates. Unfortunately only very small rotations have been observed, and little improvement is expected with presently known materials. This method is also under study at Bell Telephone Laboratories.

A related method being investigated by W. S. C. Chang at Ohio State University employs spin-lattice relaxation in ruby and water-grown crystals to achieve rotation. Here up to 100 deg of rotation has been observed, but response is on the order of only 100 cps.

Standing Waves Considered For Ultrasonic Modulation

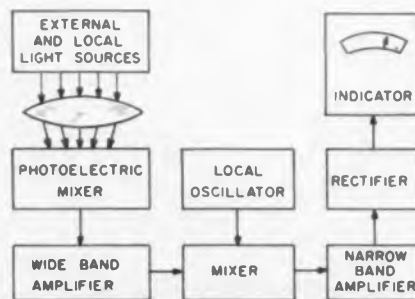
Ultrasonic modulation by means of standing waves in a suitable crystal is another suggested approach. Electro-Optical Systems, Inc., is said to be considering this method. The company has recently established a quantum electronics division to develop hardware in this area. Dr. Harold



Spatial modulation of maser beam is proposed using semiconductor screen and cassegrain optical system to converge the beam.



Fiber-optic maser bundle would also enable spatial modulation; here, multiple beams transmit entire image simultaneously.



Heterodyning system proposed for detection of maser beam. Detection of signals at 10^6 km is believed possible.

Lyons, directing the new group, suggests that Kerr cells be used to frequency-modulate a maser beam. External fields modulate the index of refraction of the cell, and light traversing the material is changed in frequency.

The inherent difficulty here is that the index of refraction can be changed by only several parts per million, and the frequency change is therefore proportionately small. One possible solution, suggested by scientists at the ITT Federal Laboratories, is the use of plasmas.

Light would traverse a chamber in which a plasma is rapidly created and destroyed. The change in index of refraction from gas to plasma is several per cent, but researchers admit that manipulating a plasma at megacycle frequencies presents formidable difficulties.

An alternate scheme would be to reflect light from a fast-moving plasma stream, thus changing frequency by the Doppler effect. By varying the speed or the bunching frequency of a plasma stream, light transmitted or reflected by the plasma would be frequency-modulated.

Spatial Modulation Suggested To Exploit Maser Beam Better

Each of these methods accepts the limiting concept of time-sequential modulation. It has been proposed that the extreme narrowness and directionality of a maser beam be more fully exploited through spatial modulation. According to Dr. Jenny Rosenthal of Bramley Consultants, Passaic, N.J., each photon in a wave front could potentially transmit a bit of information. Up to 10^{22} photons per sec could be available as compared to perhaps 10^6 bits per sec possible with time-sequential modulation. Ideally an entire finely detailed image could be transmitted instantaneously by spatial modulation.

Dr. Rosenthal suggests a cassegrain optical system to simultaneously increase the area and directionality of an optical maser beam. Despite a many-fold increase of beam area at the transmitter to permit spatial modulation, beam width at a distant receiver would be narrower because of the improved directivity imparted by the optics.

The beam would be spatially modulated by interposing a thin semiconductor screen rendered locally transparent and opaque by electron-beam scanning. Such a "light valve" has been developed by Philco for an infrared scanning system. Dr. Rosenthal believes that other materials would permit design of light valves for optical frequencies.

Another possible means of spatial modulation would use fiber-optic masers now in development. A bundle of fiber-optic masers could simultaneously transmit an entire image derived from a cathode-ray tube or camera over sub-



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36



stantial distances. Reception of a spatially modulated beam might also be accomplished by fiber-optic masers.

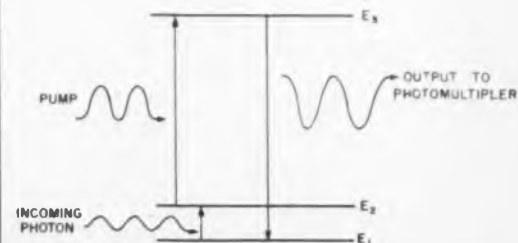
Modulated-Light Detectors Drawing Considerable Attention

Considerable attention is being given to perfecting detectors for modulated light. A method employing heterodyning of light has been proposed by A. T. Forrester of Electro-Optical Systems. Dr. Forrester believes he has observed heterodyning of two noncoherent light sources. These findings, admittedly marginal, have not been accepted in all quarters, but Dr. Forrester is confident that coherent sources will permit a dramatic improvement of this effect. Detection ranges up to 10⁶ km are thought possible.

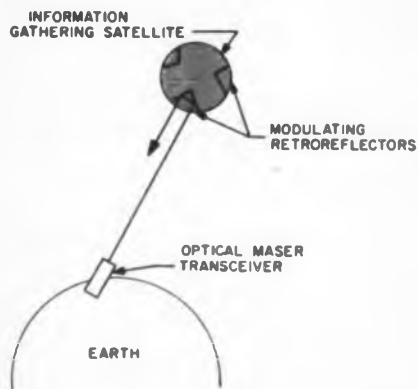
In his system, a maser would serve as a local oscillator for detection of modulated signals from a second, remote maser. The two signals, mixed in a square-law photocell, would result in an rf beat frequency that could then be handled by straightforward superheterodyne circuitry. Such beat notes have, in fact, been observed with the Bell Laboratories' gas-discharge maser and the Varian satellite-line ruby maser. Each of these devices oscillates at more than one frequency, thus providing two coherent light sources for heterodyning.

The "Snird" (Supposedly Noiseless Infrared Detector) represents a quantum approach to detection of light. The proposed quantum counter is essentially a three-level maser, designed so that output occurs only when a photon of the desired frequency is detected.

As shown in the accompanying diagram, maser



Quantum counter would permit noiseless detection of individual photons. Output depends on simultaneous presence of pumping signal and incoming photon.



Passive telemetry scheme for satellites proposed by Technical Research Group. Maser beam from earth would be modulated and returned by corner cube prisms aboard vehicle.

action from the third level to ground level is possible only when an incoming photon raises an atom to the level where optical pumping can complete the cycle. At other times, the device would, in theory, have no output.

A Snird along the lines suggested by Dr. Nicolaas Bloembergen is being developed at Johns Hopkins University under Air Force contract. The device would respond to infrared in the 2-to-3-micron range. Optical pumping is by means of a mercury-vapor lamp, and output would be at 6,100 Å. Lanthanum chloride, doped with praseodymium trichloride, is now being tested for the Snird.

Gadolinium Trichloride Studied As Possible Detector Material

At the University of Maryland, researchers are looking into gadolinium trichloride as a possible material for quantum counters. It has also been suggested that care in the selection of polarization directions for the incoming photon and the output could yield amplification by an avalanche effect.

Helium pumped by an electron beam forms the basis of a third quantum counter—a classified one at MIT's Naval Supersonic Laboratory. This device will respond to far infrared (20,582 Å), but output frequency will be in the ultraviolet (584.4 Å) region and must be detected by a scintillator.

Whether quantum counters will be as noiseless as predicted remains to be seen, for no one has yet succeeded in operating a Snird. However, the concept should be useful because of its apparently sharp frequency response. ■ ■



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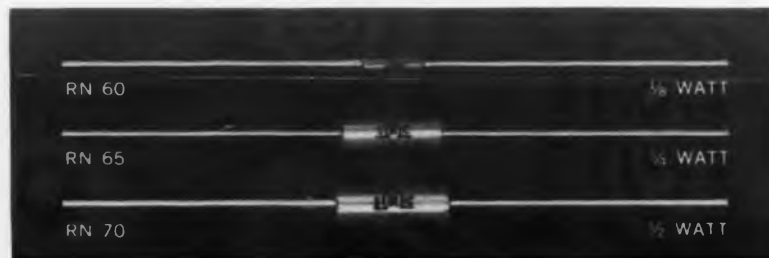
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Needed: Maser

MASER amplifiers are becoming increasingly important in the design of communication and weapons systems. Until very recently the maser amplifier was limited in use to one-of-a-kind experiments, where the demand for ultra-low noise reception overruled other practical considerations in system design. Such feats as bouncing radar signals off Venus or tuning in on distant galaxies just about encompassed the recent sum of maser applications.

Two converging developments are rapidly altering this situation:

- Demand for system performance at the limits of today's state of the art. Those few less db's of noise can make all the difference when one's design is teetering between success and failure.

- Improved masers designed for day-to-day operation in the field. Masers need not be forever tricky. As one engineer put it, "We're designing them so that you can turn them on and walk away."

Disbelievers are now taking a close, second look at masers and are finding them increasingly useful. Indications of this trend include:

- Project Echo, where successful, day-to-day operation of a 2.39-kmc, traveling-wave maser



Maser amplifiers operating at X band track reentry vehicles at 200-mile range from this Lincoln Laboratory

ELECTRONIC DESIGN • March 15, 1961

Amplifying Units

points to the feasibility of masers in satellite communications systems.

- Tracking of re-entry vehicles at Wallop's Island with a 9.35-kmc maser. Plasma trails generated by 5-in.-diam re-entry bodies are successfully tracked at a range of 200 miles by a Lincoln Laboratory installation.

- A 10-cm field radar, with maser preamplifier, developed by the Royal Radar Establishment in England.

- Airborne tracking radar and cw Doppler radar, both employing X-band maser preamplifiers, at Hughes Aircraft Co.

- Weather radar for the Signal Corps using miniature X-band radar, also by Hughes.

- Millimeter-wave radar in development by the Lincoln Laboratory of MIT, designed to use a maser amplifier.

In addition a number of classified systems employing masers are in development for the Air Force. Airborne Instruments Laboratory is developing a voltage-tunable twm to "full military environmental specifications" for the front end of a highly sensitive telemetry receiver. The device will be tunable from 2,150 to 2,350 mc by varying the magnetic field and pump frequency.



installation at Arbutle Neck, Va. The radar spots plasma trails generated by 5-in.-diam. vehicles

Most overload-protection devices have to be de-rated for elevated temperatures. As the ambient goes up, usable load capacity goes down. This is an inherent characteristic of thermal-type devices.

The Heinemann circuit breaker is magnetically actuated. It senses overcurrent not through a heat-sensitive bi-metal strip, but through a solenoid coil. The calibrated current capacity of the coil is unaffected by temperature.

If you put a Heinemann breaker in a hot, component-packed equipment enclosure (even next to a bank of tubes), it will



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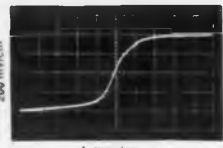
These temperature-stable characteristics are common to the entire line of Heinemann hydraulic-magnetic circuit breakers. You can have any of them (including the subminiature Series VP shown here) in any integral or fractional rating you need, from 0.010 amps on up, and with any of several inverse time delays. Our Engineering Guide, Bulletin 201, will give you detailed information.

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SA 2370

Switching Time of a Tunnel Diode ...with a Type N Unit

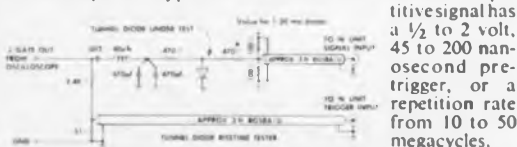


Typical waveform of gallium arsenide tunnel diode.

A Tektronix Type N Pulse-Sampling Unit enables you to convert your oscilloscope into a Pulse-Sampling Scope with risetime of 0.6 nanosecond.

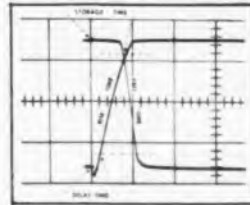
Your Pulse-Sampling Scope—without auxiliary equipment—fits many applications. For example, the schematic illustrates an easy way to test tunnel (ESAKI) diodes with nanosecond switching speeds. In this typical application the oscilloscope provides both a pretrigger for the Type N Unit and a delayed current-ramp source for the tunnel diode.

Other pulse-sampling applications requiring *only* the oscilloscope and Type N Unit include those wherein a repetitive signal has



45 to 200 nanosecond pretrigger, or a repetition rate from 10 to 50 megacycles.

High-Frequency Characteristics of a Transistor ...with a Type R Unit



Calibrated vertical display in mA/cm of collector current.

A Tektronix Type R Transistor-Risetime Unit enables you to trigger the oscilloscope sweep either on the start of a test pulse or on both the start and finish—to display delay, rise, storage, and fall times simultaneously.

Risetime of the pulse supplied by the Type R Unit is less than 5 nanoseconds (amplitude 0.02 to 10 volts across 50 ohms, positive or negative), but overall risetime depends partially upon your Tektronix Oscilloscope. For example, typically 12 nsec—with Types 541A, 543, 545A, 555, 581, 585; 14 nsec—with Type 551; 23 nsec—with Types 531A, 533, 535A; 31 nsec—with Type 536; 70 nsec—with Type 532.

Evaluating Semiconductor Devices?

...then you must know about these 4 Tektronix Plug-In Units for any Tektronix Oscilloscope that accepts Letter-Series Plug-Ins

Waveform Analysis of a Fast Diode ...with a Type S Unit

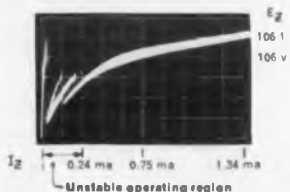


Typical display of diode reverse-recovery characteristics—with forward current at 20 ma and reverse current at 0.5 ma.

A Tektronix Type S Diode-Recovery Unit* enables you to display and measure both forward and reverse switching characteristics of semiconductor diodes. You can determine effective lifetimes to 2 nanoseconds, stored charge to 10 picocoulombs, junction capacitance to 2 picofarads, and base resistance to 0.25 ohm. Parameters measured from the curves can be used to predict the behavior of many diodes in many circuits, as well as compare diodes for performance in a particular circuit.

*Overall risetime depends partially upon your Tektronix oscilloscope—typically the same as listed with the Type R Unit.

E/I Display of a Zener Diode ...with a Type Z Unit



A Tektronix Type Z Differential-Comparator Unit provides an equivalent vertical scale length up to ± 2000 centimeters at 50 mv/cm, enabling you to accurately resolve incremental voltage or current changes in semiconductor circuits.

With Zener diodes, for example, you can display Zener voltage as a function of current or temperature. You can clearly show several important Zener diode instabilities, including white noise and microplasmas (multiple-breakdown phenomena at low junction currents).

The waveform illustrates instabilities of a $\frac{1}{4}$ watt Zener diode. With Zener voltage of 106 v at 0.75 ma and Zener impedance (calculated) of 170 Ω over the current range of 0.75 to 1.34 ma, the microplasmas shown indicate that this Zener diode should not be operated below 0.24 ma.

Type S Diode-Recovery Unit	\$250
Type R Transistor-Risetime Unit	300
Type N Pulse-Sampling Unit	600
Type Z Differential-Comparator Unit	525

(prices f.o.b. factory)



For a demonstration of any of these 4 plug-in units in your own work with semiconductor devices, call your Tektronix Field Engineer. Ask him for the free 32-page booklet—which lists complete specifications and performance details of all 16 "letter-series" plug-ins for Tektronix Oscilloscopes.

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Gain will be on the order of 30 db and instantaneous bandwidth about 25 mc. Six other traveling-wave maser projects at Airborne Instruments, calling for units to operate above X band, remain classified.

Similarly Hughes Aircraft has five classified Air Force contracts involving maser amplifiers for five different air and ground systems.

Three Methods Considered To Raise Maser Frequency

Three separate methods are being actively studied to boost maser frequency. These are:

- Cross-relaxation systems.
- Harmonic pumping.
- Pulsed field operation.

Each of these methods enables amplification of signal frequencies higher than the pump frequency. Conventional solid-state masers are operated with the pump frequency two to ten times higher than the signal frequency. For masers with signal frequencies above 20 kmc, there are no pumping sources in the millimeter and submillimeter regions. Accordingly schemes have been devised to get something for nothing, frequencywise.

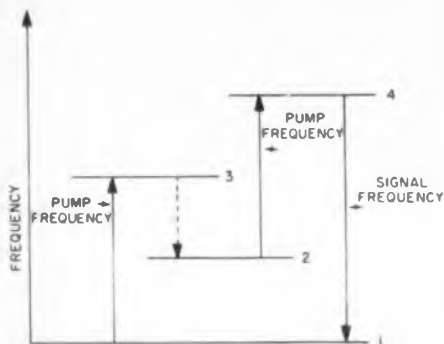
The cross-relaxation maser is a variant of the push-pull four-level maser, with energy levels so arranged that a radiating transition emits a signal of higher frequency than the pump signal.

As shown in the accompanying diagram, the pumping signal raises an atom from the first to the third energy level. From there, it undergoes a nonradiating transition to the second level, where the pump raises it to the fourth level. Note that levels one and three must have the same spacing as levels two and four. Also there must exist an empty energy level sufficiently below the fourth level to permit high-frequency radiation.

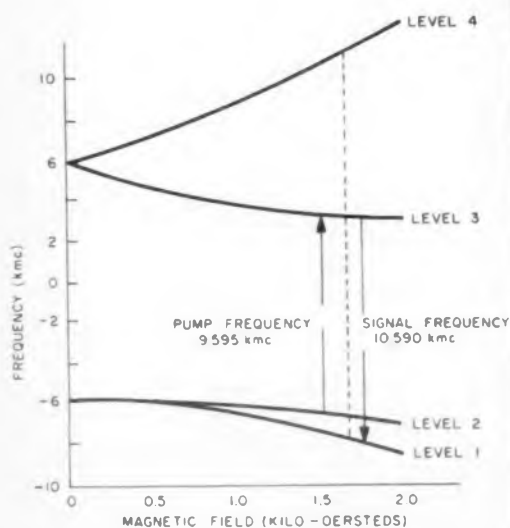
Cross-Relaxation Devices Operated in Two Projects

Cross-relaxation masers have been operated at Johns Hopkins University and the Westinghouse Air Arm Division. The Johns Hopkins maser, developed by Dr. Jan Minkowski under Air Force contract, operates at 115 kmc with a 71.5-kmc pump signal. It employs a double-doped chromium ruby in a cavity arrangement. Magnesium oxide and emerald crystals are also being tested.

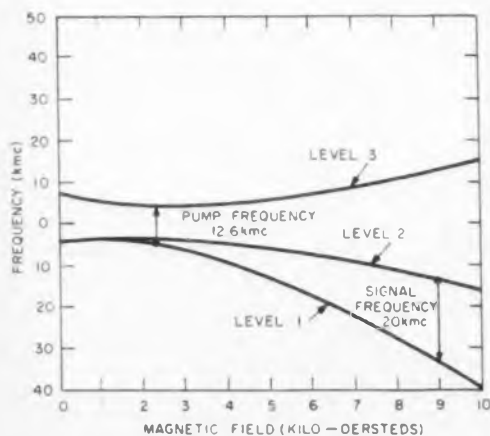
The Westinghouse device has operated at X band with C-band pumping. The active materials tested thus far include single and double-



Cross-relaxation and two-level pumping enable maser operation at frequency higher than pumping frequency.



Harmonic pumping permits frequency gain due to harmonic relationship between levels 2 to 3 and 1 to 4. Actual pumping is thus achieved at a harmonic of the pump frequency.



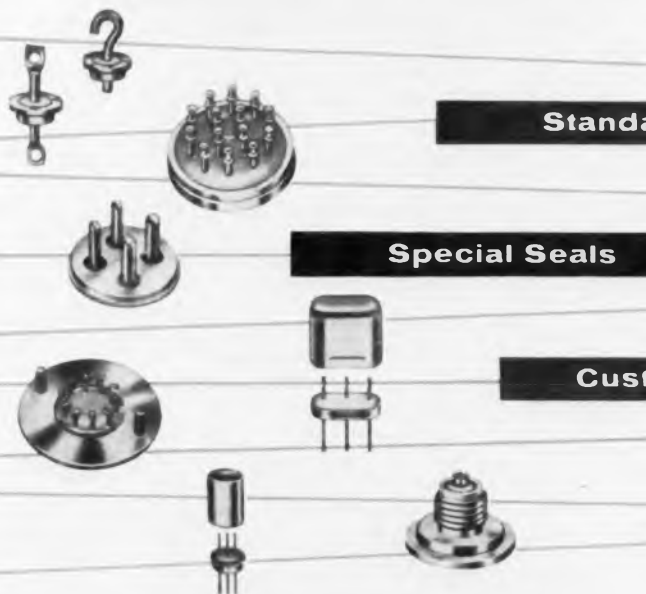
Pulsed-field maser utilizes magnetic field to separate energy levels for high-frequency amplification. Stronger magnetic fields may permit efficient operation at 300 kmc.

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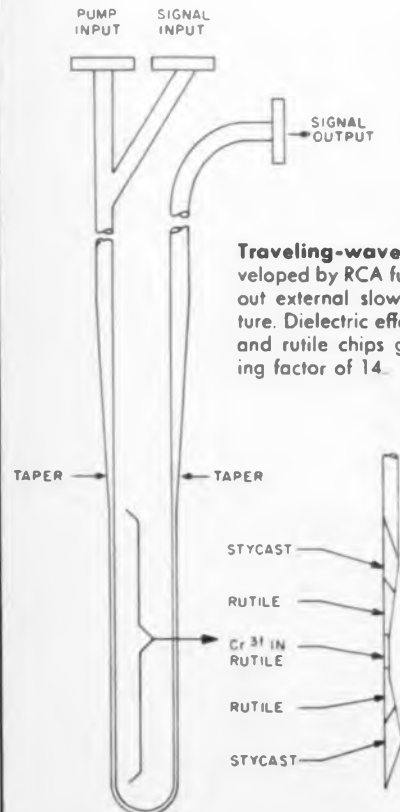


doped rutiles. Tom Hollis, in charge of the project sponsored by Air Force, expects to demonstrate a traveling-wave, single-port version of the device operating at still higher frequencies by the end of this summer.

Harmonic pumping requires the presence of harmonically related energy levels in the maser material. Given such levels, a pump signal at a certain frequency will achieve pumping equivalent to a harmonic of that signal. The excited atom is thus able to radiate at a frequency greater than the pumping frequency.

Harmonically pumped masers have been demonstrated by Dr. Frank Arams of Airborne Instruments. One such device operates at 10.32 mc with 9.58-mc pumping and is tunable over a 420-mc range. A cavity-mounted ruby was used.

Harmonic pumping is also being investigated at Bell Telephone Laboratories.



Traveling-wave maser developed by RCA functions without external slow wave structure. Dielectric effect of Stycast and rutile chips gives a slowing factor of 14.



Project Echo traveling-wave maser is discussed by Bell Telephone Laboratory scientists R. W. DeGrasse and H. E. D. Scovil. The two-channel device operates at a signal frequency of 2.4 mc.

Unlike the preceding two methods, pulsed field operation does not permit design of a maser with continuous output. The boost in frequency is due to separation of the energy levels at high magnetic fields. As shown in the accompanying diagram, the material is pumped at a low frequency and then swept by a magnetic field. Energy absorbed from the changing field spreads the lines and enables output at a higher frequency. The need for a pulsed magnetic field precludes continuous operation.

Dr. Simon Foner at Lincoln Laboratory has obtained signals at 75 mc in ruby with a 12-kmc pump. Maximum field strength was approximately 10,000 gauss.

Considerable research is also being devoted to improve the bandwidth of maser amplifiers. Two novel approaches being supported by the Signal Corps are reported here.

RCA's David Sarnoff Research Center is developing a broadly tunable traveling-wave maser without an external slow-wave structure. An array of rutile and stycast chips provides the slowing by dielectric means. A slowing factor of 14 has been obtained, giving a bandwidth of about 300 mc in the 8-to-10-kmc region.

At MIT's Research Laboratory of Electronics, a group headed by Dr. M. W. P. Strandberg is investigating the effect of multiple-cavity structures on bandwidth. An experimental device has been built that includes a negative RLC cavity (no active material) ahead of the positive RLC ruby cavity. Bandwidths of 40 mc at X band have been obtained. Dr. Strandberg indicates that this design approach imposes no theoretical limit on gain-bandwidth product. ■ ■

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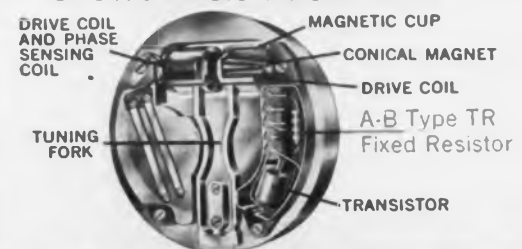
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Two Radical Devices May Give Mm Power

SUBSTANTIAL power in the millimeter range and beyond may result from two unusual quantum-electronic devices being investigated with military financing at university laboratories. The first is the Rebatron (Relativistic Electron Bunching Device), under study by Paul D. Coleman at the University of Illinois; the second is a pulsed ferrite generator, being developed by H. J. Shaw at Stanford University.

The Rebatron is based on the principle of Cerenkov radiation. This occurs when a charged particle traverses a dielectric at a speed greater than the speed of light in that medium. The particle (usually an electron) need not penetrate the medium; it must only pass very near its surface, so that the internal field of the substance can interact with the particle.

The Cerenkov principle is instrumented by passing a frequency-bunched electron beam through a cone of dielectric material. Dr. Coleman reports an output of 1 w at 40 kmc with a one Mev beam bunched at S band.

Radiation is emitted at various harmonics of the bunching frequency. Harmonics up to the 34th have been observed. By proper shaping of the dielectric, most of the power can be concentrated onto one desired harmonic and radiated over a narrow angle, Dr. Coleman asserts.

Output is continuous and infinitely tunable by varying the bunching frequency. Radiation is collected by a coaxial horn. Some workers note that the radiation has a "hole in the middle" and is therefore difficult to collect and apply effectively. It is thought, however, that Dr. Coleman should be able to overcome this problem.

Frequency can be increased by employing a higher bunching frequency. An X-band Rebatron is now under construction. Efficient operation is expected up to the 50th harmonic.

Vast Increases in Power Linked to New Materials

Power can be increased, Dr. Coleman states, by boosting the energy of the electron beam and by decreasing the distance from the beam to the dielectric surface. Such increases are believed minimal, however, compared to the power thought possible with tensor materials, such as ferrites and plasmas.

"We don't smile when we say we're shooting for 100 to 1,000 w at 1 mm," Dr. Coleman told ELECTRONIC DESIGN.

The Rebatron and its role in bridging the

"spectrum gap" will be described by Dr. Coleman at Session 16 of the IRE meetings in New York and at the Quantum Electronics Conference at Berkeley.

An experimental model of the pulsed ferrite generator at Stanford University delivers approximately 0.1 mw at 32 kmc and may yield useful power at up to 300 kmc.

The device consists of a 10-mil-diam yttrium-iron garnet sphere mounted within an open, parallel-wire transmission line. An rf input signal and a steady magnet field establish uniform gyromagnetic precession in the ferrite. A pulsed magnetic field is then applied to increase the energy of the spin system. At the top of the pulse, this energy is radiated at a higher frequency than the input signal.

This frequency is not harmonically related to the input frequency and may be varied continuously by adjusting the magnitude of the pulsed field, according to Dr. H. J. Shaw, head of the

project. For a 4-kmc input signal, a 10,000-gauss field produced a 32-kmc output; 100,000 gauss should result in a 1-mm output.

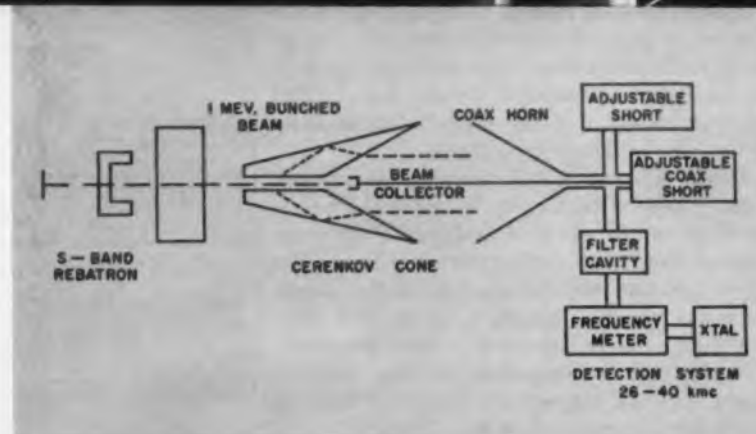
Due to the small size of the sphere, a small field coil will suffice, and high fields can be readily obtained, Dr. Shaw points out.

In future experiments, Dr. Shaw plans to use a 50-mil-diam coil fed by a parallel plate line. A charged transmission line consisting of six paralleled coaxial cables was employed in the earlier tests.

Power output can be boosted by decreasing the rise time of the magnetic pulse relative to the relaxation time of the ferrite. The new coil will have a rise time of 25 nsec, compared with a 100-nsec relaxation time for the ferrite. A larger volume of active material would also increase power. Dr. Shaw plans to employ a 1-cm-long rod in future tests. The diameter will remain at 10 mils, so as to again achieve high field strengths with small coils. ■ ■



Cerenkov radiation produced by Rebatron may enable ultra-high power at submillimeter wave lengths. Illustration shows Cerenkov cone (left) and beam-collecting coax horn. Cerenkov radiation (see diagram) is produced by high-energy, frequency-bunched electron beam passing through hole in dielectric cone. Output is at various harmonics of the bunching frequency.



2d Quantum Conference Due

Important new disclosures in optical, infrared and millimeter-wave masers can be expected at the Second International Conference on Quantum Electronics, to be held at Berkeley, Calif., March 23-25. Since the beginning of February, scientists have been trooping to a series of other meetings dealing in part with quantum electronics. These included meetings of the American Physical Society and Optical Society of America and the Solid State Circuits Conference. The important news, however, is being reserved for quantum electronics' Old Home Week at Berkeley.

At the first conference, held in September, 1959, Dr. Arthur L. Schawlow and others suggested the possibility of optical masers to what has since proved to be a most attentive audience. This year's "suggestions" will concern the Mossbauer effect, Cerenkov radiation, superconductive tunneling, heterodyning of light, modulation of light at microwave frequencies and millimeter-wave masers.

Most eagerly awaited is a contingent of Russian scientists who last time mostly sat and listened. This time, barring last-minute international complications, the Russians will deliver papers on negative temperatures in gases and millimeter-wave masers. Dr. Ali Javan of Bell Telephone Laboratories will read a paper cautiously titled "Formation of Negative Temperatures in Gaseous Mixtures." Meanwhile he has been credited with development of the first cw infrared maser.

Adherents of ruby, calcium-fluoride and gaseous masers of various types will all deliver papers, and there is a strong likelihood that some of them will not make the trip to Berkeley empty-handed.

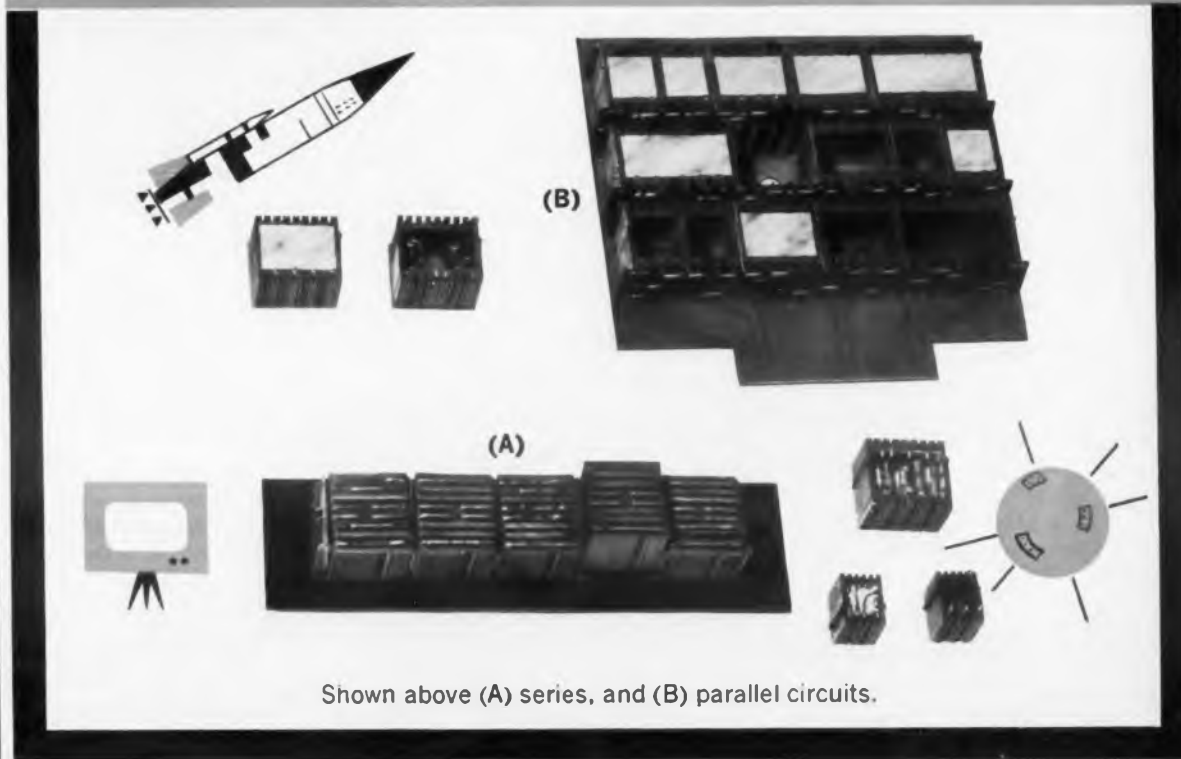
Other significant papers will discuss the prospects of developing optical fiber and semiconductor masers.

The conference is again being sponsored by the Office of Naval Research. Prof. John R. Singer of the University of California will be chairman.

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Big Gain for Standards and Magnetometers

QUANTUM electronics has permitted design of frequency standards and magnetometers of unprecedented accuracy and sensitivity. A cesium-beam unit at the National Bureau of Standards generates a 9.192-kmc signal accurate to 2 parts in 10^{-11} , and improvement of several orders of magnitude is contemplated. Rubidium-vapor magnetometers, carried aloft in rockets, can measure fields down to 10^{-2} gauss.

Such devices are in regular service in the laboratory, industry and the armed forces. Miniaturized units for space and airborne use are in design, and a variety of unusual applications have been proposed. These include:

- Air traffic control and collision-avoidance systems based on precise airborne and ground-frequency standards.
- Confirmation of the theory of relativity by a satellite-borne frequency standard.
- Single, universal time, generated by local frequency standard, radio-synchronized to one master atomic clock.
- High precision time transfer by transporting atomic clocks.
- Mapping of planetary and interplanetary fields with magnetometers in space probes.

Quantum-electronic frequency standards fall into three categories: masers, atomic-beam types and optically pumped vapor units.

The masers, such as the original ammonia maser and the more recent Harvard hydrogen maser, offer the greatest accuracy and stability by several orders of magnitude. However, such devices are highly sensitive and complex and have not been employed outside the laboratory.

Beam types, such as the National Company's Atomichron, are less accurate than masers. However, they can be conveniently instrumented and have enjoyed considerable application in the field.

The recently introduced optically pumped vapor standard, derived from the rubidium magnetometer, is more simple and compact than atomic-beam units. Accuracy, however, is not yet equal to that of more elaborate versions of beam-type standards.

Quantum-electronic magnetometers are divided into proton precession and optically pumped types. A proton instrument was aboard the Vanguard II satellite. However, optically pumped units require less power and are more sensitive. Varian's pumped rubidium instruments

have been flown in sounding rockets and will be aboard the National Aeronautics and Space Agency's P-14 space probe, set for launching this month.

Electron Precession Principle Proves of Practical Aid

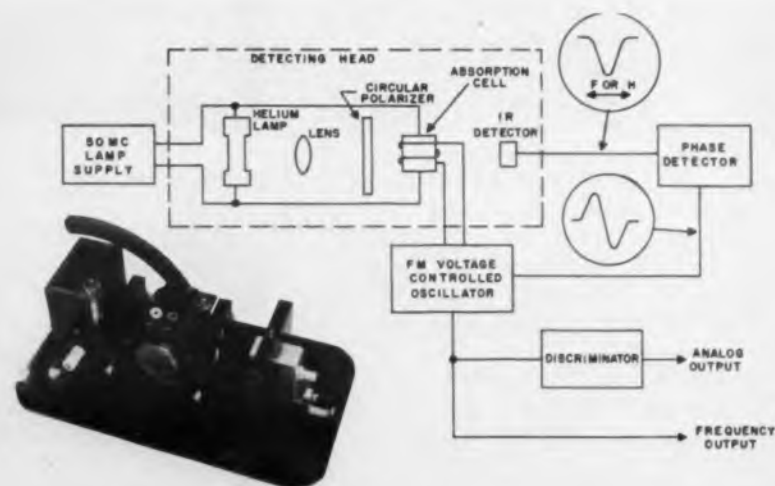
Optically pumped magnetometers and frequency standards, as well as atomic-beam frequency standards, all invoke the principle of proton or electron precession. The frequency of precession is sharply tuned by the nature of the material involved and by the strength of external magnetic fields. Precession is induced and sustained by applying a signal of that frequency.

In optically pumped devices this precession is of practical significance, because it modulates the absorption of pumping light by the material. A rubidium-vapor magnetometer, for example, would employ this effect as follows:

A chamber of rubidium vapor is pumped by circularly polarized light emitted from a similar rubidium-vapor lamp. The light corresponds to the 7,947A absorption line of rubidium. As the material is increasingly pumped, absorption of this light decreases. When pumping is complete,



Cesium-beam frequency standard at the National Bureau of Standards. Accuracy is said to be 2 parts in 10^{-11} .



Helium vapor magnetometer circuit typifies operation of optically pumped devices. Texas Instruments unit forms compact package.



Industrial version of Atomichron cesium-beam standard is reportedly accurate to two parts in 10^{10} . Smaller versions are being designed for airborne use.

light transmission is maximum.

If precession of electrons in the rubidium-vapor is now induced by applying an rf signal at the correct frequency (about 700 mc per gauss), absorption of the polarized light is modulated at that frequency. This modulated signal is detected by a photocell, amplified and fed back to the rubidium-vapor to sustain precession. Since the strength of the magnetic field determines the precession frequency, it can be conveniently measured.

The rubidium-vapor magnetometer was developed by Arnold Bloom at Varian Associates.

A similar scheme using helium instead of rubidium vapor has been developed by Peter Franken at the University of Michigan. Instruments of this type are being manufactured by Texas Instruments' apparatus div.

Optically pumped vapor chambers can also be used as frequency standards by controlling the magnetic field, so that the precession frequency remains constant. Space Technology Laboratories has flown rubidium-vapor instruments of this type aboard Atlas missiles (for Doppler tracking) and is preparing to market a miniature unit said to be accurate to 2 parts in 10^4 . The National Bureau of Standards, RCA, and Hewlett-Packard are also reported to be developing optically pumped frequency standards.

Magnetic Fields Focus Atomic Beam Standards

Atomic-beam frequency standards, which are essentially mass spectrometers, utilize the precession effect in a somewhat different manner.

Here nuclear precession, induced by a signal of the correct frequency, alters the magnetic dipole moment of the atom. A series of magnetic fields can then focus atoms of a particular dipole

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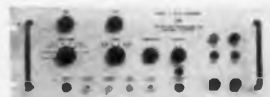
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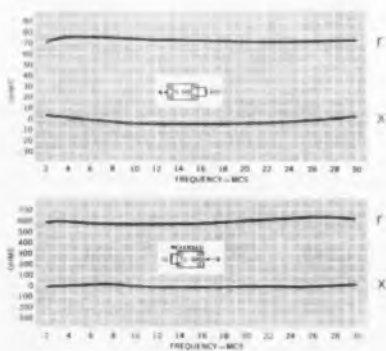
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moment (or energy) onto a collector. Since the existence of these atoms is determined by an rf signal of the correct frequency, one has a convenient method of detecting and controlling this frequency quite accurately.

In the Atomichron, for example, a beam of cesium atoms is employed. A magnetic state selector channels atoms of one particular energy into an rf chamber. There a precession signal alters the energy of these atoms to a particular level. These atoms are then focused by a second state selector onto an ionization detector, whose output controls the precession signal.

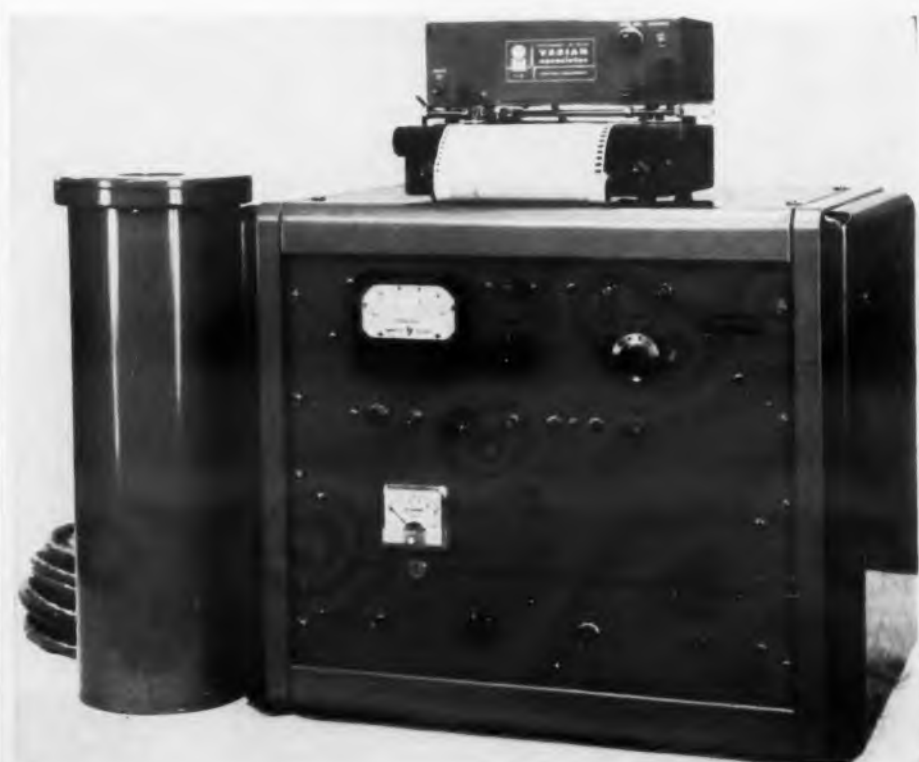
**Variety of Atomichrons
Designed for Civilian-Military Use**

A wide range of Atomichrons has been designed for laboratory, industrial and military use. Accuracies of 2 parts in 10^{10} are claimed. Similar units have also been developed by ITT.

More elaborate atomic-beam devices employing both cesium and thallium vapors have been developed by the National Bureau of Standards. Precession frequency of cesium is 9.192 kmc, that of thallium about 20 kmc. NBS is also developing a rubidium-vapor maser standard to operate at 6.835 mc. ■ ■



Nuclear precession forms basis of many quantum devices such as proton magnetometers and atomic beam frequency standards. Frequency of precession indicates strength of magnetic field, or controls action of beam devices.



Rubidium vapor station magnetometer by Varian Associates measures field strength changes less than 10^{-6} gauss. A miniaturized version is to be carried aboard space vehicles.

Success Depends on Materials

IMPROVED materials are the key to success in quantum electronics. Given suitable materials, designers could tailor a quantum system to meet any reasonable set of performance specifications. Since there can be only one winner in a race, materials research remains a closely guarded professional secret.

The general area of such research is, however, clearly in the paramagnetic substances. Here lie the best opportunities of finding materials with the desired position and spacing of quantum energy levels. The rare earth and trans-uranic groups are presently the subject of considerable research.

These include at least a dozen possible candidates that may be combined in a large number of salts and as dopants. A painstaking routine of microwave and optical spectroscopy is thus required; for one cannot predict, except very generally, the behavior of these compounds at the desired excitation frequencies.

Paramagnetic crystals such as ruby, emerald, titania, garnet, and calcium fluoride, have been used in quantum-electronic systems with varying degrees of success.

Gases and gas mixtures constitute another large class of possible quantum-electronic materials. These may occur as gases at room temperatures, such as hydrogen, ammonia, helium and neon. Or they may be heated vapors of alkali metals, mercury and zinc.

Materials suitable for optical masers are among the most actively sought. Requirements are clear, but not easily achievable. The ideal material should have:

- Good optical properties.
- A sharp fluorescence line.
- Good quantum efficiency.
- An absorption line through which the fluorescence line can be excited.
- An empty lower state.

The last requirement, generally possible only at low temperatures, has been one of the more critical problems in the materials area.

Materials modified by X-rays, electron bombardment, neutrons or other irradiation are also being studied. Prof. Chihiro Kikuchi, working in this area at the University of Michigan, suggests that quantum devices may be designed for better performance in space than on earth. ■ ■



Apparently perfect crystal of potassium cobalticyanide is admired by Dr. Harry Gatos, asst. head of solid-state research at Lincoln Laboratory. Material was used in first solid-state maser.



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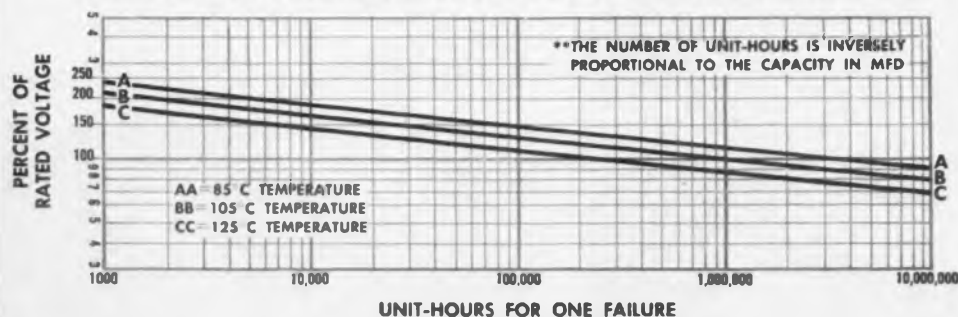
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CIRCLE 43 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

EDITORIAL

For Better Engineering:

Know Thyself, Know Thy Colleagues

Engineers, quick to detect slight differences between one electrical product and another, often fail to discern the *big* difference between engineer₁ and engineer₂. This lack of discernment hinders communications and therefore, engineering progress.

The apparent lack of awareness was demonstrated recently by a group taking an engineering writing course. One of the assignments was to pick a subject to write about. But before beginning, each engineer was asked to define his readers.

In every case the intended readers were defined in general terms—either as engineers, military personnel, or industrial persons. Only one out of ten identified his readers more specifically—as electronic *design* engineers, for example.

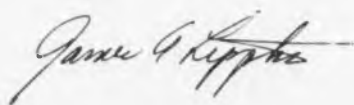
But to organize the communication so it would be helpful or meaningful to his readers, the writer would, perforce, have to be even more specific and classify the electronic design engineer as a microwave engineer, servo engineer, rf circuits designer or whoever. He would further have to be aware of the education and experience of his readers: college degrees, years of experience in a specialty, mathematical ability, etc.

Engineers in the writing course failed to define their readers precisely even though they had just heard a lecturer stress that individuals react differently, depending on their perceptive abilities, neurophysiological makeup, educational and cultural background, and experience.

This weakness of engineers for discerning individual differences comes as no surprise. Studies have shown the engineer to be primarily “thing” oriented rather than “people” oriented.

Since by nature he is slow in understanding the other fellow, he must consciously compensate for the deficiency. Reading such books as Redlich and Bingham's *The Inside Story*, Hodnet's *The Art of Working With People*, or Johnson's *People in Quarantaries* might help. Bull sessions, discussing not engineering problems but personal views on life, art, philosophy and values—preferably with some nonengineer—can help, too.

Engineering decisions in this era of complexity involve many engineers. Communication is necessary, but it can take place ideally only when two persons thoroughly understand each other. Get to know thyself and thy colleague.



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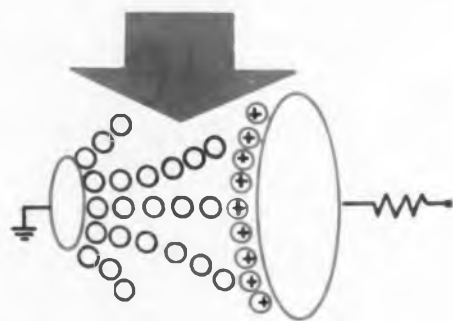
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Transistor Switching Speed from Base Storage Charges and their Lifetimes

Part I

Base storage charges and their lifetimes are basic quantities which can characterize a transistor performing a switching function. Part I of this two-part article includes a brief review of the charge-controlled mechanism and then deals with the analytical relations between switching speeds, charges and lifetimes. Finally, charge measurement techniques are described.

Part II, to appear in a subsequent issue, will be concerned with lifetime measurement and sample predictions for alloy and mesa transistors. It will be shown that the precision of predictions is within a few nanoseconds in many cases.

Y. C. Hwang, D. S. Cleverley, D. J. Monsour
General Electric Co.
Semiconductor Products Dept.
Syracuse, N. Y.

ANALYTICAL relations can be established between transistor switching speed and carrier charge and lifetime in the base region; transient response characteristics of rise, fall, delay and storage time can then be predicted to within 10 to 15 per cent of measured values.

Since 1954, transistor speeds have often been correlated to small signal parameters according to Ebers and Moll's work¹ and Easley's correction for the $R_L C_e$ effect.² Since the introduction of

the charge control concept by Beaufoy and Sparkes,³ much progress has been made in correlating transistor speeds to quantities derived from this concept, such as K factor, base time constant and collector time constant.^{4,5,6,7} If charges and lifetime of the carriers in the base region are truly measurable physical quantities, it should be possible to correlate transistor speeds directly to these quantities so as to present a unified criterion to physicists, engineers, circuit designers and device designers.

For completeness and clarification, the switching mechanism will be described in a qualitative manner and some of the quantities later used will be defined.

Physical Concepts and Definitions Of Switching Mechanism

In Fig. 1, a typical switching circuit is shown with a resistive load, R_L , in the collector circuit, and a constant voltage source with a resistive element, R_2 , in the base circuit; R_2 is the element connected to ground or to an off-bias voltage.

In Fig. 2, a pnp transistor is shown, with the shaded area representing the distribution of stored charges during the flow of collector current. The following facts are indicated:

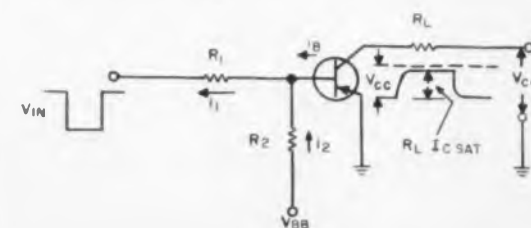


Fig. 1. A typical switching circuit with resistive load R_L in the collector circuit.

Explanation of Symbols

C_C	Collector junction capacitance.
C_E	Emitter junction capacitance.
I_{B1}	Base drive "on" current.
I_{B2}	Base drive "off" current, always opposite to I_{B1} .
I_{BS}	Saturation base current, corresponding to I_{CS} .
I_{BX}	Excess base current, corresponding to $I_{B1} - I_{BS}$.
I_{CS}	Collector current in saturation.
K	K factor, parameter related to storage time.
k	A proportionality constant, relates Q_B to ω_{ab} by $Q_B = \frac{k i_c}{\omega_{ab}}$.
Q_B	Charge stored in the base region, excluding Q_C .
Q_B^*	Total charge stored in the base region, ($Q_B + Q_C$).
Q_{BS}	Saturation charge stored in the base region corresponding to I_{CS} .
Q_C	Incremental charge stored in the collection junction capacitance when a voltage across the junction changes by a definite value; for

Q_F	The incremental charge stored in the emitter junction when the emitter bias is changed.
Q_X	Excess base charge above Q_{BS} , responsible for storage time.
R_L	Load resistance in the collector circuit.
t_d	Delay time.
t_f	Fall time.
t_r	Rise time.
t_s	Storage time.
τ_a	Lifetime of carriers in the base region during active state (below saturation).
τ_b	Lifetime of carriers in the base region in static state (in saturation).
V_{BB}	Base bias voltage.
V_{BE}	Base terminal voltage referred to emitter.
V_{CC}	Collector supply voltage.
V_{CE}	Collector terminal voltage referred to emitter.
V_{IN}	Input pulse voltage.
$\mu\mu C$	Units of charge in micromicrocoulombs.
nsec	Nanosecond, equal to 10^{-9} sec.
ω_{ab}	ω — Cut-off frequency (radians-sec).

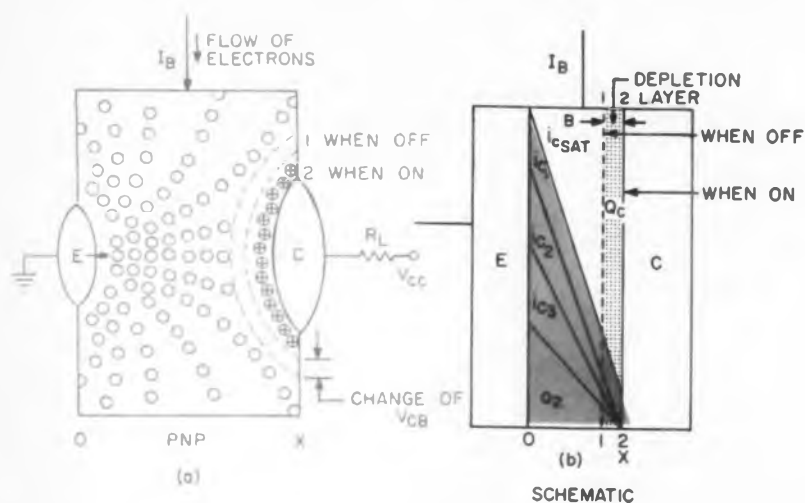


Fig. 2. Distribution of stored charge in the base region of a pnp transistor.

- The carrier distribution is not limited to the region between emitter and collector surfaces.
- The surface recombination is important in the effective lifetime of the carriers. Injected holes, shown by circles, are equal in number to the electrons which are supplied by I_B .
- A depletion layer is represented by the zone with plus, the positive ionized impurity centers; the portion extending into the collector body is considered very small and has been omitted.

When the collector current starts to increase as a result of the application of base driving current, I_{B1} , two changes occur simultaneously. First, the carrier gradient starts to increase, and, secondly, the depletion layer starts to collapse from 1-1 to 2-2 as V_{CE} decreases (Fig. 2). Both changes require I_{B1} to supply electrons to neutralize the positive charges, corresponding to the injected holes and the ionized impurity centers. As long as the change of collector voltage, $V_{CE} - V_{CE}(sat)$, remains the same, the depletion layer portion of the carrier distribution is a fixed quantity while the carrier gradient portion is linearly proportional to the collector saturation current.

It is observed experimentally that this proportionality does exist, even though the carrier distribution extends beyond the bulk region between emitter and collector. This can be true if the charge density distribution increases proportionally to the current.

For different supply voltages, the charge per unit saturation current would be expected to be the same but the charge in the depletion capaci-

tance, Q_c , would vary according to the collector to base voltage. For instance, $Q_c \propto V_{CB}$, for an abrupt junction and $Q_c \propto \sqrt{V_{CB}}$ for a graded junction.

So far, it has been assumed that the emitter junction is ready to inject or, in other words, due to zero bias on the emitter junction, no charge is required to supply the emitter junction capacitance. If the transistor emitter junction is biased negatively (as is the collector), more charge will be required to charge the emitter junction capacitance.

Returning to Fig. 2, the shaded area under the current curves is designated by Q_n (Q_{n1} , Q_{n2} , Q_{n3} , as the case may be), and the area between 1-1 and 2-2 by Q_c . The summation of Q_n and Q_c shall be called Q_n^* . Q_n^* is the total charge needed to bring the transistor to saturation for any value of V_{CE} and I_c .

In order to sustain the gradient of Q_n , electrons must be supplied through I_B . The ratio of Q_n (including that of the fringing region), to the current (I_B), is defined here as the effective lifetime in the active state, τ_a .

$$\tau_a = \frac{Q_n}{I_B}$$

$$\tau_a = \frac{Q_n}{I_B} \quad (1)$$

In general, a different effective lifetime for charge is anticipated in excess of that required for the saturation current, I_{cS} . Thus, in the saturated region, a different lifetime, τ_b , is defined by

$$\tau_b = \frac{Q_X}{I_{cS}} \quad (2)$$

Where Q_X is the excess charge beyond that required to saturate the transistor and I_{cS} is the excess forward base driving current, $I_{B1} - I_{cS}$.

Two fundamental relations are then postulated. Both the measurement techniques and the speed prediction formulas to be discussed are derived from them. These relate the base current to the total input charge which is required by the transistor in the active and saturated regions.

1. During switching on and off,

$$I_B = \frac{Q_n}{\tau_a} + \frac{\delta Q_n}{\delta t} + \frac{\delta Q_c}{\delta t} \quad (3)$$

2. During saturation,

$$I_B = \frac{Q_{nS}}{\tau_a} + \frac{Q_X}{\tau_b} + \frac{\delta Q_X}{\delta t} \quad (4)$$

Where Q_n , Q_c , τ_a and τ_b have been defined before and Q_{nS} is the charge corresponding to I_{cS} , the saturation current.

Analytical Relations for Switching Times Using Q_n^* and τ

Rise Time and Fall Time: By integrating Eq. 3 for constant current drive,

$$t_{r(t_1) \rightarrow (t_2)} = \frac{(Q_n + Q_c) \Big|_{t_1}^{t_2}}{I_{B1} - \frac{Q_n}{2\tau_a}} \quad (5)$$

the factor 2 in the term $\frac{Q_n}{2\tau_a}$ is the result of assuming a linear increase of Q_n with time. When

$$\frac{Q_n}{2\tau_a} \ll I_{B1}$$

$$t_{r(10\% \rightarrow 90\%)} \cong \frac{Q_n + Q_c}{I_{B1}} \cong \frac{Q_n^* \Big|_0^{90\%}}{I_{B1}} \quad (6)$$

$$t_{r(10\% \rightarrow 90\%)} \cong \frac{8.9 Q_n^* \Big|_0^{90\%}}{I_{B1}} \quad (7)$$

A similar procedure is used for fall time except that in this case the lifetime aids in reducing the fall time so that

$$t_f(10\% \rightarrow 90\%) = \frac{Q_n + Q_c \Big|_{10\%}^{90\%}}{-I_{B2} + \frac{Q_n}{2\tau_a}} = \frac{Q_n^* \Big|_{10\%}^{90\%}}{-I_{B2} + \frac{Q_n}{2\tau_a}} \quad (8)$$

(continued on p 54)

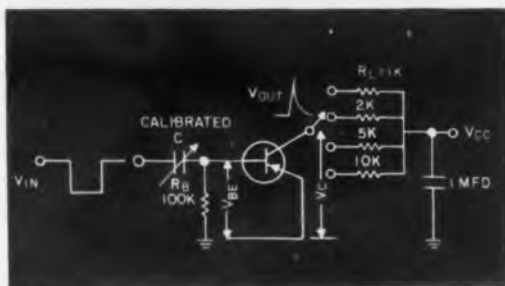


Fig. 3. Circuit used to measure base charges.

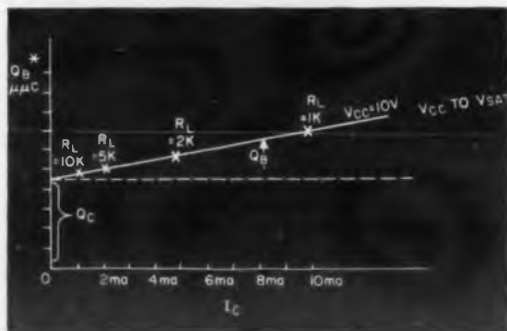


Fig. 4. Plot of the total charge, Q_B^* vs the collector current I_C .

Derivation of Relationship Between Excess Charge Q_X and Lifetime for Short Pulse Time

For a transistor which has been saturated only for a short duration, the excess charge Q_X is not equal to $I_{B1} \tau_b$. Correct expression is obtained below. Starting from equation

$$I_{B1} = \frac{Q_{BS}}{\tau_b} + \frac{q_2}{\tau_b} + \frac{\delta q_2}{\delta t}$$

we can obtain by integration,

$$t = C - \tau_b \log \left(\frac{q_2}{Q_{BS}} - I_{B1} + \frac{Q_{BS}}{\tau_b} \right)$$

at

$$t = t_r + t_d, q_2 = 0; \text{ at } t = t_{pulse}, q_2 = Q_X$$

Hence

$$t_{pulse} - t_r - t_d = -\tau_b \log \frac{\frac{Q_X}{\tau_b} - I_{B1} + \frac{Q_{BS}}{\tau_b}}{-I_{B1} + \frac{Q_{BS}}{\tau_b}}$$

Substituting $\frac{Q_{BS}}{\tau_b} = I_{BS}$ and simplify,

$$Q_X = \tau_b (I_{B1} - I_{BS}) \left[1 - \text{Exp} \left(\frac{-t_{pulse} + t_r + t_d}{\tau_b} \right) \right]$$

when $-I_{B2} \gg \frac{Q_B}{2\tau_a}$

$$t_{f(10-90\%)} \cong \frac{8 Q_B^*}{9} \left| \frac{90\%}{-I_{B2}} \right| \quad (9)$$

(I_{B2} is negative)

Note that when the transistor is switched in a time shorter than its lifetime, τ_a , then the correction factor $Q_B/2\tau_a$ becomes negligible. Otherwise the above equations are nonvalid.

Storage Time: Storage time derived from Eq. 4 is given by

$$t_s = \tau_b \log \left(\frac{I_{B1} - I_{B2}}{I_{BS} - I_{B2}} \right) + \frac{Q_B^*}{-I_{B2}} \left| \frac{100\%}{90\%} \right| \quad (10)$$

or, expressed in another form

$$t_s = \tau_b \log \left(1 + \frac{I_{B1}}{I_{BS} - I_{B2}} \right) + \frac{Q_B^*}{-I_{B2}} \left| \frac{100\%}{90\%} \right| \quad (11)$$

where I_{B1} and I_{B2} are the base turn-on and turn-off currents. t_s may also be expressed in terms of τ_b and charges as follows

$$t_s = \tau_b \log \left(1 + \frac{Q_X}{\tau_b (I_{BS} - I_{B2})} \right) + \frac{Q_B^*}{-I_{B2}} \left| \frac{100\%}{90\%} \right| \quad (12)$$

where $Q_X = I_X \tau_b$ (13)

It is important to note, however, that for a pulse time comparatively short, say less than three times the effective lifetime τ_a or τ_b , the excess charge Q_X is no longer given by Eq. 13. In such cases, the following relation is more appropriate (See Derivation section)

$$Q_X = \tau_b (I_{B1} - I_{BS}) \left[1 - \text{Exp} - \left\{ \frac{(t_{pulse} - t_r - t_d)}{\tau_b} \right\} \right] \quad (14)$$

In practice, the value of τ_b to be used in short-pulse calculations is found to be between τ_a and the τ_b of the steady state condition.

Delay Time: Delay time is given as

$$t_d(10-90\% I_{CS}) = \frac{Q_E}{I_{B1}} + \frac{1/9 Q_B^*}{I_{B1}} \left| \frac{90\%}{0\%} \right| \quad (15)$$

Where Q_E is the charge required to charge the emitter junction capacitance from a reverse bias to the edge of conduction. Q_E is a measurable quantity.

A shunt capacitance C across the input resistance, R_1 , in a switching circuit as shown in Fig. 1, affects both the rise time and the delay time, depending on the bias condition and the value of C . If the emitter is reverse biased and C is small, the effect of C is a reduction of delay time. If the emitter is already at the verge of injection, then the effect of C is to reduce the rise time. If C is sufficiently large, then both the rise and delay are affected. A separation of t_d and t_r requires information other than charge and current, such as the emitter junction capacitance and the exact Q_B^* corresponding to 10 per cent of I_{CS} . An estimation of delay time can be made by measuring the emitter junction capacitance as discussed below.

If the sum of delay and rise time is of interest, a straight deduction of charge fed through the coupling capacitance may be inserted:

$$t_d + t_r(10-90\%) = \frac{Q_B^*}{I_{B1}} \left| \frac{90\%}{0} \right| + \frac{Q_E - V_{IX} C}{I_{B1}} \quad (16)$$

Techniques For Measurement Of Charge

A circuit shown in Fig. 3 is used for charge measurement. A known constant pulse voltage is applied to the base terminal through a precisely calibrated variable capacitor C . For most of the high-speed transistors, a maximum value of 25 pf is adequate. For medium-speed alloy transistors, 100 pf is sufficient.

Two precautions need to be taken in calibrating the capacitor. First, stray capacitances of the rotor and the stator to ground are determined and corrected for. A countercheck by measuring the transfer capacitance on the jig with rf signal should be made after the capacitor is mounted.

R_B is provided to eliminate error due to low BV_{CBO} and to help recover C to the starting condition by discharging the residual charge on C between pulses. This is particularly important for silicon transistors which have high leakage resistance in the base to emitter junction. R_L consists of a group of resistances, ranging from 1 K, 2 K, 5 K to 10 K. A low impedance collector supply (V_{CC}) is essential. Therefore, the 1- μ f capacitor is provided to eliminate the effects of lead inductance. A Tektronix model 545 scope and 8-pf probe are used for collector voltage indication. A Dumont 404 pulse generator is satisfactory for the input pulse.

By adjusting the variable capacitor until the peak voltage at the collector reaches saturation at any specified collector supply voltage (see Fig. 3), the total charge, Q_B^* can be found by the relation

$$Q_B^* = Q_B + Q_C = C (V_{IX} - V_{BE}) \quad (17)$$

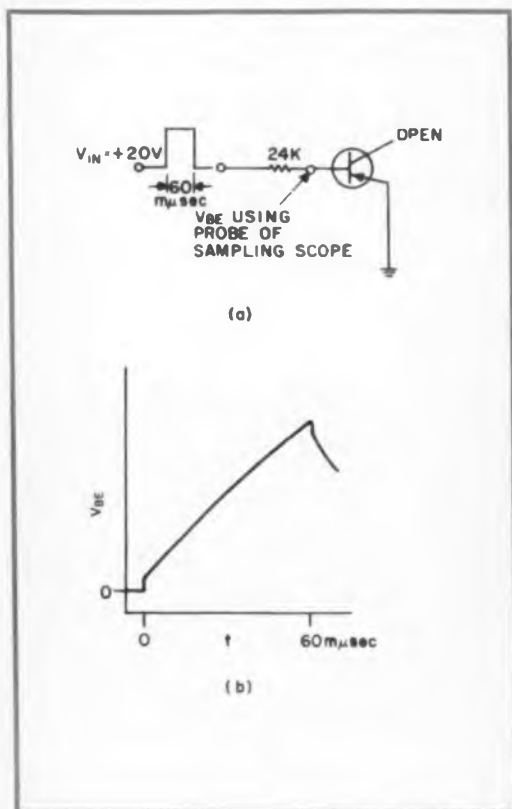


Fig. 5. Charge vs collector current for representative transistors produced by various processes.

where Q_n = the base charge corresponding to the I_c .

Q_c = the charge stored in the depletion capacitor when the voltage V_c changes from V_{cc} to V_{sat} or V specified.

V_{BE} = Base voltage when V_c reaches a peak.

By varying R_L , yet keeping the collector voltage swing the same, a plot of Q_n° vs I_c is obtained as shown in Fig. 4. The actual plots for representative transistors 2N396 (alloy), 2N706 (mesa), 2N1289 (grown) and ZJ-42 (mesa) are shown in Fig. 5. It is rather reassuring that the plot of Q_n° vs I_c remains linear for all of the units measured. However, from the results of the Q_n° test, significant differences between the medium-speed alloy transistor and the high-frequency mesa transistor are evident. For high-speed transistors, the $\Delta Q_n/\Delta I_c$ is about 1 to 2 $\mu\text{C}/\text{ma}$. Q_c corresponds to the charge in the collector junction with zero collector current. For high-speed mesa transistors, Q_c is the dominant portion of Q_n° . For instance, for a V_c swing from 10 v to ≈ 0 v, Q_c is typically 80 μC compared to Q_n of 11 μC at $I_c = 10$ ma. For medium-speed alloy transistors measured under the same

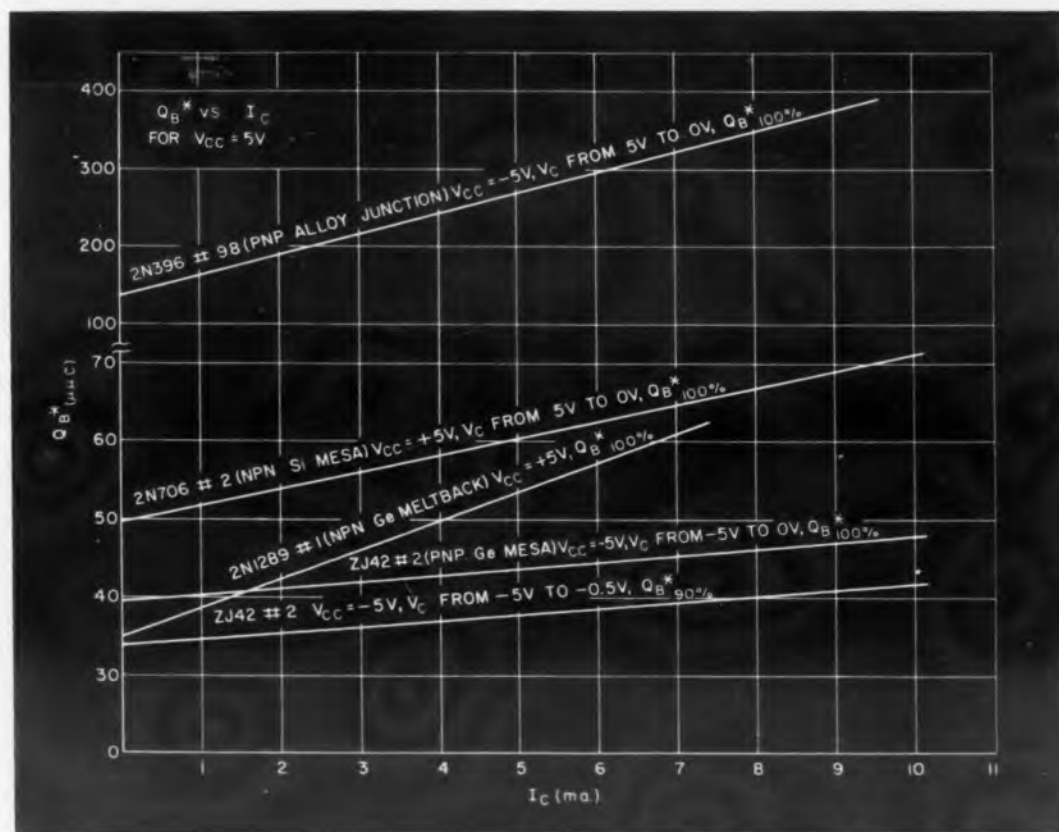


Fig. 6. Circuit used for the measurement of emitter junction charge.

conditions, Q_c and Q_n are approximately 250 and 200 μC respectively.

Measurement of emitter junction charge can be made independently. In Fig. 6 is shown a circuit for measuring the emitter junction charge. A pulse of sufficient magnitude and about 60 nsec is used to charge the junction capacitance through a 24-K resistor. The voltage at the base terminal is measured by a sampling scope. The voltage variation vs time is shown in Fig. 6. The emitter charge from zero bias to a negative bias V_{BE} is then given by

$$Q_E (\text{in } V_{BE}) = \int_0^{V_{BE}} C_E \delta v = \int \frac{V_{IN} - V_{BE}}{R} \delta t$$

For moderate rise of V_{BE} in comparison to V_{IN} ,

$$Q_E \approx \int \frac{V_{IN}}{R} \delta t \approx C_E V_{BE}$$

$$C_E \approx \frac{V_{IN}}{R} \frac{\delta t}{\delta v}$$

Part II, to appear in a future issue, will deal with measurement of the lifetime, the prediction

of rise, fall, delay and storage times based on the charge mechanism. Experimental verification will be presented to illustrate the accuracy possible with the techniques outlined in Part I. ■ ■

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All Solid-State Proportional Control Temperature Servos Can Be Simpler, Better

The author's design knowledge stems from his development work on temperature regulators for small crystal ovens. Two of the proportional action systems he designed are now on the market. The most recent is able to control temperature within 0.005 C.

Paul Gheorghiu*
Transitron Electronic Corp.
Wakefield, Mass.

TEMPERATURE servos can have full proportional action for tight control, yet be extremely simple, compact and reliable.

This is because solid-state components are available for each element in the temperature servo loop. A thermistor can be used as the sensor, a Zener diode as the reference, transistors as the amplifiers, and a resistor as the actuator.

*Formerly with Bulova Electronic Div.

The advantage of a proportionally acting system over the more usual on-off types for a temperature regulator is self-evident from a comparison of the two curves in Fig. 1. The on-off system must continually apply more heat than needed during its on-cycle to compensate for the absence of heat during its off-cycle. Continuous temperature oscillation is inherent in an on-off system.

The proportional system, on the other hand, once it comes up to the set-point temperature, stays there by steadily supplying just the amount of heat needed to keep the system in thermal equilibrium.

The schematic of a proportional temperature servo is shown in Fig. 2. This system was designed for controlling the temperature inside a crystal oven. However, as it illustrates the general problems of circuit layout and component choice for small temperature servos, it will be used as the basis of the discussion.

The control loop is made up of thermal and electrical paths. Thermally, the heat from the resistance coil wound around the inside of the oven cavity originates a heat flow which sets the cavity temperature level.

The matter of heat flow direction in a system like a crystal oven is simple, but basic to the

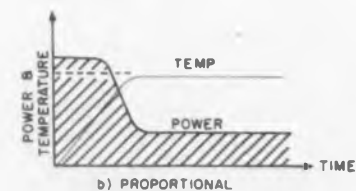
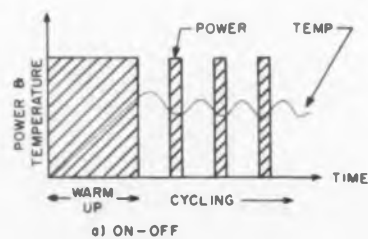


Fig. 1. Off-on control (a) subjects the system to continual power surges but can't eliminate the temperature oscillations. Proportional control (b), once it brings the system up to the reference temperature, steadily applies only enough heat to balance the thermal outflow.

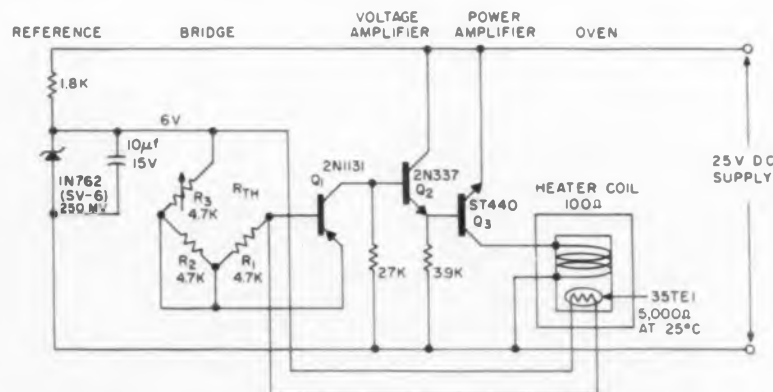


Fig. 2. Circuit for proportional oven control indicates how simple this kind of servo system can be. The heat-sensing thermistor's resistance changes are compared in the bridge circuit to bias the first stage.

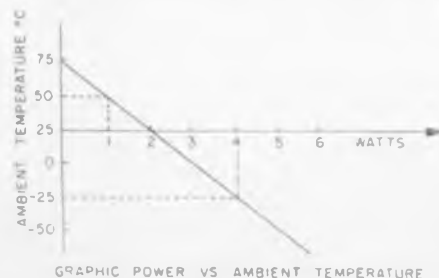


Fig. 3. Power consumed in an oven servo varies with the ambient temperature. The values are for the oven shown in Fig. 4.

Why Thermistor Proportional Control Systems Are Better—

According to author Paul Gheorghiu, "his" proportional temperature servo system has the following advantages over older, off-on systems:

- More accurate. It can control to within 0.005 C.
- Less sensitive to vibration. This is important in missile applications.
- More reliable. There are no mechanical parts, no contacts to become pitted.
- Easier on rest of system. Does not subject rest of system to continual power surges.
- Less expensive. Cost might be \$150 as against \$1,000.

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Fig. 4. An oven servo and its control packaged in a single plug-in can. This unit was manually adjustable.

operating concept. Most ovens work on the principle that it is easier to add heat than subtract it. Practically every electrical device emits heat but few absorb it. (There has been increased interest in thermoelectric coolers working on the Peltier effect, however. The circuits for these could also be based on thermistor sensing.)

Therefore, for control by a heat-producing actuator, an oven temperature must be chosen which is sufficiently higher than any expected ambient. Then the heat flow direction will always be out of the oven. Usually, the oven temperature is set at least 10 C over the highest expected ambient.

Electrically, the servo loop takes the feedback signal from the thermistor, compares it in the bridge, and uses the bridge unbalance to drive the heater coil via the amplifier.

The thermistor's resistance variation with oven cavity temperature is used in one leg of a resistance bridge. The unbalance of the bridge biases the input transistor of a three-stage dc transistor amplifier. The power stage of this amplifier controls the current through the heating coil, completing the loop.

The oven temperature level is set by a variable

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resistor in one leg of the bridge and the bridge reference voltage.

Design Considerations Start with Size of Oven

The first design consideration is obviously the size of the load. Ovens in general use range from 1-100 cu in. The power required is related to the temperature of the oven, ambient temperature range expected, and the thermal mass inside the cavity. It usually ranges from 1-15 w after the warm-up period. Fig. 3 shows a typical power variation with ambient temperature.

Thermistor Dissipation Sets Bridge Parameters

The reference voltage can come from a single-stage Zener diode circuit. The wattage dissipation specification of the thermistor determines the reference voltage. Usually, the reference voltage ranges from 5-10 v.

As a thermistor design example, assume a thermistor with a thermal coefficient of -3.9 per cent per degree C at 25 C is placed in one arm of the bridge, with the bridge's output looking into a high resistance load. The potential across the thermistor resistance R_{th} is given by:

$$E_{th} = E_{ref} \frac{R_{th}}{R_{th} + R_1}$$

The change in potential across the thermistor will be:

$$\Delta E_{th} = E_{ref} \frac{0.039 R_{th}}{R_{th} + R_1}$$

for every degree C of change. Since R_2 and R_3 are the ratio arms of the bridge, their midpoint potential will be fixed and:

$$\Delta E_{error} = \Delta E_{th}$$

The potential applied to the thermistor is limited only by its dissipation factor. The dissipation factor is a function of the thermistor size and is usually 10^{-3} w or less (exact values can be obtained from the manufacturer).

The voltage across the thermistor at any given temperature is:

$$E_{th} = \sqrt{P R}$$

And the required bridge voltage, twice E_{th} .

Three-Transistor Amplifier Uses Minimum Components

The bridge imbalance changes the bias on the first transistor in the two-stage voltage amplifier. The second transistor, an emitter follower, can

be directly coupled to the first transistor if one takes advantage of the complementary relationship between npn and pnp transistors.

Servo Actuator Is Load Resistor

The actuator of this temperature servo is "elegant" in its simplicity. It is merely the heat generated by the output transistor's load resistor. Electrically, all that is necessary here is that the power transistor be capable of supplying the wattage level called for in the oven design.

However, from the thermal standpoint, the actuator design is not so simple.

The resistor must be made from wire which has low wattage density. Wire alloys such as Hytenco meet this requirement. It is good practice to imbed the heater wire in epoxy resin. The epoxy serves both a structural and thermal function. Structurally, it holds the wire in place; thermally, it spreads the heat generated by the wire evenly throughout the oven cavity.

Oven Design Based on Thermal Flow

The oven (or other device to be temperature controlled) should be designed for even temperature distribution. It should be designed to permit the transfer of heat from the coil to the controlled space with the minimum time lag (thermal response times are notoriously long). The thermistor sensing element must be placed so that it will be able to operate accurately and without delay.

Basic guidelines in oven design are:

- Use the simplest possible geometry.
- Make the shell of a material (such as aluminum) which combines high thermal conductivity and low heat capacity.
- Make a study of thermal gradients and heat flow paths for more complex designs (for example, an oven which is to contain circuit elements which will themselves release heat.)

Oven Example Illustrates Compact Configuration Possible

Existing crystal ovens, Fig. 4, prove that this type of proportional temperature servo can be very compact. The unit of Fig. 4 had its solid-state regulating servo packaged snugly below a 6-cu in. oven, the whole system being contained in the plug-in can. The oven is set for 75 C and could be used in ambients up to 65 C. At 25-C ambient it used 2 w. Its temperature could be manually adjusted in 0.05 C steps. After the system is in balance, the cavity temperature is maintained within 0.005 C of setting point. ■ ■

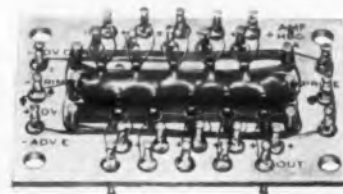
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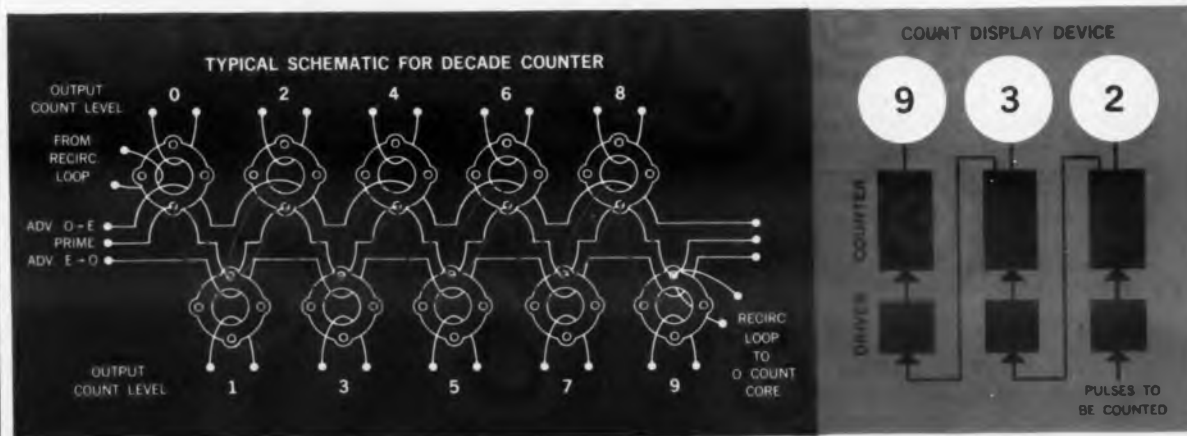


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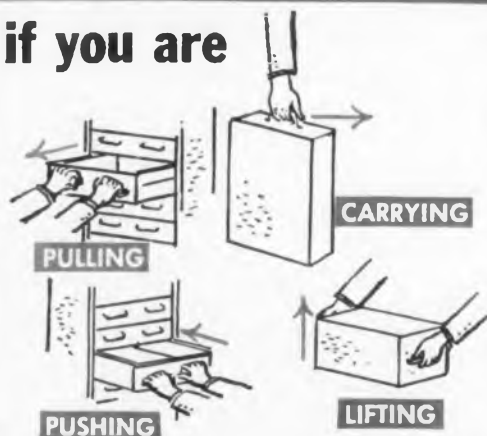
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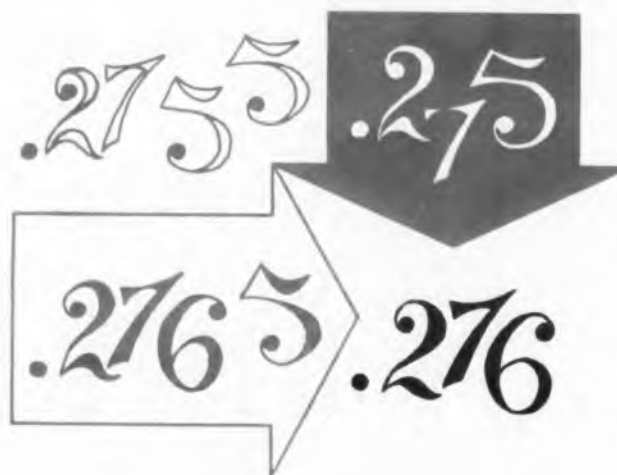
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Experimental data are not exact. Numerical data taken from readings on a 5 per cent voltmeter, for example, cannot be exact. How then can we manipulate these numbers? What errors may we expect when we add, subtract, multiply, and divide them; and what errors can we anticipate when we take their powers or roots? In this article, Edward Donald gives convenient rules for handling numerical data.

Edward N. Donald

Radio Corporation of America
Defense Electronic Products
Camden, N. J.

NUMERICAL data from laboratory experiments cannot be improved—but they can be understood and interpreted better. Too often, computations are made with these data without regard to the error inherent in the data or the errors that can accumulate from mathematical processing. Fortunately, there is a practical and simple approach to treating numerical data.

It is necessary, first, to resolve the ambiguity in determining the number of significant figures in a number. This confusion can be settled if the numbers are written in powers-of-ten notation. Thus, 1.230×10^2 has three significant figures, as indicated by the number of places to the left of the power-of-ten factor. 1.230×10^2 has four different figures.

Rounding Off Numbers Helps Minimize Work

Numbers can be rounded off to minimize the work involved in handling them. This process also minimizes the questionableness of the last significant figure. Here are four handy rules for rounding off numbers:

1. Count off the desired number of significant figures (n), starting from the left. Discard all places to the right of the n th figure.

2. If the discarded number(s) is greater than one-half unit in the n th place, add 1 to the n th place figure.

3. If the discarded number(s) is less than one-half unit in the n th place, do not add anything to the n th place figure.

4. If the discarded number is exactly one-half unit in the n th place, add 1 to the n th figure if it is odd, do not add anything if it is even.

This procedure makes the complete number even, reducing the chance of a remainder after division. For example:

Change	1434.53	to	1.435×10^3
Change	27.522	to	2.752×10^1
Change	0.00305550	to	3.056×10^{-3}
Change	10005.0	to	1.000×10^4

Three Common Errors Associated with Numbers

There are three common types of errors associated with numbers.

1. **Absolute Error.** The absolute error is the small difference by which a number can vary from its true value. The absolute error is a common means of expressing tolerances. For example, in 5.00 ± 0.05 , the absolute error of ± 0.05 indicates that the exact dimension can range from 4.95 to 5.05.

2. **Relative Error.** The relative error is the ratio of the absolute error to its true value. The rela-

tive error in 5.00 ± 0.05 is $0.05/5.00$ which equals 0.01.

3. Percentage Error. The percentage error is simply the relative error multiplied by 100.

General Formula Gives Error of a Function

A general formula for error of a function covers all cases of arithmetic manipulation. This formula can be used to determine the relative errors in products, quotients, and logarithms. The tolerances of additions and subtractions can be handled by using absolute errors.

The total relative error of a function is the total derivative of that function. If N is a function of several variables,

$$N = f(u_1, u_2, \dots, u_n) \quad (1)$$

then variations of N can be expressed as

$$N + \Delta N = f(u_1 + \Delta u_1, u_2 + \Delta u_2, \dots, u_n + \Delta u_n) \quad (2)$$

If the absolute Δu errors are small, all powers of the error greater than one can be neglected. The total relative error can now be presented as

$$E_r = \frac{\Delta N}{N} = \frac{\partial N}{\partial u_1} \frac{\Delta u_1}{N} + \frac{\partial N}{\partial u_2} \frac{\Delta u_2}{N} + \dots + \frac{\partial N}{\partial u_n} \frac{\Delta u_n}{N} \quad (3)$$

where E_r is the total relative error and ΔN is the total differential of the function N .

Rules for Determining Errors In Arithmetic Operations

A few simple rules can be used to determine the errors for the different types of arithmetic operation.

1. Multiplication. If the errors of every factor in a multiplication are known, the total error of the product can be resolved by using Eq. 3.

Let P equal the product of a constant and three variables.

$$P = K \cdot X \cdot Y \cdot Z$$

where K is a constant with no significant error. Then

$$E_r = \frac{\Delta P}{P} = \frac{\partial P}{\partial K} \frac{\Delta K}{P} + \frac{\partial P}{\partial X} \frac{\Delta X}{P} + \frac{\partial P}{\partial Y} \frac{\Delta Y}{P} + \frac{\partial P}{\partial Z} \frac{\Delta Z}{P}$$

But the first term

$$\frac{\partial P}{\partial K} \frac{\Delta K}{P}$$

equals zero because $\Delta K = 0$. A general statement can now be made: *The total relative error of a*

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Capacitor	Capacitance (uuf)	Volume (approx.)	WL Weights (approx.)
W, WL-5	1 to 560	0.00204 in. ³	.30 gm.
W, WL-4	561 to 1000	0.00327	.37
W, WL-3	1001 to 2700	0.00702	.71
W, WL-2	2701 to 4300	0.01951	1.12
W, WL-1	4301 to 10,000	0.02106	2.50

Corning wafer capacitors come with or without leads.



CORNING ELECTRONIC COMPONENTS

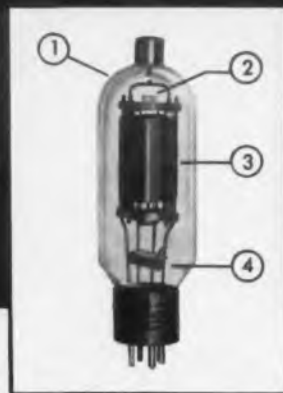
CORNING GLASS WORKS, BRADFORD, PA.

CIRCLE 48 ON READER-SERVICE CARD

RELIABILITY



UNDER GLASS



New Ruggedized Power Triode — For Ground Support — For SSB and RF Service — For Industrial and Military Equipment

The 572 — a newly designed power triode — is another product of the broad experience and production know how of United Electronics. This ruggedized tube is a one way replacement for the prototype 811A in most applications.

Ruggedized components and up-dated assembly techniques provide a longer life and greater resistance to shock and vibration. This new tube is particularly useful for Class B service in single sideband or audio applications and wherever reliability and ruggedness are required.

You can use this practical reliability. Call or write for Technical bulletin which includes operating characteristics and dimensional specifications.

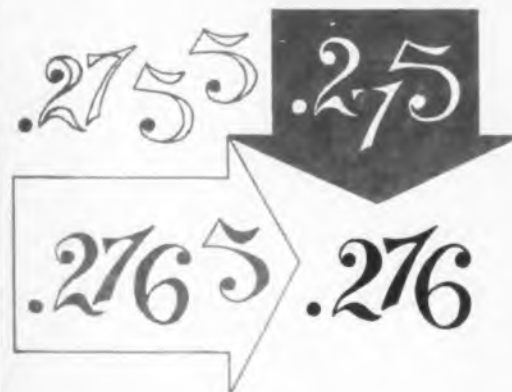
FEATURES

1. Hard Glass Envelope—
For higher temperatures
 2. Non frangible filament
—Increases ruggedness
 3. Special Graphite Anode
—50% increase in plate
dissipation
 4. Dual enclosed getter
traps — Long gas-free
life
- Delivery from stock

UNITED ELECTRONICS COMPANY

A SUBSIDIARY OF  LING-TEMCO ELECTRONICS, INC.

42 SPRING STREET • NEWARK, NEW JERSEY • HU 4-6300
CIRCLE 49 ON READER-SERVICE CARD



product is the sum of the relative errors in the individual factors.

2. **Division.** Since division can be treated as an inverse multiplication, the total relative error of a division can also be treated as the sum of the relative errors in the individual factors. Though the derivative of a division is negative, the tolerance can also be negative. To include all possible error combinations: *The total relative error of a quotient is the numerical sum of the relative errors of the individual factors.*

When determining the product of a quotient of two or more approximate numbers of different significant figures, the more accurate number should be rounded off so as to contain one more place than the other number(s). The error of the product or quotient is then largely due to the less accurate number. The final result should be shortened to have as many places as are contained in the least accurate figure, and no more.

3. **Raising to Powers.** *The total error of a number involving an exponent is equal to the power of the exponent times the relative error of the base number.*

Let $e = X^a$

$$E_r = \frac{\Delta e}{eX} = \frac{eX^a}{eX} \frac{\Delta X}{X^a} = \frac{a\Delta X}{X^a} = a \left(\frac{\Delta X}{X} \right)$$

Note that the relative error of numbers involving powers less than one is smaller than the relative error of the base number itself.

4. **Using Logarithms.** *The relative error of a logarithm to the base 10 is equal to 2.3026 times the absolute error of the given number.*

Let $L = \log_{10} X = 0.4343 \log_e u$

$$\Delta L = \frac{\partial \log_{10} X}{\partial X} \Delta X = 0.4343 \frac{\Delta u}{u}$$

$$\frac{\Delta u}{u} = 2.3026 \Delta L$$

5. **Addition.** *The total absolute error of a num-*

ber of terms is the algebraic sum of all the absolute errors.

$$\text{If } S = X + Y + Z$$

$$\text{Then } \Delta S = \Delta X + \Delta Y + \Delta Z$$

Or as in most cases, $|\Delta S| = |\Delta X| + |\Delta Y| + |\Delta Z|$

An example of an addition is given to illustrate the summing of numbers of different tolerances.

```

543.1795
789.244
897.3154
-----
17414.5

```

The range of numbers that 17,414.5 could have varies from 17,414.59 to 17,414.50 since its second decimal place has not been stated. The dotted line shows that doubt exists at this decimal place by 0.09 units. The doubt is generated by the lack of decimal places in the last number.

It would certainly be "gilding the lily" if the remaining numbers were not rounded off to the second decimal place since ambiguity already exists in this place by an order of magnitude.

In the addition of numbers one should round off all the numbers to one more decimal place than the number with the least decimal places, irrespective of the number of significant figures. The given example can then be rewritten as

```

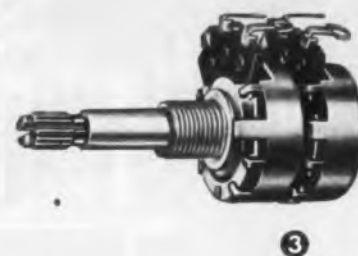
543.18
389.24
897.32
-----
17414.5
-----
19244.24 ± 0.10

```

6. Subtraction. The total absolute error of the difference of two terms is the algebraic sum of each term. The procedure includes the worst case of error combinations.

The difference of two numbers should always be taken with figures having the same number of decimal places. If necessary, one number should be rounded off to match the number of decimal places of the other.

The loss of significant figures becomes pronounced whenever the difference is taken between two numbers which are numerically close to each other. This may, at times, render a computation worthless whenever the accuracy of finite differences is of prime importance. This situation may call for more accurate figures. One must be on guard to avoid this condition if at all possible. ■ ■

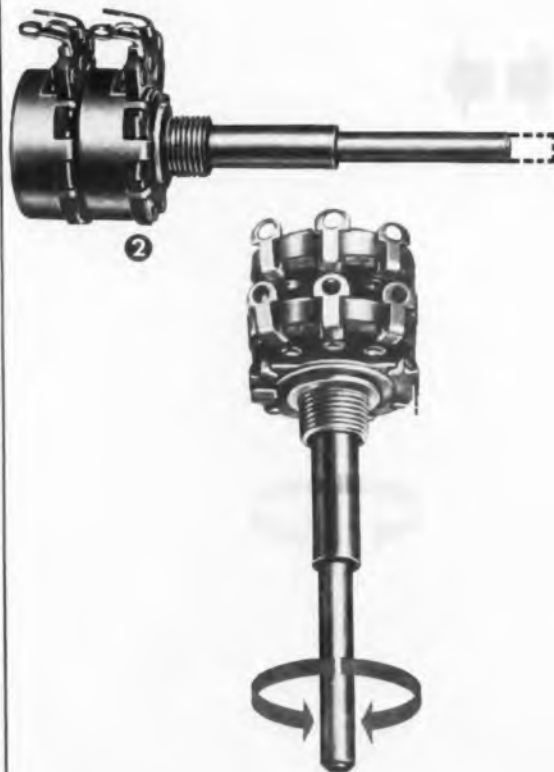


NEW CONTROLS FOR STEREO

Flexibility without Complexity

Even a wife can appreciate the major points of these special dual-element controls for 2-channel stereo equipment! No longer is it necessary to fiddle with 2 bass controls, 2 treble controls, and 2 volume controls to obtain proper stereo balance—then re-adjust everything when listening to monophonic material. No longer, that is, unless you're an ardent audiophile who would have it no other way.

For these new Stackpole controls "clean-up" the panels of stereo equipment, make them easier to operate and understand . . . yet retain all the flexibility of individual adjustments required on the most elaborate equipment.



1 FRICTION SHAFT DUAL—Type LS3: A friction fit between shafts causes both elements of this dual concentric shaft control to operate in tandem when either shaft is turned. Either element can also be adjusted independently by holding one shaft while rotating the other. Once set, either knob can be turned while maintaining stereo balance through a wide range of adjustment.

2 CLUTCH SHAFT DUAL—Type LS1: This wonderfully convenient control allows either simultaneous or individual adjustment of its two elements. A push on the inner shaft engages a clutch which connects both elements together for tandem operation by either shaft. Pulling the inner shaft permits each element to be individually adjusted without disturbing the other.

3 MATCHED ELEMENT TANDEM—Type L-Tandem: Through precise electrical matching and careful mechanical alignment, this stereo tandem control allows convenient, single-knob adjustment of both channels. It's ideal for adjustment of master volume or of bass or treble in systems where an absolute minimum of panel complexity is desired.

STACKPOLE

Coldite 70+® fixed composition Resistors • Slide & Snap Switches • Ceromag® Ferrite Cores • Fixed composition Capacitors • Ceramagnet® Ceramic Magnets • Electrical Contacts • Brushes for all rotating electrical equipment • Hundreds of related carbon, graphite, and metal powder products.



Mechanical and electrical specifications on these dependable 0.75-watt variable composition resistors are available on request. Electronic Components Division, Stackpole Carbon Company, St. Marys, Pa.

CIRCLE 50 ON READER-SERVICE CARD

as simple as



... plugging-in
**EAGLE'S
NEW CYCL-FLEX TIMER**



THE HP5 SERIES CYCL-FLEX FOR
TIME CONTROL

Yes, our *New Cycl-Flex Timer* is as easy to adapt and change as a simple electric plug.

Don't let automation troubles get you down! . . . use our *New Cycl-Flex* for **TIME CONTROL** functions. Should your automatic controls fail for any reason, you can trace your trouble by plugging-in a spare timer. Movement of the **TIME** pointer indicates whether trouble is in the input or the output circuits.

Eagle's *New Cycl-Flex Timer* has been enthusiastically adapted by leading manufacturers of molding presses, dielectric heaters, machine tools and feed controls.

Write for Bulletin 125 or call your local Eagle Representative. He's listed in Sweet's Product Design File, Section 7d, or in Thomas Register.

SPECIFICATIONS • 10 sec. to 60 hr. dial • 2 instantaneous switches • 2 delayed switches • 12 terminals • Resets in 1/3 sec. • Mounts in 3/8" dia. hole

MANUFACTURERS OF THE MOST COMPLETE LINE OF INDUSTRIAL TIME-COUNT CONTROLS AVAILABLE



Precision Interval Timers



Multiple Circuit Timers



Heavy-Duty Step Switches



Multiple Cam Timers



Predetermined Counters

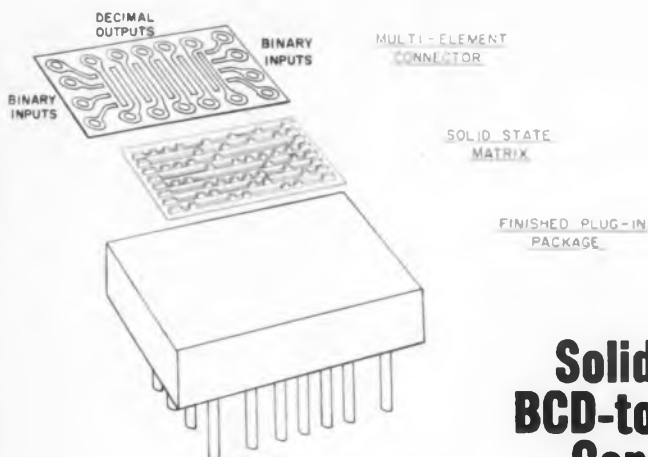


Hermetically Sealed Timers



EAGLE SIGNAL COMPANY • Moline, Illinois
INDUSTRIAL DIVISION

A DIVISION OF THE GAMEWELL COMPANY, AN E. W. BLISS COMPANY SUBSIDIARY
CIRCLE 51 ON READER-SERVICE CARD



Solid State BCD-to-Decimal Converter Available at Low Cost

FORTY diodes plus the necessary interconnections to obtain a binary coded decimal-to-decimal converter are now available in a low cost (\$45), compact (1.0 in. by 0.6 in. by 0.313 in.) module. Groups of diodes, fabricated in an orderly array on a single silicon wafer, are joined to a screened circuit plate to create a low-cost assembly with simple input-output connections.

BIPCO, short for "built-in-place components," represents Burroughs Corp.'s entrance into the microminiaturization field. As many as 1,000 elements can be fabricated on a single semiconductor in one simultaneous operation; the predetermined pattern of elements facilitates internal connections. The first BIPCO product, a BCD-to-decimal converter

using the 4-2-2-1 code (Table I), has been designed to drive a Nixie indicator tube directly from BCD-encoded inputs. The schematic for the converter is shown in Fig. 1, mechanical characteristics in Fig. 2. Typical specifications for the individual diodes are: minimum forward current at 1 v = 10 ma, maximum inverse current at 100 v, 25 C = 5 μ amp and piv = 200 v.

In the first step of assembly, a large planar diode is fabricated on a single silicon wafer, large enough to cover the entire matrix required for the final device. The wafer is then ultrasonically machined into a group of electrically isolated strips, each strip having a large number of mesa diodes. Both mesas and strips are fabricated simultaneously.

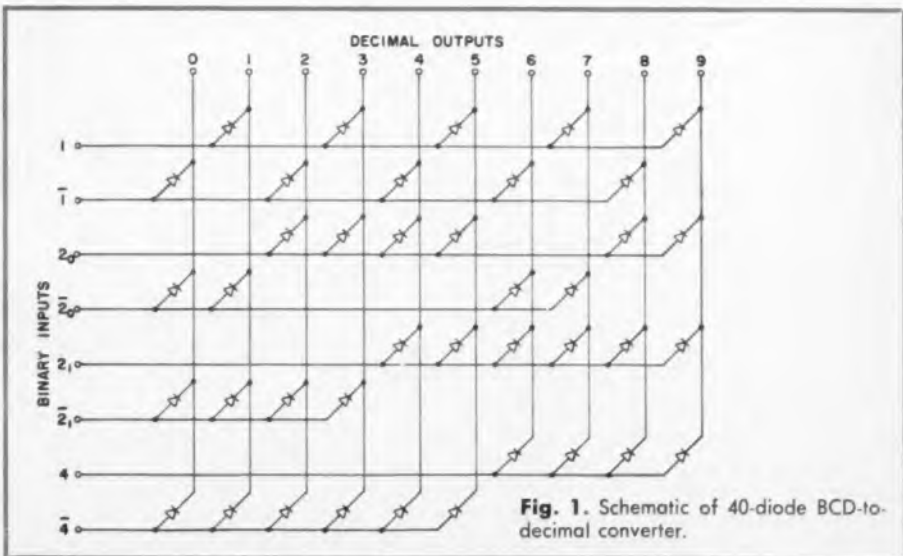


Fig. 1. Schematic of 40-diode BCD-to-decimal converter.

Table 1. 4-2-2-1 code and decimal equivalent.

	4	2	2	1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	1	0
5	0	1	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1

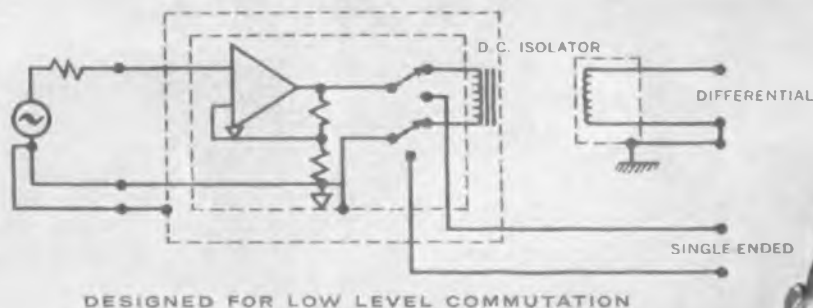
The resultant array of diode-bearing silicon strips is connected to a circuit plate that provides the input and output connections. The circuit plate is fabricated by simple silk-screen techniques on a glass or ceramic substrate having a coefficient of expansion matching that of the silicon wafer. The connections to the silicon strips from the circuit plate are made by means of a conductive coating applied to the silicon wafer before ultrasonic machining. After machining, this conductive coating then carries the connection from the front of the wafer around the end of the strip to the back of the silicon strip. After the machined wafer is attached to the circuit plate, the entire assembly is etched and washed, a surface passivation applied and the entire device encapsulated in a suitable medium, such as epoxy resin. Terminals are provided for soldering or plug-in mounting arrangements.

Some of the advantages of the BIPCO module technique are that large numbers of diodes within a single package are processed under identical conditions, reducing variations between individual diodes to a minimum. Diode types available in this process cover the entire range of presently available diffused silicon types.

Other BIPCO module products in advanced development include a two-out-of-five-to-decimal code converter, a decimal-to-5-x-7-matrix code converter, and a teleprinter decoder-encoder.

The BCD-to-Decimal converter is available at \$45 from the Burroughs Corp., Electronic Tube Div., Plainfield, N.J.

For further information on the BIPCO module, turn to the Reader-Service Card and circle 251.



Announcing the TDA 875 SOLID STATE Differential and Single-Ended AMPLIFIER*

- * Recovery from 500% overload in 300 microseconds.
- * Output voltage clamped at ± 13 volts, can't burn out delicate recording equipment.
- * Completely isolated, 3000 megohm leakage path to ground.

Built to meet the needs of the engineer designing low-level multiplexing systems, Epsco-West's new TDA 875 Differential Amplifier features high reliability, high gain, wide band-width, negligible drift, high ac/dc common mode rejection, low noise, fast rise time, fast recovery time, integral power supply, and high input impedance. No other amplifier combines all these design parameters to such a useful degree.

DESCRIPTION

The Model TDA 875 contains an integral power supply which operates from a 117-volt, 60-400 cps line, requiring only 15 watts of power. Chopper drive circuits are included with each amplifier.

Two modes of operation are available: differential and single-ended (potentiometric); selection is made by means of a front panel control. Five fixed gains are also chosen by a front panel switch.

In its differential mode, the amplifier provides ± 10 volts at 10 milliamperes as its full scale output; in its single-ended mode, full scale output is ± 10 volts at 50 milli-

amperes. High input impedance ensures that all transducer voltage will appear at the amplifier input terminals. Changes in transducer or line resistance will have little consequence.

The Model TDA 875 Amplifier may be mounted in the Model TDA 870A Carrying Case for easy portability, or in the Model TDA 870 Rack Adapter which holds 5 amplifiers in a standard 19-inch relay rack.

*One of six new E-W amplifiers now available to meet your low-level instrumentation needs.

Ask your nearby Epsco-West engineering representative to demonstrate these new amplifiers. For complete technical information, write for Brochure No. 875.



Epsco-West

A Division of Epsco, Inc.

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8



CRITICAL SPECIFICATIONS (Differential Mode)

VOLTAGE GAIN
Fixed steps of 1000, 500, 200, 100, 50. Lower gains optional.

LINEARITY
 $\pm 0.05\%$ of full scale (20 volts at dc)

INPUT IMPEDANCE
Greater than 100 megohms shunted by 0.002 microfarad.

COMMON MODE LEVEL
 ± 300 volts dc, 117 volts rms ac

TRANSIENT COMMON MODE RECOVERY
300 volt step of common mode voltage does not cause overload.

DRIFT - 40 HOURS
 ± 2 microvolts referred to the input, plus $\pm 0.02\%$ of full scale at 25°C.

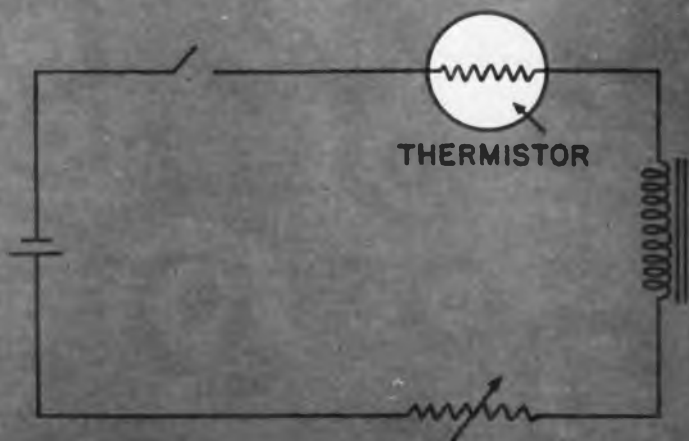
DRIFT - 6 MONTHS
 ± 4 microvolts referred to the input, plus $\pm 0.02\%$ of full scale at 25°C.

NOISE REFERRED TO THE INPUT
Less than 2 microvolts peak-to-peak (99% confidence) from dc to 20 cps. Less than 5 microvolts rms from dc to 5 kc for source resistances of 1000 ohms or less.

SETTLING TIME
300 microseconds to within 1% of final value all ranges.

OVERLOAD RECOVERY TIME
300 microseconds or less to within 1% of final value from 500% overload.

SHORT CIRCUIT PROTECTION
Sustained output short circuit will not damage amplifier.



a little thermistor makes a big difference in a time delay circuit

Circuits like the one above are often used where variable or fixed delay are required. Circuit ingredients: a thermistor and a variable resistor, in series with a battery and a relay.

With the switch closed, current flow is limited by the high resistance of the thermistor. The thermistor then heats up, permitting sufficient current flow to close the relay. Delay time can be increased or decreased by increasing or decreasing series resistance.

This is just one example of putting the thermistor to work. There are hundreds more — including temperature control, liquid level measurement, remote control, switching, power measurement, voltage control — or you name it.

There are just two kinds of thermistors, really: ordinary, which are good; and FENWAL ELECTRONICS', which are a little bit better. One reason is that FENWAL ELECTRONICS has the edge in experience. We pioneered in this field. Another reason is that we can suit your application exactly — FENWAL ELECTRONICS has the most complete line of thermistors available anywhere.



For details, application assistance, and new Thermistor Catalog EMC 4, write:

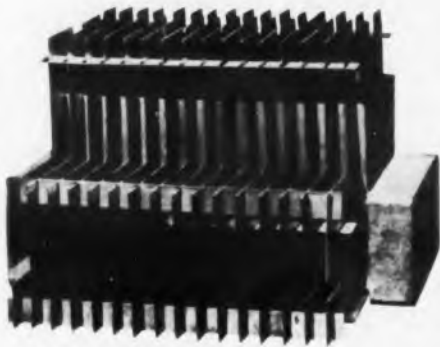
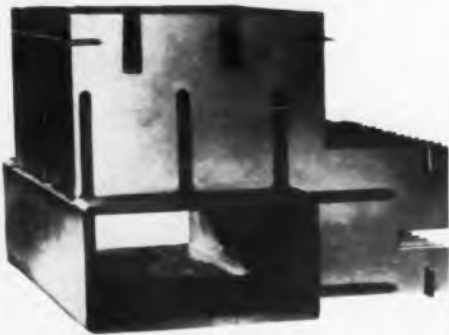
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THE MOST COMPLETE LINE ANYWHERE: beads and glass probes · discs · washers · rods · probe assemblies · Et. matched pairs





"Egg-crate" construction of new filters simplifies manufacture. Note slots within primary waveguide leading to fins that form secondary waveguides. Actual unit is entirely surrounded by the secondary waveguide fins.

Harmonic Absorption Filters Use "Leaky Wall" Principle

MICROWAVE RFI can be substantially reduced with a new line of harmonic absorption filters introduced by General Electric's Power Tube Dept., Palo Alto, Calif.

The filters are designed for high-power transmitters in the 400- to 6,000-mc region. Peak powers range from 1 to 10 megawatts and average powers from 10 to 300 kw. Pass band and insertion loss are said to be 1.15:1 and less than 0.15 db, respectively. Harmonic attenuation exceeds 30 db.

These filters operate on the "leaky wall" principle and resemble automobile mufflers in design and action.

The desired signal and harmonics enter a primary waveguide forming the axis of the filter. The waveguide is perforated with hundreds of large slots opening into secondary waveguides and a power absorber. Each slot acts as a high-pass filter because of the cut-off characteristics of the secondary waveguide. Harmonics are

coupled into the slots, pass down the secondary waveguides and are absorbed. The fundamental signal is meanwhile propagated along the primary waveguide without any significant attenuation.

Each slot provides an insertion loss of a fraction of a decibel for the harmonic frequencies. Since the filter may contain several hundred slots, absorption of harmonic signals is considerable.

In normal applications, the filter would be located in the output waveguide between transmitter and antenna near the output tube.

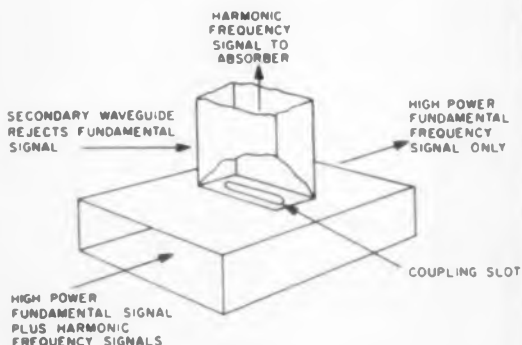
A typical application would be in a C-band transmitter (such as weather radars) where harmonics might interfere with TH or TJ microwave relay links.

The filter line is the result of similar units developed by GE for military radars such as the AN/FPS-20, AN/FPS-7, and AN/FPS-6.

The commercial filters are constructed of aluminum alloys with component parts



Largest and smallest units in General Electric's new harmonic absorption filter line. The MPF-400, consisting of the two identical assemblies, provides a pretty perch for model cuddling the MPF-4000 baby of the line.



"Leaky wall" filter absorbs harmonics in hundreds of these secondary waveguides. Fundamental signal travels straight through primary waveguide; harmonics enter secondary waveguide through coupling slot and are absorbed.

joined by dip brazing. Fabrication and assembly are simplified by the "egg crate" design. The power absorbers consist of molybdenum or lamp-black deposited on asbestos sheets.

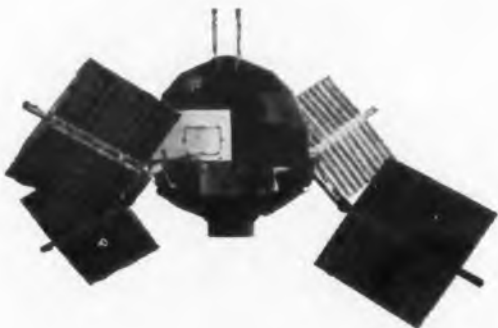
Developmental samples are available on 60- to 90-day delivery. The smallest of the five units available is the MPF-4000, costing \$2,195. Its pass band is 5 to 6 mc; peak and average powers are 1 megawatt and 10 kw, respectively.

Largest unit is the MPF-400, costing \$9,995. Pass band is from 400 to 450 mc; peak and average powers are 5 megawatts and 300 kw, respectively. The manufacturer notes that prices are subject to reduction with volume orders.

For more information on these microwave filters, turn to the Reader-Service Card and circle 252.



THREE AND ONE-HALF TIMES ACTUAL



CANNON GOLDEN-D SUBMINIATURE PLUGS

**DESIGNED ESPECIALLY FOR MISSILE CIRCUITRY
AND MAXIMUM RELIABILITY APPLICATIONS**

The "Golden-D" Cannon Plugs are engineered to deliver superior performance in a subminiature size! Supplementing our famous standard D-Subminiature line, the "Golden-D" has these

new design features: • MONO-BLOC INSULATORS • PROBE-PROOF CLOSED-ENTRY SOCKET CONTACTS • LOW ENGAGEMENT/SEPARATION FORCES • GOLDEN CADMIUM SHELL FINISH • MATES WITH ANY CANNON "D" OF SAME SIZE AND LAYOUT. Wherever maximum reliability

is needed in a subminiature multi-contact plug—for both military and industrial applications—ask for the new "Golden-D" ...another reason why you should contact the world's most experienced plug manufacturer for all your plug requirements. The "Golden-D" is available in four types with a large variety of contact layouts. For further information write to:



CANNON ELECTRIC COMPANY, 3208 Humboldt St., Los Angeles 31, Calif.
SEE CANNON AT BOOTH 2727-31, IRE SHOW

NEW PRODUCTS

Covering all new products generally specified by engineers designing electronic original equipment. Use the Reader's Service Card for more information on any product. Merely circle number corresponding to that appearing at the top of each description.



Switching-Time Tester For Components and Circuits

257

Model 200 switching-time test set makes possible the rapid and precise checking of switching times of transistors, diodes, and computer circuits. It has built-in pulse sources, scope display, meter readout, bias supplies, and test jig. Time intervals from 1 nsec to 500 nsec can be measured with accuracies of 3 to 5%. Positionable marker bugs ride on the oscilloscope waveform and set the time interval for meter readout. The pulse source allows a 2-mc test rate with 7 v into 150 ohms, at 1.5-nsec rise time. A stroboscopic effect is achieved which allows an automatic, continuous oscilloscope sync and eliminates the need for delay cables.

Wiltron Co., Dept. ED, 717 Loma Verde Ave., Palo Alto, Calif.

Price: \$3,200.

Availability: 8 to 10 weeks.



Time Quantizer Has 10-Nsec Resolution

258

Wide application in high-speed transient analysis is expected for the LFQ-10 time quantizer. The system is capable of measuring or quantizing time intervals to a resolution of 10 nsec. It may be used in conjunction with high-speed digital computers for real time analysis of the physical phenomena being measured. Output may be binary, binary-coded decimal, or decimal. Time intervals may be transient, repetitive, or varying in duration. The system permits sampling rates up to 1 million per sec. Cabinet is 35 in. high, 24 in. wide, and 24 in. deep.

Computer Equipment Corp., Dept. ED, 11612 Olympic Blvd., Los Angeles 64, Calif.

Price: \$5,000 up.



Laboratory Test Set For PNP Switching Circuits

256

Model 1320 experimenter is a general-purpose laboratory instrument for designing, testing, and demonstrating pnp transistor switching circuitry. The set contains three regulated power supplies, a square-wave generator, and output control switches. Outputs are 0 to 15 v, 200 ma, and 12 v, 100 ma. Two output square waves are produced 180 deg out of phase, at frequency variable from 5 kc to 500 kc. All circuitry is located on a single internal card module.

Navigation Computer Corp., Dept. ED, Valley Forge Industrial Park, Norristown, Pa.
Price: \$295.



Welded Logic Circuits Occupy 1/3 Cu In.

255

A typical Weld-Pak plug-in logic circuit incorporates 17 diodes, capacitors and resistors plus two transistors in a module measuring 1 x 3/4 x 3/8 in. Precision welds join the components. The assembly is potted in epoxy resin; temperature range is -55 to +55 C. Circuits WM-101 through WM-109 are: NOR gate, NOR gate and emitter follower, flip-flop, emitter follower, diode AND, diode OR, counter-shift register flip-flop, clock variable, and an inverter. All employ pnp transistors and use +10 and -10 v supplies.

Industrial Components Div., Raytheon Co., Dept. ED, 55 Chapel St., Newton 58, Mass.
Price: \$25 to \$50.

Availability: 30 to 60 days.

ELECTRONIC DESIGN • March 15, 1961

why use two? when one will do!

JFD LC tuner



WHY USE TWO...?

a trimmer capacitor and inductor
when one JFD LC Tuner will do!

When your tuned circuit "package" calls for higher stability, greater economy, finer tuning — it's time for the versatile JFD LC Tuner.

This unique package combines the characteristics of a precision variable capacitor and a metalized inductor in one compact tuneable LC circuit. It improves performance, simplifies specifying, speeds assembly, and enhances high frequency capability.

JFD LC Tuners are available in 16 different standard panel and printed circuit types. The inductance, capacitance range, Q and other parameters can be designed to

suit individual circuit requirements. Performance characteristics can also be varied by using other core materials or other lead configurations, by having the piston grounded or ungrounded, and by various types of loading.

For complete information, contact your local JFD Field office or your local JFD franchised Industrial Distributor, or write direct for Bulletins 216 and 216-1.

FEATURES: Rugged shock-proof, vibration-proof electro-mechanical construction. • Glass or quartz dielectric and invar assures low temperature coefficient • No derating at high temperature. • Precisely repeatable tuning—no reversals. • Single resonating frequency for each adjust screw setting.

Model	Self-Resonating Freq. Range, Mc.		Nominal Q of Inductor Over Tuning Range	Nominal Inductance uh.	
	Min.	Max.		Min.	Max.
LC 303	400	725	170-200	.025	.028

JFD

JFD ELECTRONICS CORPORATION

Components Division • 6101 16th Avenue • Phone DEWey 1-1000 • TWX-NY25040

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7311 Van Nuys Blvd.
Van Nuys, Calif
Phone STate 1-3530

JFD MIDWESTERN
6414 W Higgins Ave.
Chicago, Illinois
Phone SPring 4-4175

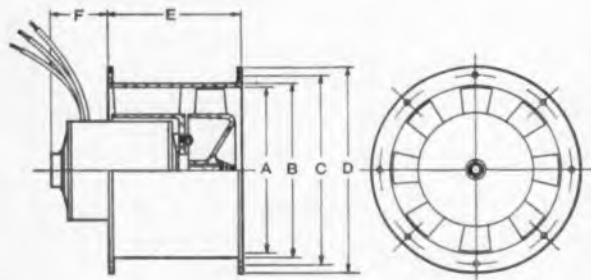
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CIRCLE 55 ON READER-SERVICE CARD



A Complete New Line of Electronic Cooling Fans JOY Axivane Series 60

Developed by Joy specifically for 60 cycle commercial duty, the Series 60 vaneaxial fans operate at 3400 rpm, 115 volts, single phase, 50/60 cycles and produce from 50 to 500 cfm at static pressures of 1/4" through 1" wg. They are extremely compact and ruggedly built

of anodized aluminum. There are only four major parts; rotor, housing, motor, and separately mounted capacitor. Production quantities are available on order and small quantities are available off-the-shelf. For more information write for bulletin 2518-57.



Model X702-402

Model No.	Design CFM ±3%	Max. CFM at Free Flow	Design PS ±7%	Max. Pressure	Motor Data		Mechanical Dimensions (Inches)						1/32" Holes Per Flange	Total Weight Pounds
					BHP	CAP* MFD	A	B	C	D	E	F		
X702-401	50	70	0.30	0.45	.005	NONE	4.37	4.62	5.25	5.87	4.50	0.9	4	5.4
X702-402	100	145	0.35	0.60	.010	NONE	5.12	5.37	6.00	6.62	4.50	0.9	4	5.8
X702-403	150	180	0.35	0.80	.015	NONE	5.62	5.87	6.50	7.12	4.50	0.9	4	6.1
X702-404	200	265	0.40	0.79	.035	5	5.62	5.87	6.50	7.12	5.00	1.3	8	7.2
X702-405	250	330	0.40	0.82	.043	5	5.87	6.12	6.75	7.37	5.00	1.3	8	7.4
X702-406	300	340	0.40	0.93	.052	5	6.12	6.37	7.00	7.62	5.00	1.3	8	7.6
X702-407	350	430	0.50	1.10	.060	5	6.37	6.62	7.25	7.87	5.00	1.5	8	8.5
X702-408	400	520	0.75	1.20	.068	5	6.62	6.87	7.50	8.12	5.00	1.5	8	8.7
X702-409	450	560	0.75	1.30	.075	5	6.87	7.12	7.75	8.37	5.00	1.5	8	8.9
X702-410	500	625	0.75	1.40	.083	5	7.12	7.37	8.00	8.62	5.00	1.5	8	9.1

*Rated 236 WVAC—

Note: Spun aluminum inlet bells and aluminum wire inlet bell screens are available to fit all sizes of fans.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY



CIRCLE 56 ON READER-SERVICE CARD

JOY

Joy Manufacturing Company
Olliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company
(Canada) Limited, Galt, Ontario

NEW PRODUCTS AT THE IRE SHOW

Oscilloscope Camera

604

For trace recording



Model SM-209 oscilloscope trace-recording camera allows up to nine different trace exposures per print. Full size prints may also be taken with perfect edge-to-edge definition. Object-to-image ratio is 1 to 0.9. Original crt resolution is not degraded.

Electronic Tube Corp., Dept. ED, 1200 E. Mermaid Lane, Philadelphia 18, Pa.

P&A: \$345 *job Philadelphia; from stock.*

See at Show Booth 3112-13.

Molded Transformers

611

Rated to 150 w



Epoxy-molded toroids and miniature, molded transistor transformers are custom-engineered to power levels of up to 150 w, frequencies from 20 cps to 100 kc, and a dc current range governed by size, frequency and power level. Operating temperature range is -65 to 130 C; size ranges from 3/16 to 4 in. OD. Impedance ratings match many transistor circuits.

Microtran Co., Inc., Dept. ED, 145 E. Mineola Ave., Valley Stream, N. Y.

See at Show Booth 2311.

Digital Millivoltmeter

597

For low-level measurements



Model 60 millivoltmeter has a range of ±99.99 mv for making low-level measurements without

ELECTRONIC DESIGN • March 15, 1961

a preamplifier. Its scale factor control permits making any value from 10 to 100 mv appear as 99.99 in the readout. Input impedance is 10 meg, accuracy is $\pm 0.1\%$ of reading or 1 digit, and precision is $\pm 0.01\%$ of full scale. Its uses include calibrating dc millivoltmeters and recorders, reading output of strain gages, thermocouples, and other transducers.

Non-Linear Systems, Inc., Dept. ED, Del Mar, Calif.

Price & Availability: \$1,625; immediate delivery.
See at Show Booth 3041-42.

High-Voltage Assemblies 603

Silicon type



Designed to solve space and reliability problems, these silicon high-voltage assemblies have ratings of 50,000 prv, 3 amp dc in a package 3 x 11-1/2 x 2 in. Typical characteristics are: max circuit, prv-50 kv; peak recurrent current, 18 amp; surge current, 160 amp (1-2 cps at 60 cps); reverse leakage current, 500 μ a max at 25 C.

Bradley Semiconductor Corp., Dept. ED, 275 Welton St., New Haven, Conn.

See at Show Booth 2922.

Toroidal Coils 600

Have high Q



Toroidal coils, designed for high-Q and low distributed capacitance, range in size to approximately 1 cu-in. Models include: pot core coil with stability of 150 ppm per deg C; toroidal inductor with molybdenum permalloy, ferrite or powdered-iron cores for use from 200 kc to 10 mc; and miniature variable pot core inductor with $\pm 8\%$ tuning range.

Bulova Watch Co., Inc., Dept. ED, 40-41 61st St., Woodside 77, N.Y.

See at Show Booth 1821-23.

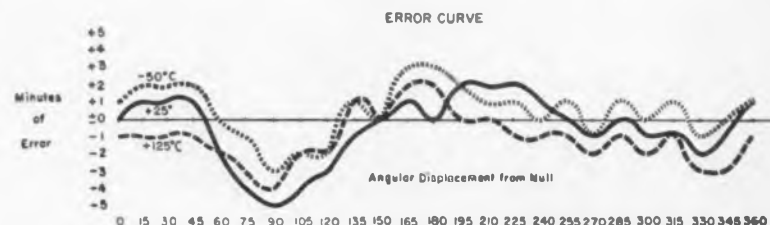


This SYNCHRO offers temperature stability plus lightness

This Size 8 Daystrom Transicoil synchro provides temperature stability without increasing weight.

The encapsulated stator windings permit these units to be operated under severe environmental conditions. And, of greatest importance, in random sampling of Daystrom Transicoil Size 8 synchros, error shift from room temperature has not exceeded 2 minutes over the entire temperature range of -55C to $+125\text{C}$.

Daystrom Transicoil Size 8 "temperature stable" units are



available as transmitters, differentials, control transformers and resolvers. Standard accuracy is ± 7 minutes, but 5-minute units are also available on special order.

Data sheets and prints on the "temperature stable" Size 8 synchro are available on request. And remember, too, Daystrom

Transicoil makes a complete line of precision rotating components.

Foreign: Daystrom International Division, 100 Empire St., Newark 12, New Jersey. *In Canada:* Daystrom Ltd., 840 Caledonia Road, Toronto 19, Ontario. *Mid-West:* Daystrom Incorporated, 905 W. Hillgrove Avenue, La Grange, Illinois.

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SEE US AT THE IRE SHOW

CIRCLE 57 ON READER-SERVICE CARD

NEW PRODUCTS

AT THE IRE SHOW

Instrument Calibrator 585

For voltmeters and ammeters



Standardization and calibration of dc voltmeters and ammeters can be done with the model 1900 dc semiautomatic instrument calibration standard. There are 21 voltage ranges from 0 to 150 μ v to 0 to 1.5 kv, and 20 current ranges from 0 to 15 μ a to 0 to 30 amp. Accuracy is $\pm 0.05\%$. Short-term stability is better than 0.01%. A matching unit for ac calibration is available.

Radio Frequency Laboratories, Inc., Dept. ED, Powerville Road, Boonton, N. J.

See at Show Booth 3115-19.

Tape Simulator 590

Provides 50 channels



Repetitive playback of data for training, computer, and control applications is provided by this continuous tape loop simulator on 50 or more channels. The device uses 1-in. tape with 33 tracks in standard IRIG head configuration. Bandwidth is done on one channel at a time; any or all channels may be played back simultaneously. Designation is model PS-250-L.

Precision Instrument Co., Dept. ED, 1011 Commercial St., San Carlos, Calif.

See at Show Booth 3035.

NEW FROM WESTINGHOUSE AT YOUNGWOOD



New Westinghouse High Gain Transistor simplifies circuitry, increases reliability, eliminates driver stage components, reduces cost of assembly.

NEW WESTINGHOUSE SILICON POWER TRANSISTOR PROVIDES

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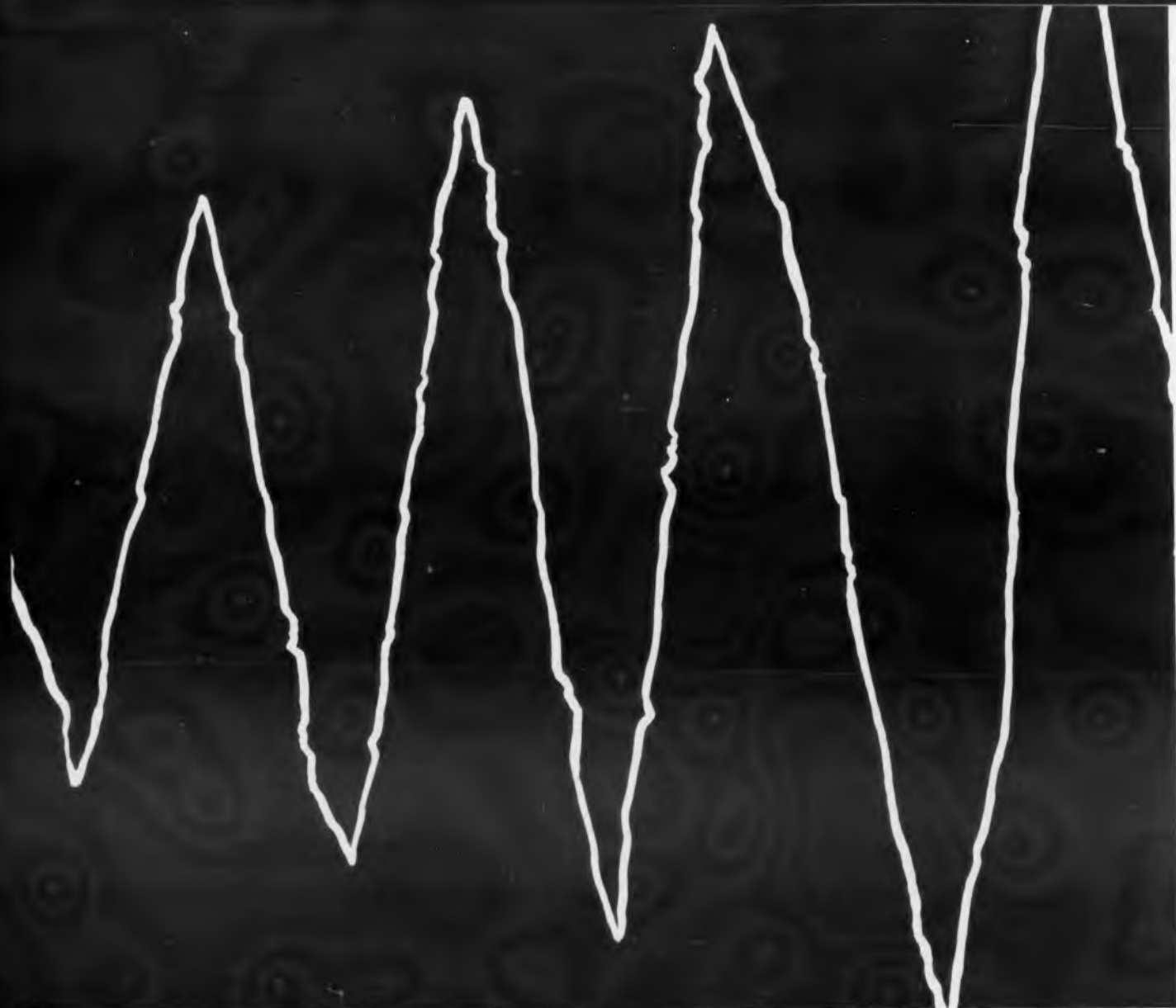
Westinghouse introduces a complete new family of High Gain Silicon Power Transistors providing a gain of 1000 or more at 2 amps . . . with guaranteed minimum gain of 400 at 10 amps (WX118X series) . . . a guaranteed minimum gain of 100 at 10 amps (WX118U series). These devices can substantially reduce circuit components, increase reliability, save space and weight.

They're ideal for application in high power, high efficiency regulators, amplifiers and switching circuits. For example, 1500 watts of power can be easily controlled with a 50 milliwatt signal! For full information call your nearest Westinghouse representative or write to Semiconductor Dept., Youngwood, Penna. You can be sure . . . if it's Westinghouse.

SC-1025

OTHER FEATURES INCLUDE

- True Voltage Ratings to 150 volts
- Power dissipation of 150 watts
- Collector current—10 amperes
- Operating temperature to +150°C.
- Low thermal impedance: .5°C/watt



1000 AT 2 amps!

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CIRCLE 58 ON READER-SERVICE CARD

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Now Available for the First Time...



SAGE RESISTORS with The Amazing New Moisture-Resistant "IMPERVOHM" silicone coating

WHAT IS "IMPERVOHM"? . . . It is a new non-porous silicone encapsulant representing a significant moisture seal "break through," which has been developed exclusively for SAGE Characteristic "G" and "V" Power Resistors.

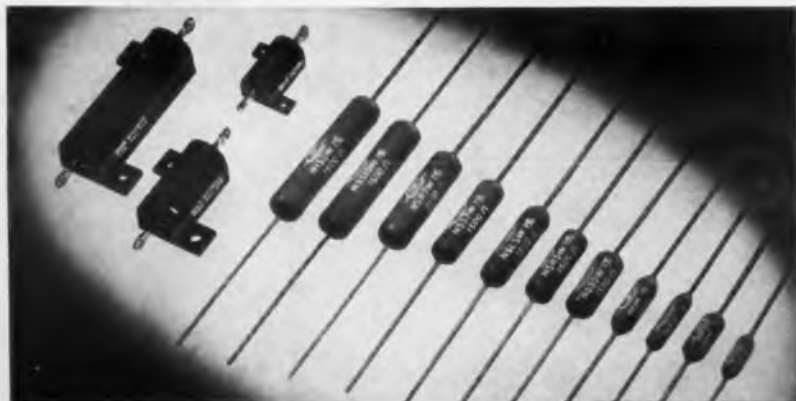
WHAT ARE ITS ADVANTAGES? . . . Because of its unusual characteristics attributed to optimum balance of resin and precise filler particles, this new coating requires no compromise in offering:

- Improved heat endurance (-65°C to $+350^{\circ}\text{C}$).
- Superior resistance stability (0.1%) after severe moisture cycling.
- Availability of all type "S" Resistors as reliable body insulated styles (1000 Volts rms min.).
- New ruggedness in ultrasonic solvent wash not previously available. These features signify an insulating achievement unmatched in the power resistor field.

WHERE DO SAGE "IMPERVOHM"-SEALED RESISTORS EXCEL?

Component and Circuit Design Engineers will be wise to specify SAGE in all applications demanding critical sensitiveness to moisture and temperature extremes. They will also take advantage of the insulation ruggedness these Resistors offer for printed circuit assembly as well as for metal chassis contact mounting. Of special significance in all cases is long life environment protection.

YOU PAY NO PREMIUM FOR "IMPERVOHM" PROTECTION . . . This remarkable coating is now "Standard" on SAGE Resistors—conventionally wound types "S" and "CS" and non-inductively wound types "NS" and "NCS."



Write for samples and engineering data

SAGE

ELECTRONICS CORPORATION

COUNTRY CLUB ROAD • EAST ROCHESTER, N. Y.

CIRCLE 60 ON READER-SERVICE CARD

NEW PRODUCTS AT THE IRE SHOW

Silicon Photocells

598

Read 10,000 characters per sec



Silicon readout photocells, with response time from 5 to 20 μ sec, are capable of reading 10,000 characters per sec in perforated tape and punched card data-reading systems. Available with 5 to 10 readout positions, active cell area per segment is 0.128 x 0.067 in.; center-to-center spacing is 0.087 in. Typical current generated is 350 μ a for 0.01 sq in. of active area at 1,000 ft-c illumination. Cells operate to 150 C and have low-noise output.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

P&A: \$14.40 to \$27 ea, 1 to 99; delivery from stock.

See at Show Booth 2901-03.

Electroluminescent Panels

601

Are 1-1/2 in. in size



Models AN-150 and NU-150 are 1-1/2 in. electroluminescent panels for the display of numeric and alphanumeric information. They are composed of segments of electroluminescent lamps insulated from one another and individually terminated. Type AN-150 has 14 segments and produces the complete alphabet, 0-to-9 numerics, a decimal point and selected mathematical symbols. Type NU-150 consists of nine segments which produce 0-to-9 numerics, a decimal point and selected mathematical symbols.

Sylvania Electric Products, Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.

See at Show Booth 2322-32 and 2415-25.

The Allison 650 Random Noise Source



HERE'S A NEW TRANSISTORIZED NOISE SOURCE

The new Allison 650 Random Noise Source consists of a silicon diode as the noise source driving a transistorized amplifier. It is non-microphonic and can be used in areas of high ambient noise and vibration. It is suitable for shaker tables or high level environmental acoustic testing; and microphone and other transducer calibration signal.

ALLISON 650 SPECIFICATIONS

- Output—0-1.5 VRMS
- Load impedance—600 ohms
- Size—6 $\frac{3}{4}$ " x 6 $\frac{3}{4}$ " x 6"
- Weight—4 $\frac{1}{2}$ pounds
- Price—Battery powered
\$265.00 F. O. B.
AC powered
\$280.00 F. O. B.
- Rack mount model (650R) available

Miniature noise source



The Allison 655 Random Noise Source has a uniform output over the frequency range of 5 cps to 30 kcps. Characteristics similar to 650. 1" x 1 $\frac{3}{4}$ " x 1 $\frac{3}{4}$ ". 2 $\frac{1}{2}$ oz. \$36.00 each in 100 lots. Write for Technical Bulletin 655.

Write for Technical
Bulletin 650



**Allison
Laboratories, Inc.**

11301 OCEAN AVENUE
LA HABRA, CALIFORNIA

Data Logger

587

For low-cost systems



A low-cost automatic data logger, the RS2 has been built as an integrated scanning, measuring and printing system. It provides four-digit voltage readings with correct polarity and range, and has two digits for input channel identification. Accuracy is 0.01% of full scale on each range. Functions include: scanning up to 20 double-pole channels; measuring dc voltage from ± 0.001 to ± 999.9 in three decade ranges; printing channel number, four-digit reading, polarity and decimal point placement.

Non-Linear Systems, Inc., Dept. ED, Del Mar, Calif.

Price: \$3,600.

See at Show Booth 3041-42.

Crystal Filters

589

From 1 kc to 110 mc



Ranging in frequencies from 1 kc to 110 mc, these crystal filters have Q in excess of 200,000, bandwidths ranging from 0.01 to 12% and inductances in the thousands of henries with stability of 1 part in 10^6 . Typical specifications for model 69A are: f_0 , 140 to 148 kc; bandwidth attenuation, 1.2 db at 270 cps, 3 db at 394 cps, 30 db at 2,000 cps; impedance, input, 10 K, output, 43 K.

Bulova Watch Co., Inc., Dept. ED, 40-01 61st St., Woodside, N.Y.
See at Show Booth 1821-23.

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every
soldering iron
ever
invented



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old-fashioned as
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with the space age

NEW PRODUCTS AT THE IRE SHOW

Pulse Generator

602

Completely transistorized



Model B-10 high-speed pulse generator is completely transistorized and portable. A self-contained, rechargeable battery pack allows in-the-field operation. Specifications are: main output pulse, continuously variable from 20 to 2 million pulses per sec; delay, continuously variable from 0 to 10,000 μ sec; pulse widths, continuously variable from 0.05 to 10,000 μ sec; amplitude, 18 v into 50 ohms; rise and fall times, 0.02 μ sec or less.

Rutherford Electronics Co., Dept. ED, 8944 Lindblade St., Culver City, Calif.

See at Show Booth 3317.

High-Vacuum Seal

615

The Gask-O-Seal is a reusable gasket for vacuum, capable of sealing to military hermetic specifications. Its design features controlled confinement of the seal with full metal-to-metal contact of faying surfaces. A nonconductive high-pressure seal is also made.

Parker Seal Co., Dept. ED, 10567 Jefferson Blvd., Culver City, Calif.

See at Show Booth 4243

General Purpose Relay

605

For loads to 10 amp



Series 46 ac-dc relay is a general purpose, heavy-duty unit designed for switching loads up to 10 amp. Rated life is 500,000 operations on 10-amp loads, 10 million with no contact load. Dc sensitivity is from 200 mw to 1 w. Ac sensitivities are 0.5 to 3.5 va.

Sigma Instruments, Inc., Dept. ED, 170 Pearl St., S. Braintree 85, Mass.

P&A: \$7 to \$8 ea; samples in 3 to 4 weeks.

See at Show Booth 2628-30.

TANTALUM CAPACITORS



from the industry's widest selection...

the highest temperatures—up to 200°C . . . the highest capacitances—up to 2250 microfarads . . . the smallest sizes—new 125°C miniature TAH . . . many terminal arrangements are available in the XT series.

seven different high temperature types . . . with the

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A complete line of aluminum and tantalum electrolytics, motor start and run capacitors

Crystal Oven

607

With stepless control



A solid-state, stepless control system in this crystal oven is claimed to eliminate temperature cycling, noise, surges of oven power, and drift of temperature differential due to aging. Stability at any temperature is 0.01 C or better. Oven temperature can be set between 40 and 125 C. Usable cavity volume is over 13 cu in. Model PG03 is 5.02 in. high and 3.02 in. in diameter. Weight is about 15 oz; power required is 28 v dc.

Bulova Watch Co., Inc., Dept. ED, Electronics Div., 40-01 61st St., Woodside 77, N. Y.

Price & Availability: \$175; 5-week delivery.
See at Show Booth 1821-23.

Alloy Spheres

616

Alloy spheres of tin-selenium, tin-tellurium, gold-tin and gold-tellurium, used in the manufacture of gallium-arsenide semiconductor devices are produced in diameters as small as 0.002 in. They are available with up to 0.6% selenium and 1.7% tellurium.

Alpha Metals, Inc., Dept. ED, 56 Water St., Jersey City 4, N.J.

See at Show Booth 4328.

Power Supplies

606

In 17 models



Increased versatility in output, controls, and size are featured in these 17 power supplies. Outputs range up to 1,080 w in the QR series. Constant current, remote voltage programming, and current-limiting controls are featured in two low-current units, with ripple of less than 100 μ v rms and 200 μ v peak-to-peak. Both units have a regulation of 0.02% and an input range of 105 to 125 v at 50 to 400 cps.

Sorenson & Co., Inc., Dept. ED, Richards Ave., South Norwalk, Conn.

See at Show Booth 2604-06.



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CIRCLE 64 ON READER-SERVICE CARD

NEW PRODUCTS AT THE IRE SHOW

True-RMS Voltmeter

613

Is servo-operated

Model 21 true-rms voltmeter is a multi-range, servo-operated indicating device. Designed for general laboratory use, it is also capable of driving output digitizers or potentiometers for data reduction or process control. The rack-mounting unit has a step attenuator providing 14 voltage ranges from 10 mv to 200 v in a 1-2-5 attenuator sequence. The large linear scale is easily read. The instrument will sustain large overvoltages without damage.

F. L. Moseley Co., Dept. ED, 409 N. Fair Oaks Ave., Pasadena, Calif.

See at Show Booth 3310-12.

Null Indicators

610

Show large unbalance



Made in miniature (MM-1) and edgewise (MCE-1) configurations, these null indicators can indicate large amounts of unbalance in bridge or other detection circuits without damage. They employ core magnet, self-shielded mechanisms in structures providing high sensitivity at the null point and sharp square-law attenuation as the pointers deflect. Standard sensitivities are 1/2, 1, and 2 μ a at the null point, with end scale values of 100, 200, and 500 μ a. Other sensitivities can be supplied.

Precision Meter Div., Minneapolis-Honeywell Regulator Co., Dept. ED, Grenier Field, Manchester, N. H.

See at Show Booth 2202.

Solder

614

Made by a special process, type AAA solder reduces inherent inclusions, improves wetting, and minimizes drossing. It is for use on printed circuit boards and dip-soldering leads of diodes and transistors.

Alpha Metals, Inc., Dept. ED, 56 Water St., Jersey City 4, N.J.

See at Show Booth 4328.

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CIRCLE 65 ON READER-SERVICE CARD

CIRCLE 66 ON READER-SERVICE CARD >

Transitron

SILICON CONTROLLED RECTIFIERS

augmenting the industry's broadest line

With the addition of the 50-Amp Silicon Controlled Rectifier, Transitron now offers the industry the broadest line of Controlled Rectifiers available on the market today.

Research and development efforts during the past year have already produced an impressive array of types which include the following series:

TSW31S SERIES (TO-18 package) operating current range to 200mA

TCR251 SERIES (TO-5 package) operating current range to 1 amp

2N1595 SERIES (TO-5 package) operating current range to 1 amp

2N1600 SERIES (7-16" hex package) operating current range to 3 amps

TCR505 SERIES (7/16" hex package) operating current range to 5 amps

TCR510 SERIES (11/16" hex package) operating current range to 10 amps

TCR520 SERIES (11/16" hex package) operating current range to 20 amps

NOW AVAILABLE — NEW 50-AMP CONTROLLED RECTIFIER

The latest addition to the Transitron line — the 50 Amp Silicon Controlled Rectifier — is a three-terminal, four-layer device designed to control very large load currents with small gate current signals. A mechanically rugged and electrically stable device, the new Controlled Rectifier is provided in the 1 1/8" hex base stud-mounted package and is hermetically sealed. Wherever high power handling ability is required, the 50-Amp Silicon Controlled Rectifier will find wide application ranging from frequency changing to welding control.

TCR550 SERIES (1 1/8" hex package)
operating current range to 50 amps

Type	Min. Peak Reverse Volt. and Min. Forward Breakover Volt. (volts)	Max. Average Forward Current at 90°C case (amps)	Package Configuration
TCR4050	400	50	1 1/8" hex
TCR3050	300	50	1 1/8" hex
TCR2050	200	50	1 1/8" hex
TCR1050	100	50	1 1/8" hex
TCR550	50	50	1 1/8" hex

Requires 50mA to turn on 50 Amp



For information on any or all of Transitron's line of Controlled Rectifiers, call or write today for Bulletin TE-1356.

**WHY BIAS
CONTROLLED
RECTIFIERS?**

THE
BIASING
OF SILICON
CONTROLLED
RECTIFIERS
AND
SWITCHES

Pioneering in new application techniques, Transitron application engineers have assembled information which demonstrates how "gate biasing" will improve the circuit reliability of the SCR. This informative booklet, entitled "The Biasing of Silicon Controlled Rectifiers and Switches," deals individually with each of Transitron's Controlled Rectifiers and Switches. It is an indispensable aid to the design engineer seeking longer life and greater stability in higher temperature applications . . . It's yours for the asking.

MEET US AT IRE — BOOTH NOS. 1220-1224

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NEW PRODUCTS

AT THE IRE SHOW

Overload Interrupter 594

For overloads to 5 amp

Designed to protect rectifiers and transistors from destruction by dc overload currents as high as 5 amp, the overload interrupter operates in 0.5 to 5 msec. It can be set locally or remotely and can be designed to cycle. It is available in a variety of set points.

Sigma Instruments, Inc., Dept. ED, 170 Pearl St., S. Braintree 85, Mass.

P & A: \$20 to \$30 ea; sample quantities, 3 to 4 weeks.

See at Show Booth 2628-30.

Power Supply 588

Uses tunnel diodes



Model TD6M, a tunnel-diode power source, has a low-impedance output adjustable from 0 to 6 v dc. A vernier control is provided. Current rating is 0 to 100 ma. Regulation is 0.05% or 2 mv for input voltage variation from 105 to 125 v ac, 60 to 400 cps, and 0 to 100% load change. Internal impedance is less than 0.01 ohm at dc. Ripple is under 1 mv rms. Panel size is 3-1/2 x 9-1/2 in.

Electronic Research Associates, Inc., Dept. ED, 67 Factory Place, Cedar Grove, N. J.

Price: \$275.

See at Show Booth 2830-32.

Random Motion System 596

Has narrow-band sweep

This narrow-band sweep random motion system is claimed to represent a new concept in random motion testing. The narrow-band equalizer will enable laboratories

CBS Semiconductors

● **NOW ORDER ALL YOUR
COMPUTER SEMICONDUCTORS FROM
ONE DEPENDABLE SOURCE**



Three Lines of Switching Transistors

MADT* Switching Transistors

Type	Min. BV _{CEO} (Volts)	Typical f _{ab} Mc.
2N501	-15	250
2N501A	-15	250

MAT† and SBT° Switching Transistors

2N393	- 6	50
2N1122	-12	100
2N1122A	-15	100
2N1411	- 5	85
2N1427	- 6	120
2N240(SBT)	- 6	60

NPN Switching Transistors—Core Driver and Logic Circuitry Types

2N312	15	2
2N356	20	3
2N356A	30	3
2N357	20	6
2N358	20	9
2N377	25	5
2N377A	40	5
2N385	25	6
2N385A	40	6
2N388	25	8
2N388A	25	8
2N438	30	4
2N438A	30	4
2N439	30	8
2N439A	30	8
2N440	30	12
2N440A	30	12
2N444	15	1
2N445	15	3
2N446	15	8
2N447	15	10
2N556	25	1
2N558	15	3
2N634	20	8
2N635	20	12
2N636	20	17
2N1000	40	9
2N1012	40	5
2N1090	25	8
2N1091	25	12



MADT* SWITCHING TRANSISTORS

CBS MADT transistors are PNP Germanium Micro Alloy Diffused-base types with optimized electrical characteristics for extremely fast switching service. Cadmium junctions increase dissipation capacity. Over-all quality exceeds MIL-S-19500.

MAT† & SBT° SWITCHING TRANSISTORS

CBS PNP Germanium Micro Alloy Transistors and Surface Barrier transistors are designed for computer switching circuits up to 5 mc. Low collector saturation voltage makes them ideal for Direct Coupled Transistor Logic Circuitry (DCTL). Good high frequency response permits a pyramiding factor of 5 at moderate switching speeds.

NPN SWITCHING TRANSISTORS—CORE DRIVER AND LOGIC CIRCUITRY TYPES

These CBS types are Germanium NPN Alloy Junction Transistors, possessing superior reliability. Construction features include: ruggedized package, and hermetic sealing in the welded JEDEC TO-5 package, which is designed particularly for automatic handling.

Special processing steps include thorough bake-out to stabilize gain and advanced surface chemistry techniques to seal out moisture and contamination. The welded package is equipped with flexible, plated leads designed for connection by soldering, welding or socketing.

*MADT: Micro Alloy Diffused-base Transistor.

†MAT: Micro Alloy Transistor.

°SBT: Surface Barrier Transistor.

Trade-Marks of Philco Corp.

AT THE IRE SHOW:



Use CBS "Facts-Phone" for direct dialing to applications engineering, customer service and other facilities at the CBS Electronics' Lowell plant. Get complete and immediate information on CBS Semiconductors for Computer Circuitry right at CBS Electronics' IRE booths 1401 and 1403. Be sure to see us at the Show!

for Computer Circuitry



Two Lines of Switching Diodes

Bonded Germanium Diodes

Types	Peak Reverse Voltage (Volts)	Min. Forward Current (MA @ +1V)
1N95	-75	10
1N96	-75	20
1N97	-100	10
1N98	-100	20
1N99	-100	10
1N100	-100	20
1N107	-15	150
1N108	-60	50
1N117	-75	10
1N118	-75	20
1N273	-30	100
1N276	-75	40
1N278	-60	20
1N279	-35	100
1N281	-75	100
1N283	-20	200
1N287	-60	20
1N288	-85	40
1N289	-85	20
1N298	-85	30 @ 2V
1N447	-50	25
1N497	-30	100
1N498	-50	100
1N499	-65	100
1N500	-75	100
1N631	-70	100
1N634	-115	50
1N699	-105 @ 70 °C	100
1N770		15 @ 0.5V

Point-Contact Germanium Diodes

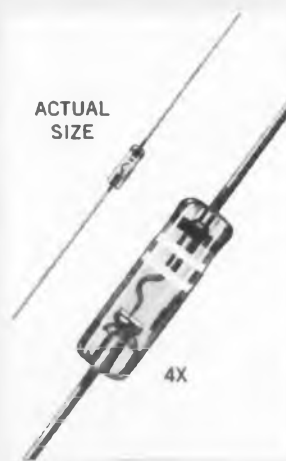
Type	Peak Reverse Voltage (Volts)	Min. Forward Current (MA @ +1V)
1N34 A	-75	5
1N35	-75	7.5
1N38 A/B	-120	4-25
1N48	-85	4
1N51	-50	2.5
1N52	-85	4
1N54/A	-50/75	5
1N55 A	-170	4
1N56 A	-50	15
1N58/A	-120	5
1N60	-30	3
1N63	-125	4
1N64	-20	-
1N65	-85	2.5
1N67/A	-100	4
1N68/A	-130	3
1N75	-125	2.5
1N90	-75	5
1N116	-75	5
1N126/A JAN	-75	5-25
1N127/A JAN	-125	3-25
1N128 JAN	-50	3
1N191	-105	5
1N192	-80	5
1N198 JAN	-100	4
1N290	-120	5
1N294	-70	5
1N295	-50	-
1N541	-50	4.5
1N636	-60	2.5
1N933	-100	4-17

BONDED GERMANIUM DIODES—CBS Bonded Diodes are specially designed to eliminate opens and shorts, major causes of failures in computer diodes. They are capable of withstanding extreme shock and vibration both during printed circuit assembly and through their operating life. They achieve 100% survival in a shock test that exceeds MIL specs!

Here is a wide variety of computer diodes offering a choice of high voltage, high reverse resistance, high conductance, fast reverse recovery or high temperature characteristics. The line also includes general-purpose types.

POINT-CONTACT GERMANIUM DIODES—CBS Point-Contact Germanium diodes possess outstanding efficiency plus long and reliable life. These diodes are fusion-sealed in miniature glass envelopes. This glass construction supplies "locked-in" electro-mechanical stability and dependability required to withstand the stresses imposed by severe environmental and operating conditions.

In addition to subminiaturization, the CBS Point-Contact diodes package provides a true hermetic seal for greater protection against moisture and contamination.



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CBS ELECTRONICS, Semiconductor Operations, Lowell, Massachusetts • A Division of Columbia Broadcasting System, Inc. Semiconductors • tubes • audio components • microelectronics

Sales Offices: Lowell, Mass., 900 Chelmsford St., GLenview 2-8961 • Newark, N. J., 231 Johnson Ave., TAlbert 4-2450 • Melrose Park, Ill., 1990 N. Mannheim Rd., EStebrook 9-2100 • Los Angeles, Calif., 2120 S. Garfield Ave., RAYmond 3-9081 • Toronto, Ont., Canadian General Electric Co., Ltd., LEnnox 4-6311.

with low-power amplifiers to perform random motion tests which previously demanded high-power units.

MB Electronics, Dept. ED, 781 Whalley Ave., New Haven 8, Conn. See at Show Booth 3107-09.

Frequency Standard 586

For airborne use



Designed for missile and other airborne applications, the MB 400 provides 400 cps, ± 10 ppm. Stability is maintained at temperatures from -20 to 71 C, at vibration levels of 15 g, 5 to 2,000 cps, and up to 100-g shock. Input is 25 to 29 v dc, 1 v rms ripple. Maximum power for oven and oscillator circuitry is 11 w. Output is a square wave of 2 v peak-to-peak amplitude into a 1-K load. The hermetically sealed can is 2 x 2 x 4-1/4 in. External adjustment is provided to compensate for aging.

Bulova Watch Co., Inc., Electronics Div., Dept. ED, 40-01 61st St., Woodside 77, N. Y.

P & A: \$475 to \$895; 4 weeks.

See at Show Booth 1821-23.

Impulse Relay 595

Has no lock-in mechanisms

The spdt impulse relay alternately transfers from one switch position to another on a series of successive similar pulses. It has no lock-in mechanisms or mechanical escapements and has vibration immunity in the order of 30 g to 2,000 cps.

Sigma Instruments, Inc., Dept. ED, 170 Pearl St., S. Braintree 85, Mass.

P & A: \$30 to \$40 ea; sample quantities in 3 to 4 weeks.

See at Show Booth 2628-30.

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CIRCLE 68 ON READER-SERVICE CARD

NEW PRODUCTS AT THE IRE SHOW

AC-DC Power Supply

609

Precision-type, for calibration



Designed for the calibration of digital, indicating and recording instruments, model 2120 ac-dc precision power supply provides emf outputs from 0 to 1.5 kv and current from 0 to 30 amp. Output ranges in frequency from 50 cps to 20 kc. Rated output is in excess of 30 va; short-term stability is better than 0.03%. Resolution of output current and voltage adjustment is $\pm 0.01\%$. Front panels are standard rack width.

Radio Frequency Laboratories, Inc., Dept. ED, Powerville Road, Boonton, N.J.

See at Show Booth 3115-19.

Vernier Potentiometer

612

Accurate to 10 ppm

Designed for voltage measurement from 1 μ v to 1.8 v, the P.10 precision vernier potentiometer is accurate to 10 ppm at the 1-v setting. Standardization is effected by balancing the standard cell against a built-in auxiliary divider. All terminals, studs, etc. are copper, tipped with a precious metal alloy. Temperature coefficient is held to a minimum. An ac converter is available.

Muirhead Instruments, Inc., Dept. ED, 441 Lexington Ave., New York 17, N. Y.

Price & Availability: \$995; delivery from stock.

See at Show Booth 3230.

Power Packs

599

With battery-voltage output



Solid-state, miniaturized power packs TR-4R and TR-8R are designed to replace battery power

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rf instruments and co-axial components

Slotted Lines



Residual VSWR of the line itself is under 1.01.

Rated error in detected signal is under 1.005. Standard slot lengths are 20, 40, 60, 80, and 130 inches. These lines are available with a wide variety of interchangeable precision tapered reducers for measurements in different types of rigid and flexible coaxial lines.

Coaxial Switches



High power ratings with VSWR under 1.06. Pressurized. Motor-driven and manually operated models. For use with $3\frac{1}{8}$ " and $6\frac{1}{8}$ " transmission lines.

Instrument Loads



High stability; very low VSWR; wide temperature ranges. Available in nearly all transmission-line sizes.

Automatic Impedance Plotters



Display impedance-vs-frequency curves on a self-contained 5" CRT and on an external X-Y recorder (not supplied). Frequency ranges are 0.1 — 2.5 mc, 2.5 — 250 mc, 30 — 400 mc, 180 — 1100 mc, 1100 — 1700 mc. Made in portable and rack-mounted units.

Other Products

- Tapered Reducers
- Line Stretchers
- Hybrids
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sources. Voltage outputs may be 6, 12, 18, 24, 28, or 32 v. Output current is 0 to 4 amp for the TR-4R, 0 to 8 amp for the TR-8R. Input is 105 to 125 v ac, 60 to 400 cps. Line or load regulation is better than 0.05% or 5 mv. Ripple is less than 2 mv rms. Typical size of the 4-amp unit is 5 x 9 x 10 in.

Electronic Research Associates, Inc., Dept. ED, 67 Factory Place, Cedar Grove, N. J.

Price: \$225 ea.

See at Show Booth 2830-32.

Power Tetrode

Operates to 110 mc



The PL-4-1000A power tetrode can be operated at frequencies up to 110 mc. With a plate-dissipation rating of 1 kw, it will provide up to 3.4 kw of plate power output as a class C fm or cw amplifier, and more than 2.6 w as an am amplifier. Cooled by radiation and by the circulation of forced air, it is also suitable for use as an af amplifier and modulator.

Penta Laboratories, Inc., Dept. ED, 312 S. Nopal St., Santa Barbara, Calif.

See at Show Booth 2736.

Coated Nickel Strip

For transistors

Nickel strip, coated with a high-purity alloy consisting of 0.6% gallium, is for stamping of base tabs to support the silicon or germanium wafer in transistors. The coated area serves as a solder preform to establish a bond between the wafer and the support.

Alpha Metals, Inc., Dept. ED, 56 Water St., Jersey City 4, N.J.

See at Show Booth 4328.

Accuracy Is Our Policy . . .

Price information accompanying the New Product description of the series TR dc power supply, made by Electronic Measurements Co. of Red Bank, Eatontown, N. J., is in error. The notice, on p 85 of the Feb. 1 issue, should read: From \$159 to \$189.

ELECTRONIC DESIGN • March 15, 1961

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G_I ANNOUNCES INDUSTRY'S MOST RELIABLE SILICON MESA TRANSISTORS!

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Micrograph shows precision of junction metalizing and lead contacting.

Exclusive combination of reliability benefits offered by G_I through long-term R & D:

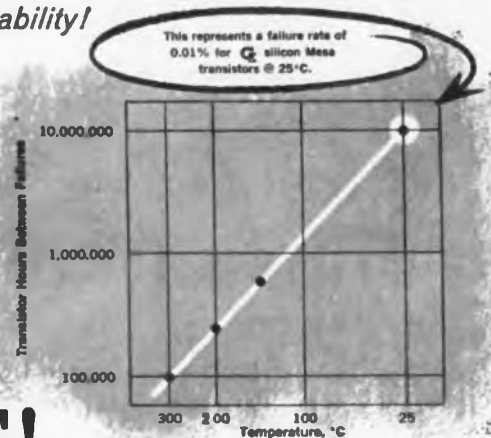
- Advanced techniques of junction metalizing;
- Superior junction contacting;
- Permanent surface passivation;
- 100% lot stabilization with 96-hour bake at 300°C; and
- Critical analysis with automatic equipment for exhaustive parameter testing.

COMPLETE LINE OF G_I SILICON MESAS...FROM STOCK

What are your needs? General Instrument offers a full line of double diffused NPN silicon mesas for your most exacting applications. Abbreviated ratings and characteristics below indicate a wide range of usefulness: Very high speed saturated switching; VHF tuned amplifiers; and units with high beta linearity for magnetic memory drivers

and video amplifiers.

Available in accordance with MIL-S-19500/99A (G_I 2N696, 2N697) and MIL-S-19500/120 (G_I 2N706). Contact General Instrument today for more information on these realistically-priced units, and the name of your local authorized stocking distributor.



PROOF! Extended life tests at each of temperatures shown above, demonstrate G_I superior mesa performance with 0.01%/per 1000-hrs. failure rate at 25°C.

GENERAL INSTRUMENT NPN SILICON MESA TRANSISTORS										
Type	Case	RATINGS			I _{CO}	CHARACTERISTICS				
		V _{CE}	V _{BE}	Maximum Dissipation (T _{case} = 25°C)		I _B V _{CE} = 10 v I _C = 150 ma pulsed	I _B V _{CE} = 10 v I _C = 50 ma f = 20 Mc	V _{CE} I _B = 15 ma I _C = 150 ma	V _{CE} (SAT.) I _B = 15 ma I _C = 150 ma	C _{ob} I _C = 0 V _{CE} = 10 v
2N696	TO-5	60 v	5 v	2 watts	@ V _{CE} = 30 v T = 25°C Ambient: 1 μa max T = 150°C Ambient: 100 μa max	20 min 60 max	2 min	1.3 v max	1.5 v max	35 pf max
2N697	TO-5	60 v	5 v	2 watts	@ V _{CE} = 30 v T = 25°C Ambient: 1 μa max T = 150°C Ambient: 100 μa max	40 min 120 max	2.5 min	1.3 v max	1.5 v max	35 pf max
2N699	TO-5	120 v	5 v	2 watts	@ V _{CE} = 60 v T = 25°C Ambient: 2 μa max T = 150°C Ambient: 200 μa max	40 min 120 max	2.5 min	1.3 v max	5.0 v max	20 pf max
2N706	TO-18	25 v	3 v	1 watt	@ V _{CE} = 15 v T = 25°C Ambient: 0.5 μa max T = 150°C Ambient: 30 μa max	V _{CE} = 1 v I _C = 10 ma 15 min	V _{CE} = 15 v I _C = 10 ma f = 100 Mc 2 min	I _B = 1 ma I _C = 10 ma 0.9 v max	I _B = 1 ma I _C = 10 ma 0.6 v max	6 pf max
2N1252	TO-5	30 v	5 v	2 watts	@ V _{CE} = 20 v T = 25°C Ambient: 10 μa max T = 150°C Ambient: 600 μa max	15 min 45 max	2 min	1.3 v max	1.5 v max	45 pf max
2N1253	TO-5	30 v	5 v	2 watts	@ V _{CE} = 20 v T = 25°C Ambient: 10 μa max T = 150°C Ambient: 600 μa max	30 min 90 max	2.5 min	1.3 v max	1.5 v max	45 pf max
2N1420	TO-5	60 v	5 v	2 watts	@ V _{CE} = 30 v T = 25°C Ambient: 1.0 μa max T = 150°C Ambient: 100 μa max	100 min 300 max	2.5 min	1.3 v max	1.5 v max	35 pf max

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GENERAL TRANSISTOR



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DIVISION OF GENERAL INSTRUMENT CORPORATION

55 Gouverneur Street, Newark 4, New Jersey



IN CANADA: General Instrument—F. W. Sickles of Canada Ltd., P.O. Box 408, 151 S. Weber Street, Waterloo, Ontario, Canada, Sherwood 4-8181.

CIRCLE 70 ON READER-SERVICE CARD

13 MOVES TO RELIABLE TRIMMING

SPECTROL'S FULL LINE of trimming potentiometers features 10 of the smallest square trimmers ever made, plus the only *transistor-size* units for solid state circuitry. This selection covers almost every conceivable application—a sure way to avoid checkmate when you need reliable trimmers.

SQUARE TRIMMER DATA. Models 50 and 60 measure $\frac{3}{8}$ " and $\frac{1}{2}$ " square respectively • humidity proofing a standard feature • available in resistances to 100K • greater surface contact between mandrel and aluminum case for better heat dissipation, no external heat sinks needed • dual wiper for positive contact under all conditions of shock and vibration.

SINGLE TURN TRIMMER DATA. Model 80 built into TO-9 transistor type case • measures less than $\frac{1}{8}$ " in diameter, weighs 1 gram—smallest trimmer on the market • completely sealed against moisture and humidity • resistance element twice as long as ordinary trimmers • designed for complete package encapsulation with other printed circuit components • available in 3 case styles with resistance range to 20K.

IMMEDIATE DELIVERY. Your nearby Spectrol distributor stocks standard models of trimmers and miniature potentiometers as well as other standard Spectrol precision potentiometers and turns indicating dials. Prices are \$6 to \$8 in quantities of 1-9 for most styles and resistances.

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See the complete Spectrol line at I.R.E. Show—Booth 1907-09

MODEL 60



Printed circuit pins, top adjust

MODEL 50



Teflon insulated leads

MODEL 60



Teflon insulated leads

MODEL 80



Transistor size case

MODEL 80



Transistor size case,
bushing mount

MODEL 50



Printed circuit pins from base

MODEL 60



Printed circuit pins, side adjust

MODEL 50



Bushing panel mount

MODEL 50



Printed circuit pins, top adjust

MODEL 80



Transistor size threaded case

MODEL 50



Printed circuit pins
side adjust

MODEL 60



Printed circuit pins from base

MODEL 60



Bushing panel mount

NEW PRODUCTS AT THE IRE SHOW

Strap-Frame Tubes 592 In four subminiature types



High-gain, low-noise, subminiature receiving tubes, using a strap-frame grid construction, show characteristics improved over their standard prototypes. Of two medium- μ ulf double triodes, one exhibits a 100% increase in g_m and g_m per ma of plate current; the other has 80% higher g_m at 40% lower heater power. Of the high- μ triodes, one has a 1,300:1 ratio of g_m to plate current, while the other employs $\frac{1}{3}$ the heater power with a 3-db improvement in noise figure.

Sylvania Electric Products Inc., Dept. ED, 730 Third Ave., New York 17, N. Y.

See at Show Booth 2322-32, 2415-25.

Digital Voltmeter 591 With plug-in switches



Model 481A, a low-cost industrial digital voltmeter, has plug-in stepping switches and a snap-out readout for simplified troubleshooting. It measures dc voltages from ± 0.001 to ± 999.9 . Addition of a preamplifier extends the range to ± 99.99 and ± 999.9 mv full scale. With an ac-dc converter, the meter measures ac voltages from 0.001 to 999.9 in 3 ranges, 30 cps to 10 kc.

Non-Linear Systems, Inc., Dept. ED, Del Mar, Calif.

Price: \$1,525.

See at Show Booth 3041-42.

← CIRCLE 71 ON READER-SERVICE CARD

NOW IT'S YOUR MOVE



Servo Amplifiers

472

Rated 3.5 to 12 w



Made to meet or exceed ABMA soldering specification PDS-C1, MIL-E-5400A, and MIL-E-52772A, these high-temperature, transistorized servo amplifiers are available in 3.5, 6, and 12-w sizes. Power outputs and input impedances are: 3.5 w (size 11 motor), constant 10 K resistive; 6 w (size 15 motor), 25 K; and 12 w (size 18 motor), 50 K. Sizes range from 1 to less than 2 cu in.; the largest weighs 8 oz. Basic design includes push-pull output stage, driver stage, and preamplifier, all using silicon transistors.

Bulova Watch Co., Inc., Electronics Div., Dept. ED, 40-01 61st St., Woodside 77, N.Y.

Price & Availability: \$90 to \$279 ea; 2 to 3 weeks.

See at Show Booth 1821-23.

Tape Reader

476

Meets military requirements



Design, components, workmanship and manufacture of the model 90 photoelectric tape reader are in accordance with MIL-E-4158B. Nominal tape length of 500 ft provides a total punched tape capacity of about 500,000 bits. Reading head system accommodates 5, 6, 7, and 8 level codes, punched 10 holes per in. along and across the tape. Guides will handle tape from 11/16 to 1 in. wide. The 85-lb reader has a panel height of 11 in., width of 17 in., and depth of 13 in. Power requirement is 115 v \pm 10%, 60 cps, 650 va. Operation is bi-directional, up to 80 in. per sec.

Cook Electric Co., Data-Stor Div., Dept. ED, 8100 Monticello Ave., Skokie, Ill.

Availability: 90 to 120 days.

See at Show Booth 3056.



TRANSISTORS—Shown here in magnification is a Mesa transistor with fine gold wire. Handy & Harman manufactures this whisker wire to exact tolerances and highest purity standards. The cap is gold plated from Handy & Harman fine gold anodes. Photo courtesy of Western Electric.



CAPACITOR CANS—These tantalum electrolytic capacitors are completely leaktight and highly resistant to corrosion. The containers that are also used to seal the liquid and internals are drawn from Handy & Harman fine silver sheet. Photo courtesy of Fansteel Metallurgical Corporation, North Chicago, Ill.



CAPACITORS—Electrodes in these solid-state porcelain capacitors are formed from silver paste derived from Handy & Harman silver flake. Other types of capacitors for high-temperature applications have lead wires of Handy & Harman Consil 998, a nickel-bearing alloy. Photo courtesy of Vitramon, Incorporated, Bridgeport, Conn.

TRANSISTORS, CAPACITORS AND COME WHAT MAY

*... just a few of the jobs involving
HANDY & HARMAN precious metals*

Handy & Harman's effectiveness in supplying the semiconductor and related fields is based on long experience with precious metals, coupled with our interest and ability in working closely with designers, engineers and manufacturers in the electrical and electronics industries.

These few examples are indicative of our continuing and expanding activities in furnishing precious metals: gold and silver and their alloys in wire, strip and foil; silver powders, flake and paint; silver bimetals; silver sintered metals; anodes, etc. The "etc." is our invitation to you to send us any questions you may have regarding the applicability of precious metals in your products or processes.

Would you like further information on these and others of our precious-metals products? Our Technical Bulletins contain a wealth of information and are yours for the asking:

A-1	Fine Silver	A-4 ...	Silver Conductive Coatings
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AIRPAX

Space-Saver Discriminators for

TELEMETRY



COMPACT MODEL
Requires special supply equipment

The unique use of a MAGMETER[®] saturating magnetic core frequency detector permits stable, accurate performance at a minimum cost in these completely solid state units. Power requirement is relatively small and the low internal dissipation eliminates rack cooling problems.

This latest addition to the Airpax CALIBRATOR Series of frequency discriminators features high performance in an exceptionally small package. Versatility is inherent—plug-in components permit accommodation of all IRIG bands. Deviation of 40% as well as other bands supplied on special order.

See the latest developments in Choppers, Circuit Breakers and Telemetry . . . IRE Booths 2306-08



CAMBRIDGE, MARYLAND • FORT LAUDERDALE, FLA.
CIRCLE 76 ON READER-SERVICE CARD

SOLID STATE
for high reliability, service free life, and low power dissipation.

COMPACT SIZE
1.27-3.2" wide, 4.3-8" high
Eighteen units mount in a standard 19" rack panel, 8-3/4" high.

STANDARD IRIG
center frequencies, percentage deviation and intelligence bandwidths.

PLUG-IN COMPONENTS
Unit supplied for a given band may be converted to any other IRIG band by changing plug-in frequency detector and filters.

INPUT SENSITIVITY and DYNAMIC RANGE
10 mv RMS min.; 60 db

LINEARITY
Deviation 0.25% of bandwidth or better.

STABILITY
Drift will not exceed 0.3% of bandwidth over 36 hour period.

NEW PRODUCTS AT THE IRE SHOW

Current Drivers

482

Are completely solid-state



Solid-state current drivers, suitable for driving thin-film and magnetic core memories, have a current rating of 0.1 to 1.0 amp, and ± 50 v back voltage. Negative type 52 and positive type 62 have rise and fall times of 0.05 to 0.5 μ sec. Output impedance is greater than 2 K at 1 amp. The units measure 10-1/2 in. high, 10-1/2 in. deep, and 2-1/2 in. wide. Seven drivers can be mounted across a standard rack panel.

Digital Equipment Corp., Dept. ED, Maynard, Mass.

See at Show Booth 3S40.

Digital Modules

481

500-kc flip-flops and gates



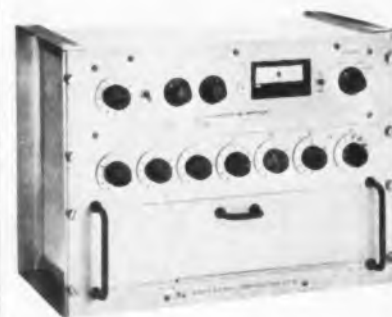
Capacitor-diode gating circuits and quadruple flip-flops have been added to a line of 500-kc digital modules. The static-logic units permit such applications as parallel-serial conversion, up counting, down counting, up-down counting, binary-coded decimal counting, storage, and reset. An accessory panel, with taper-pin patch-cords, provides quick connections and changes.

Digital Equipment Corp., Dept. ED, Maynard, Mass.

P&A: Flip-flops, \$90 to \$100; gates, \$40 to \$68; stock.

See at Show Booth 3S40.

Don't miss an issue of **ELECTRONIC DESIGN**; Return your renewal card.



new Keithley megohm bridge

MODEL 515 measures 10^5 to 10^{15} ohms with accuracy of .05 to 1%

The new line-operated 515 Megohm Bridge answers the need for a highly accurate, guarded Wheatstone Bridge for standardization and calibration of resistors in the ranges of 10^5 to 10^{15} ohms. It is also ideal for measurement of resistor voltage coefficient, leakage and insulation resistances. Speed of calibration is greatly increased over previously available bridges by a semi-automatic calibration feature. Subsequent direct reading speeds operation. Other features include shielded measuring compartment, self-contained bridge potential, a remote test chamber, bench or rack operation. \$1,500.00



Shielded measuring compartment, easily accessible in front panel, permits critical measurements without stray pickup.



for details write

**KEITHLEY
INSTRUMENTS**

12415 EUCLID AVENUE
CLEVELAND 6, OHIO

CIRCLE 77 ON READER-SERVICE CARD

Frequency-Selective Voltmeter 563

With carrier reinsertion

Model 125B-CR voltmeter covers the 3- to 620-kc frequency range. It is of modular construction and uses two selectivity settings and a flat voltmeter position. Narrow selectivity bandwidth is 250 cps wide at the 3-db points, and 1 kc wide at the 45-db points. Broad selectivity bandwidth is 2.5 kc wide at the 3-db points and 10 kc wide at the 45-db points.

Philco Corp., Sierra Electronics Div., Dept. ED, 3885 Bohannon Drive, Menlo Park, Calif.

See at Show Booth 3031-32.

Traveling-Wave Tubes 564

Metal-ceramic type

Two compact, metal-ceramic traveling-wave tubes are designed to operate as the driver and final amplifier in a pulsed high-power chain for X-band applications. Type Z-3090, the driver tube, has a nominal output of 5 kw and a peak power output of 10 kw within the band. Type Z-3091 has a 250-kw min power output over the entire band and a peak power output of 500 kw within the band.

General Electric Co., Power Tube Dept., Dept. ED, Schenectady 5, N.Y.

See at Show Booth 2912-14.

Semiconductor Testers 565

Include in-circuit tester

Semiconductor-device test equipment includes an in-circuit test set for both transistors and diodes. Leakage currents down to 1.5 μ a, full scale, can be detected. Alpha-cut-off and gain-bandwidth test sets feature direct-reading scales with simple calibration. The alpha-cut-off set operates from ac line; the gain-bandwidth set operates on either ac or battery power.

Molecular Electronics, Inc., Dept. ED, 85 Weyman Ave., New Rochelle, N.Y.

See at Show Booth M-9.

Sanborn has probably already designed your "custom" oscillographic recording system

"Building block" recorder and amplifier design permits maximum flexibility to meet specific application needs

950 Series — truly low cost — identical channels

6 or 8 identical DC recording channels — either high gain, 10 uv/div; medium gain, 0.5 mv/div; or low gain, 10 mv/div. Medium and high gain types are completely transistorized, have floating and guarded input circuits. Frequency response DC to 150 cps within 3 db, 10 div peak-to-peak with low and medium gain systems, to 100 cps with high gain system. Amplifier panel space only 7" x 19", recorder 17½" x 19".

850 Series — economical, flexible — miniature plug-in preamps

Interchangeable plug-in preamps, eight to a 7" high module, available in Phase Sensitive Demodulator, DC Coupling, Carrier and Low Level types. System response to 150 cps within 3 db, 10 div peak-to-peak, depending on preamps used. Input circuits single-ended, push-pull, or floating and guarded, depending on choice of preamp.

350 Series — versatile, high performance — interchangeable preamps

Provides greatest possible application flexibility, with interchangeable preamps in Carrier, DC Coupling, Phase Sensitive Demodulator, Differential DC, Low Level, Logarithmic and Frequency Deviation types. System response DC to 150 cps within 3 db at 10 div peak-to-peak — input single-ended, floating and guarded, or push-pull — depending on pre-amplifier used. Eight preamps in two 4-unit modules occupy 21" x 19" of panel space; usable separately with individual power supplies to drive meters, scopes, etc.

"350" style Recorder Assembly — used in all the above systems. Provides transistorized, plug-in, current-feedback power amplifiers . . . low impedance, velocity feedback damped galvanometers . . . 8" of visible record . . . 9 electrically controlled chart speeds . . . inkless traces on rectangular coordinate charts . . . flush front recorder, vertical chart plane. Recorders with horizontal chart plane also available for 350, 850 and 950 systems.

Sanborn oscillographic recording systems also include the tube-type 1- to 8-channel "150" Series with 12 plug-in preamplifiers; and the "650" 1- to 24-channel optical oscillograph with response to 5 KC and 8-channel amplifier available separately for driving any galvanometer. For complete data contact one of the Sanborn Sales-Engineering representatives located in principal cities throughout the United States, Canada and foreign countries.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman Street, Waltham 54, Massachusetts

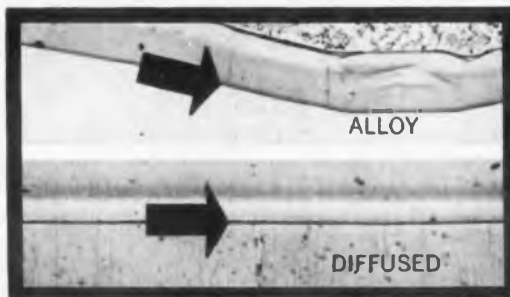
CIRCLE 73 ON READER-SERVICE CARD ►

SEE THIS EQUIPMENT AND OTHER SANBORN OSCILLOGRAPHIC RECORDING SYSTEMS, AMPLIFIERS AND TRANSDUCERS ON DISPLAY AT BOOTHS 3701-03-05, I.R.E. SHOW, NEW YORK COLISEUM, MARCH 20-23.

THESE RAYTHEON DISTRIBUTORS

offer 3 Big Advantages

1. Local Stocks
2. No Price Penalty
3. Broad Rectifier Line

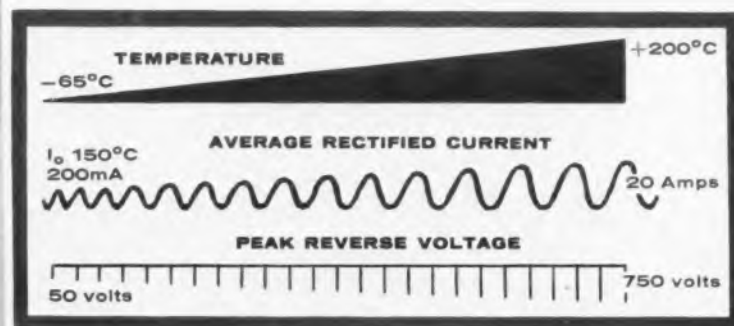


DIFFUSED JUNCTION UNIFORMITY

Far superior to irregular Alloy Junction Types, the planar uniformity of Raytheon diffused junction silicon Rectifiers assure higher performance and maximum reliability.

1 2 3

RAYTHEON Rectifiers offer



A FULL LINE OF RECTIFIERS offering selection throughout the following ranges:

Temperature . . . -65°C to +200°C,
Average Rectified Current, I_o (150°C) . . . 200 mA to 20 Amps,
Peak Reverse Voltage . . . 50 volts to 750 volts.

There's a reliable Raytheon Rectifier for every application. Call your nearest Raytheon sales office for further information.

RAYTHEON

RAYTHEON COMPANY
SEMICONDUCTOR DIVISION

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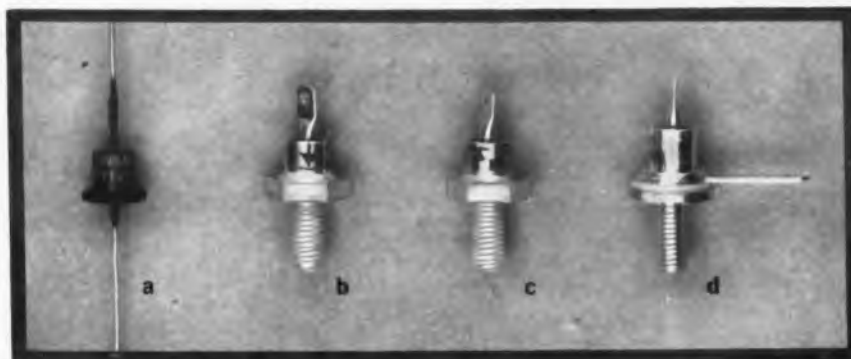
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FL 3-2769

Distributor listings continued on opposite page.

PACKAGING FLEXIBILITY

The wide variety of packaging gives you maximum flexibility in mounting techniques. Select from:

- (a) Coaxial—lead types;
- (b) Cathode to Stud;
- (c) Reverse polarity (anode to stud);
- (d) Ceramic Insulated Stud.



BIG ADVANTAGES

RAYTHEON

LOW CURRENT, COAXIAL TYPES

Description

A. Maximum forward conductance at high temperature (+175°C) Military Types* (JAN 1N538, 1N540, 1N547)

Series

1N536—1N540,
1N547, 1N1095
—1N1096

B. Extremely low leakage current. High temperature (+175°C)

1N440—1N445
1N440B—1N445B
1N1100—1N1105

C. Medium Temperature (150°C) *(125°C)

1N1487—1N1492
*1N2850—1N2864
1N599—1N606
1N599A—1N606A

D. Medium forward conductance, low temperature (100°C) *(115°C)

1N1763—1N1764
*1N1692—1N1695

MEDIUM CURRENT, STUD-MOUNTED

Description

A. High forward conductance, low leakage current, high temperature. (+165°C case temperature)

*The 1N2518—1N2523 are insulated stud types. (R) denotes availability in reverse polarity (anode to stud).

B. Medium forward conductance low leakage current, high temperature. (+150°C case temperature)

Series

1N2518*—1N2523*
1N2512(R)—1N2517(R)
1N1124(R)—1N1128(R)
1N1124A(R), 1N1126A(R)
1N1128A(R)
CK846—CK851

1N253†—1N256†

†1N253—1N256 available to JAN specifications.

HIGH CURRENT, STUD-MOUNTED

A. High forward conductance low leakage current, high temperature. (+190°C junction Temp.)

B. Medium forward conductance, low leakage current, high temperature. (+190°C junction Temp.)

1N1191A—1N1194A
1N1195—1N1198
1N248A—1N250A

1N248(R)—1N250(R)

THESE RAYTHEON DISTRIBUTORS

offer 3 Big Advantages

1. Local Stocks
2. No Price Penalty
3. Broad Rectifier Line

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BALtimore 1-1155
St. Louis
Graybar Electric Company
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University City
Olive Industrial Electronics
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Concord
Evans Radio
CAPital 5-3358

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General Radio Supply Co., Inc.
WO 4-856D (in Phila. WA 2-7037)
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Federated Purchaser Inc.
AD 8-8200

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Stack Industrial Electronics, Inc.
RA 3-6326

Buffalo
Genesee Radio & Parts Co., Inc.
TR 3-9661
Wehle Electronics Inc.
TL 4-3270

Elmira
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RE 3-6513

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RAYTHEON

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CIRCLE 79 ON READER-SERVICE CARD

CIRCLE 78 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

CASTELL

is for

Perfectionists

A layman picks up two drawing pencils and sees no difference. But the Perfectionist knows. His trained eye instantly observes the rich, crisp opaque line that stays black without flaking or feathering.

His fingers sense the low index of friction which gives him smooth, effortless strokes. He sharpens CASTELL, testing for non-crumbling, strong-textured lead and non-splintering wood. Next he tries chisel point, then needle point. He checks the perfect balance between coverage and easy erasability on paper and vellum, on Cronar and Mylar base films. When the print comes out of the machine, he examines it with a magnifying glass.

Then he knows the satisfaction that only a Perfectionist feels when he finds the perfect working tool. 20 superb degrees, 8B to 10H. Join the masters of your profession. Buy CASTELL, call your dealer today.

#9800 SG Locktite Tel-A-Grade Lead Holder with no-slip, functional grip that's kind to tired fingers ■ Bull dog clutch ■ Unique degree indicator ■ Carries 2-year guarantee ■ Castell Drawing Leads #9030, identical in grade and quality with world-famous Castell drawing pencil ■ Usable in all standard holders, but perfect for Locktite ■ Draws perfectly on all surfaces, including Cronar and Mylar base films ■ 7B to 10H, and a kaleidoscope of colors ■



A.W.FABER-CASTELL

Pencil Co., Inc., Newark 3, N. J.

Our Bicentennial year—1761-1961
200 years of uninterrupted manufacturing experience.

NEW PRODUCTS AT THE IRE SHOW

Band-Pass Filter

483

3 kc to 400 kc



Model 718 is a narrow band-pass filter covering the frequency range from 3 to 400 kc. Bandwidth is about 2.5%, 3 db down. Harmonic rejection averages about -65 db at $2f_0$ and $1/2f_0$. A panel selector switches input impedance values among 135 ohms, 600 ohms, or 100 K. Total hum and noise is less than 0.25 mv. Frequency dial accuracy is better than $\pm 1\%$ at all frequencies.

Dytronics Co., Dept. ED, 5485 N. High St., Columbus 14, Ohio.

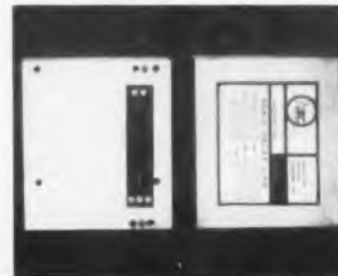
Availability: 3-week delivery.

See at Show Booth 3003.

Sonic Delays

475

With high-density storage



Sonic wire delay lines are available in both standard and custom designs. Magnetostrictive lines have delays of 5 to 10,000 μ sec and center frequencies from 500 kc to 2 mc. One-mc, fixed-length digital storage lines are also made. With high-density storage, some models have essentially zero temperature coefficient.

Computer Control Co., Inc., Dept. ED, 983 Concord St., Framingham, Mass.

See at Show Booth 3905-07.

Crystal Oscillator

466

Is highly stable



A high-precision glass crystal is used in this plug-in crystal oscillator. The 1-mc unit is said to have frequency stability of 1 part in 10^8 under

ELECTRONIC DESIGN • March 15, 1961

room ambient temperature conditions. With transistor circuitry, it is designed for use in frequency counters or as a master oscillator in frequency control systems. Available from 950 kc to 3 mc on special order.

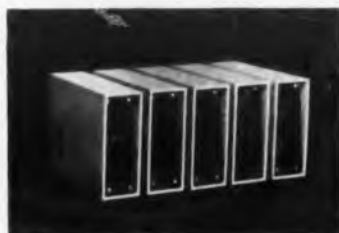
Bliley Electric Co., Dept. ED, Union Station Bldg., Erie, Pa.

Price: \$250 ea.

See at Show Booth 1318.

Digital Packages

Have 10-mc rate



Inverters, flip-flops, multivibrator and crystal clocks, pulse amplifiers and delay lines are included in this 10-mc package array. The 5000 and 6000 series units permit rapid design and construction of digital circuits and systems. Static logic is short-proof; logic levels are compatible with 500-kc and 5-mc patchcord and plug-in circuit modules.

Digital Equipment Corp., Dept. ED, Maynard, Mass.

Price & Availability: \$97 to \$173; stock.

See at Show Booth 3840.

Crystal-Can Relay

For missile applications



Rugged and reliable, the BR-12 crystal-can relay has 5-amp contacts rated for 100,000 operations at 125 C, 3-amp resistive load. The 1/2-oz relay is shock rated for 125 g, 11 msec, with vibration immunity of 30 g from 50 to 3,000 cps. Design meets requirements of MIL-R-5757D. Units are hermetically sealed, with plug-in, solder hook and 3-in. printed circuit leads, arranged for 0.200 grid. Can size is 0.875 x 0.70 x 0.400 in.

Babcock Relays, Inc., Dept. ED, 1640 Babcock Ave., Costa Mesa, Calif.

Price & Availability: \$14 to \$18 ea; 30 days.

See at Show Booth M-15.

480

MODEL 801H

a GOOD MEASURE of user benefits...

0 to 500V
INFINITE INPUT
RESISTANCE
AT NULL

UNKNOWN VOLTAGE REFERENCE VOLTAGE

NEW! 1MV FULL SCALE NULL SENSITIVITY—RECORDER OUTPUT—AUTOMATIC LIGHTED DECIMAL—IN-LINE READOUT—TAUT BAND SUSPENSION METER

precision DIFFERENTIAL DC VOLTMETER

Using the same accurate principal to find the unknown as the beam balance, the Model 801H Differential Voltmeter gives you balanced accuracy, guarantees a "good measure for your money."

Like all jf differential voltmeters, the Model 801H provides infinite input impedance at null over the entire 0-500 Volt range. This jf feature is unique on today's voltmeter market and is of prime consideration when making precise DC measurements. The source loading of 1 to 10 megohms above a nominal 10 volts, which is inherent in other differential voltmeters now available, cannot be tolerated when 0.05% or better accuracy is to be maintained.

PARTIAL 801 H SPECIFICATIONS

Voltage Ranges:	0.5, 5, 50 and 500V DC
Accuracy:	0.05% from 0.1 to 500V 0.1% or 50uv, whichever is greater, below 0.1V
Null Sensitivity Ranges:	10V, 1V, 0.1V, 0.01V and 0.001V
Maximum Meter Resolution:	5uv
Input Impedance:	Infinite at null
Dimensions:	Cabinet 9 3/4" W x 13 1/2" H x 14" D Rack 19" W x 8 3/4" H x 13 1/4" D
Weight:	Cabinet 25 lbs., Rack 28 lbs.
Price:	Cabinet \$555.00, Rack \$575.00 Prices F. O. B. factory, Seattle

Extreme accuracy and stability are achieved by advanced circuit design which incorporates a chopper stabilized null amplifier and a standard cell reference.

Write for complete specifications.

Also ask for information on the jf A-70 recorder, companion to the 801H, and the Model 803.

Prices and technical data subject to change without notice.



JOHN FLUKE MFG. CO., INC.

P. O. BOX 7161

SEATTLE 33, WASH.

CIRCLE 81 ON READER-SERVICE CARD

NEW PRODUCTS AT THE IRE SHOW

Decoder Module

467

Binary to decimal



Transistorized decoder module DC-115 uses a Beam-X switch as a binary decoder. Two models are available for conversion of 1248 or 1224 binary-coded decimal information to decimal form. Output drives a Nixie indicator tube, or can be used to activate printers or gates. Access and decoding times of less than 20 μ sec are possible.

Burroughs Corp., Electronic Tube Div., Dept. ED, Box 1226, Plainfield, N. J.

Price & Availability: \$85 ea; after March 15.

See at Show Booth 1211-15.

Power Supply

474

Rated at 30 amp



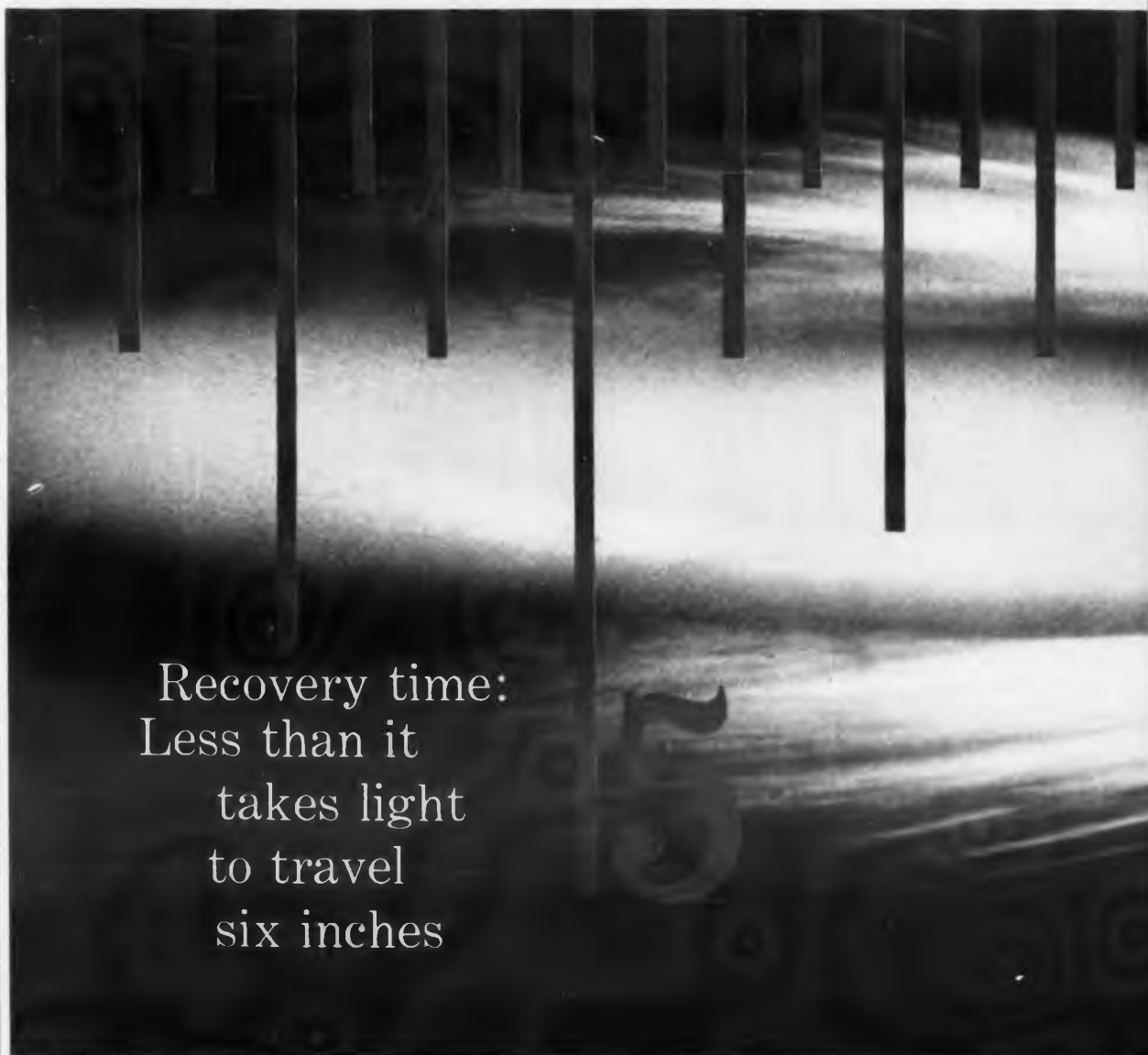
Silicon controlled rectifiers are used in model BC236-30, a voltage-regulated, 30-amp dc power supply. Voltage is adjustable from 2 to 36 v. Voltage regulation is $\pm 0.5\%$; ripple is 1% rms. The supply will deliver 50 amp for 1 min. Dimensions are 13-3/8 x 17-5/8 x 15-1/4 in.; a rack-mounting model is also available. Model BC236-30B has provision for charging lead-acid and nickel-cadmium batteries automatically.

Christie Electric Corp., Dept. ED, 3410 W. 67th St., Los Angeles 43, Calif.

Availability: Delivery from stock.

See at Show Booth 2911.

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Recovery time:
Less than it
takes light
to travel
six inches

The recovery time of the new Hughes[®] HD-5000 Diodes is guaranteed less than half a nanosecond!

These are the fastest switching devices commercially available today. They are so fast, in fact, that storage time can't even be measured.

Now computer circuits can be designed that work 10 times faster than ever before. This important speed break-through was made possible through an exclusive bonding process developed by Hughes research. The result is a low-capacity diode that solves recovery time problems.

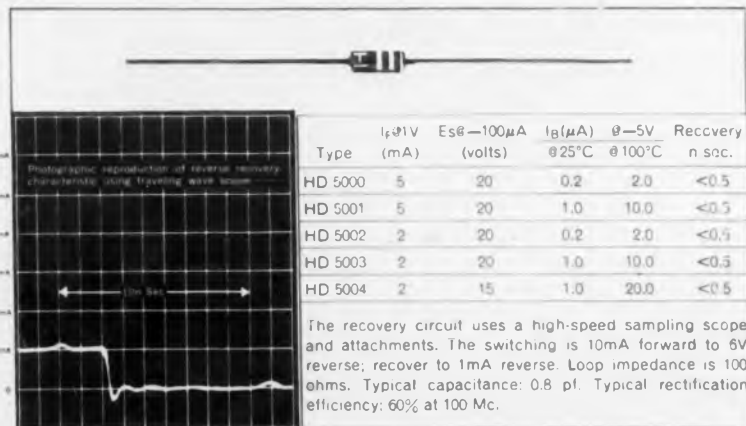


The HD-5000 diode series is available now from Hughes. Call your local Hughes Semiconductor sales engineer or distributor. Or write Hughes Semiconductor Division, Marketing Department, Newport Beach, California. For export write: Hughes International, Culver City 5, California.

CREATING A NEW WORLD WITH ELECTRONICS

HUGHES

HUGHES AIRCRAFT COMPANY
SEMICONDUCTOR DIVISION



CIRCLE 82 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

Switching Module

468

For general usage



Universal Beam-X module DC-112 has counting, distributing, multiplexing and scanning capabilities. Function is changed by reconnecting input and output terminals. The module provides direct drive for Nixie indicator tubes, printers, and other devices. It can resolve pulses at 110-kc rates. As a distributor for telemetering, controlling, gating and similar functions, two modules can commutate 20 positions, generating 2.5 ma constant current outputs at each point. The module may be used as a variable-bit word generator for test instrumentation, coding, and airborne transponder applications.

Burroughs Corp., Electronic Tube Div., Dept. ED, Box 1226, Plainfield, N. J.

Price & Availability: \$55 ea; delivery after March 15.

See at Show Booth 1211-15.

Counter Module

469

At low cost



A 1-kc decade counter module, DC-113 uses no tubes or transistors to activate succeeding decades. It is designed to directly drive Nixie indicators, printers, and other devices without need for decoders or amplifiers. Using the 50,000-hr Beam-X switch, the module provides reliable medium-speed switching particularly suited to the control field.

Burroughs Corp., Electronic Tube Div., Dept. ED, Box 1226, Plainfield, N. J.

Price & Availability: \$45 ea; March 15.

See at Show Booth 1211-15.



POWER When and Where You Need It!

NWL portable AC power supply

The portable AC power supply shown here is just the thing for hard to reach places or when the main power source is too far removed. It has numerous types of outputs and many voltages and phases offer a wide selection of power requirements. The unit can also be designed for outdoor use. Input and output are 3 ϕ , 60 to 400 cycles. Output voltages are 120, 240, and 460 in single, 2 or 3 ϕ . The portable AC power supply can also be furnished with an adjustable voltage control from 0 to full output. This unit can be built with any output to meet your requirements.

Each NWL unit is thoroughly tested and must meet all customer requirements before shipment. We shall be pleased to quote you according to your individual requirements.



Nothelfer
SAY: NO-TEL-FER

NOTHELPER WINDING LABORATORIES, INC., P. O. Box 455, Dept. ED3, Trenton, N. J.
(Specialists in custom-building)

CIRCLE 83 ON READER-SERVICE CARD

NEW PRODUCTS AT THE IRE SHOW

Digital Voltmeter

478

Is explosion-proof



Digital voltmeter model 2100, designed for critical environments, withstands 50-g shock. The waterproof meter resists salt spray and corrosive chemicals. Voltage measurement is accurate to 0.01% from 1 mv to 1 kv; polarity and ranging are automatic. Attenuator accuracy and bridge linearity accuracy are 0.003%. Common-mode noise rejection is 80 db. The meter is 5-1/2 in. wide, 11-1/4 in. high, and 14 in. deep. Input power is 25 w.

Cubic Corp., Dept. ED, 5575 Kearny Villa Road, San Diego 11, Calif.

Price: \$3,150.

See at Show Booth 3111.

10-Mc Counter-Timer

465

Is fully transistorized



A reliable, all-transistor counter-timer, model 1144A has a two-year warranty. The militarized unit is available with vertical decade panels or inline Nixie readout. Ranges are dc to 10 mc for frequency, 0.1 μ sec to 10 million sec for time interval, and 0.1 μ sec for period. Suitable for automatic programming, it may be operated remotely. Seven basic functions are selected by a front-panel switch. Sensitivity is 0.25 v rms; input impedance is 25 K per v. The counter-timer consists of 3 input channels, a decade count-down time base, and a series of plug-in, transistorized decade counting units.

Computer Measurements Co., Dept. ED, 12570 Bradley Ave., Sylmar, Calif.

Price & Availability: \$3,500; 60 to 90 days.

See at Show Booth 3226-28.



Here are sixteen standard models of BECKMAN® Size 8 & 11 Servomotors...all precision built by Helipot. You'll find complete mechanical and electrical specs in the new 24 page catalog. There are outline drawings, and Torque-Speed curves for every model...including servomotors and motor generators. For the theorist there's an added attraction; a full discussion of Electromagnetic Damping, with applicable transfer function equations.

To get the complete BECKMAN Size 8 & 11 Servomotor story at no cost, just write to us.

Beckman / **Helipot**

POTS / MOTORS / METERS

Helipot Division of
Beckman Instruments, Inc.
Fullerton, California

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CIRCLE 84 ON READER-SERVICE CARD
ELECTRONIC DESIGN • March 15, 1961

Micromodule Circuitry

Has high reliability



Encapsulated, transistorized digital and logic circuit modules in the 789 series are made with high-reliability components. Predictions of mean time before failure, at 40 C, range from 30,960 hr for a binary counter to 136,699 for the AND gate. Circuits operate at 10 mc. Modules are color-coded by function, and measure 7/16 x 1/2 x 9/16 in. Normal operating temperature range is -55 to 100 C. The 9 and 11-pin headers are suitable for dip soldering, space wiring, or welding. Encapsulant is glass epoxy or diallyl phthalate; military requirements are met.

Walkirt Co., Dept. ED, 141 W. Hazel St., Inglewood, Calif.

Price & Availability: \$70 to \$150; late March.

See at Show Booth 1824.

Card Reader

For 30 or 80 columns



A simple and reliable device for reading punched cards, the CR-100 series are useful in card-programmed control systems, data gathering systems, and other digital instrumentation. Model CR-101 reads 30 columns; model CR-102 reads 80 columns. Contact-closure output is provided at 150 v peak, 500 ma. Cards are read in one mechanical operation. Reader is virtually immune to adverse temperature, humidity, shock, and vibration effects.

Datex Corp., Dept. ED, 1307 Myrtle Ave., Monrovia, Calif.

Price & Availability: CR-101, \$695; CR-102, \$895, OEM; 60 to 90 days.

See at Show Booth 3935.

464



UP to 150 KMC at -45 VOLTS BV! WITH NEW SYLVANIA SDV-4166 EPITAXIAL SILICON VARACTOR

Through the use of epitaxial techniques, SYLVANIA has proven the practicability of manufacturing Silicon Varactors with cutoff frequencies as high as 150 KMC at a 45-volt breakdown voltage. As an indication of the significance of this Sylvania development, previously available diodes made with conventional techniques and with equivalent breakdown voltage exhibit cutoff at less than 15 KMC at -6 volts.

DIODE

Capacitance values of the new Varactors are as low as 0.15 pf at -6 volts. They are ideally suited for service as harmonic generators with exceptional power handling capabilities. Conversion efficiency in doubler circuits at L-band is approximately 70%. Units are hermetically sealed in compact Sylvania Micro-Min pack-

ages and double-ended cartridges that offer extraordinary reliability and performance at high temperature.

For the complete story on how SYLVANIA EPITAXIAL SILICON VARACTOR DIODES can help upgrade the performance of your microwave equipment, contact your Sylvania Sales Engineer now. Semiconductor Division, Sylvania Electric Products Inc., Woburn, Mass.

SYLVANIA

SUBSIDIARY OF

GENERAL TELEPHONE & ELECTRONICS



NEW PRODUCTS AT THE IRE SHOW

Signal Generator 558

Sweep 10 kc to 400 mc

Sweep widths from 10 kc to 400 mc are provided by the 900-B rf sweep signal generator. The highly stable instrument has built-in attenuator, marker generator, and scope preamplifier. Center frequency dial is accurately calibrated; output is metered.

Jerrold Electronics Corp., Dept. ED, 15th & Lehigh Ave., Philadelphia 32, Pa.

See at Show Booth 3904-06.

IF Attenuator 546

Is voltage-controlled



Series VCA voltage-controlled attenuators offer a remote means of continuously varying gain level at intermediate frequencies. With little frequency sensitivity across the bandwidth, the unit is suitable for use in coaxial systems where existing attenuation methods are inadequate in range or cause undesirable tuning effects. Standard 50-ohm models cover 30 or 60 mc, have a 1-db 30-mc bandwidth, minimum insertion loss of 1 db, and a maximum attenuation range of 50 db.

LEL Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

See at Show Booth 2106-08.

Multitracer Unit 560

Used with storage oscilloscope

An accessory for the Memoscope oscilloscope, this multitracer unit allows presentation and storage of consecutive sweeps. Sweeps on the face of the Memoscope appear at

Entirely New Diode Concept...Combinations

LAMINAR SILICON DIODE

Pacific Semiconductors, Inc. announces a new approach to the production of silicon diodes to provide performance characteristics never before possible.

The PSI Laminar process makes possible large scale production of diodes having these outstanding features:

- Great Mechanical Stability
- Ultra-Fast Recovery
- Extremely Low Capacitance
- Extremely Low Leakage
- Extremely Low Stored Charge
- High Rectification Efficiency
- Double Hermetic Seal
- 200°C. Storage Temperature

HOW IS SUCH PERFORMANCE AND GREAT MECHANICAL STABILITY POSSIBLE?

Briefly, the PSI Laminar Diode with its many layers, permits extremely low series resistance coupled with a very small junction area to provide a structure yielding

a combination of speed, conductance and capacitance never before obtainable.

The laminated silicon element is provided with a glass-like surface layer which passivates the silicon and gives the element complete moisture integrity. This thoroughly sealed element is then welded within the standard PSI package... *double hermetic sealing.*

The front contact of the PSI Laminar Diode is decisively imbedded in a gold lamination on the crystal giving the device complete and absolute protection against failure due to shock and vibration. *Front contact failure is positively eliminated!*

WHAT DIODE TYPES WILL BE AVAILABLE?

All diode types now being made from conventional mesa and planar processes. These include types ranging from high conductance core driver to ultra fast computer logic diodes.



Pacific Semicond



12955 CHADRON AVENUE, HAWTHORNE, CALIFORNIA • A SUBSIDIARY

of specs never before possible!

LAMINAR

DIODES

LAMINAR type IN3257

Forward current @ 1 volt > 30mA
Saturation voltage > 100V @ 25°C
I-20V < .025μA @ 25°C; I-50V < 25μA @ 150°C
Reverse recovery < 3 nanosec
Capacitance @ zero volts < 2mmfd
Rectification efficiency 45% @ 100mc

LAMINAR type IN3258

Forward current @ 1 volt > 100mA
Saturation voltage > 100V @ 25°C
I-20V < .025μA @ 25°C; I-50V < 25μA @ 150°C
Reverse recovery < 4 nanosec
Capacitance @ zero volts < 4mmfd
Rectification efficiency 40% @ 100mc
(Recovery test conditions switching from 10 mA forward to -6V.
Recovery to 1 mA, Lumatron recovery tester.)

LAMINAR high conductance core driver types also available.

The new PSI Laminar diodes will make possible many new approaches to high performance, high reliability circuit design. For full details phone, wire or write a PSI field office near you.

ductors, Inc.

ARY OF THOMPSON RAMO WOOLDRIDGE INC.

equal intervals, forming a raster-type display so that a number of stored sweeps can be shown simultaneously without confusion.

Signals to be compared can be stepped automatically or positioned at intervals in space and time down the face of the Memoscope.

Hughes Aircraft Co., Industrial Systems Div., Dept. ED, Florence & Teale Sts., Culver City, Calif.

Price: About \$300.

See at Show Booth 1811-17.

Complex Ratio Bridge 562

Is solid state

A complex ac ratio bridge, model CRB-4 is capable of generating and indicating the complex ratio needed to duplicate a ratio under test. A self-contained, phase-sensitive null indicator is used to show when the two ratios are equal. Models can be supplied for any fixed frequency in the range of 50 to 1,000 cps. Adjustment allows operation to $\pm 5\%$ of specified frequency.

Signal input impedance at null is greater than 20,000 meg. The rack-mounted bridge is 5-1/4 in. high, and operates from ac line or internal battery.

Gertsch Products, Inc., Dept. ED, 3715-17 S. La Cienega Blvd., Los Angeles 16, Calif.

See at Show Booth 3715-17.

Carbon Resistor 559

Rated at 1/10 w

A molded, deposited carbon resistor, rated at 1/10 w, this unit (RN-55 size per MIL-R-10509) also meets RC-07 size requirements. It can be operated at 1/10 w at 125 C. and at 1/4 w at 70 C. Maximum voltage is 200 v with a standard range of 10 ohms to 30 K. Standard tolerance of the flameproof resistor is $\pm 1\%$.

International Resistance Co., Dept. ED, 401 N. Broad St., Philadelphia 8, Pa.

Price & Availability: \$0.20, in quantity; 3 weeks.

See at Show Booth 2428-32.



NEW Plug-In Card Selects Mode of Operation



MODEL
808A

- Constant voltage or constant current operation
- Units can be combined in series and parallel
- Printed card makes all internal wiring changes
- Continuously variable output voltage and current
- No overshoot on turn-on or turn-off
- No moving parts

H-Lab Model 808A is a versatile compact constant voltage/constant current transistor power supply possessing a combination of features that make it a truly unusual and exceptional power supply. All internal wiring changes for adaptation to constant voltage, constant current, auto series, and auto parallel modes of operation are accomplished by simply inserting one of the several plug-in printed circuit cards provided with the 808A supply. The model 808A also features a continuously adjustable current limit control located on the front panel. The output current will not exceed the preset current limit value under any load conditions including a short circuit. This fast acting, adjustable protection circuit not only provides full protection for the power supply, but gives optimum protection to the load device as well.

For more stringent regulation requirements, chopper-stabilized Model 808AX is available. H-Lab Model 808A is priced at

\$475

SPECIFICATIONS

Output: 0-36 volts, 0-5 amps.

Constant Voltage or
Constant Current

Input: 105-125 VAC 50 cps

Load Regulation:

Constant Voltage
0.01% or 3.6 mv

Constant Current
0.1% or 5 ma

Ripple:

Constant Voltage 500 μ v rms

Constant Current 3 ma rms

Size: 3 $\frac{1}{2}$ " H x 16 $\frac{3}{4}$ " D x 19" W

Remote Programming • Remote Sensing
Short-Circuit Proof

OTHER PRECISE, VERSATILE AND COMPACT POWER SUPPLIES INCLUDE:

Model	E Out	I Out	Bench Model	Rack Model	Continuously Variable	Special Comments	Price
400D	150-315	0-1.5		X	No	Vacuum Tube Type	\$595.00
520A	0-36	0-20		X	Yes	High Efficiency	575.00
800A-2	0-36	0-1.5	X	X	Yes	Dual Output	580.00
800B-2	0-36	0-2.5	X	X	Yes	Low Cost Medium Current Supply	339.00
802B	0-36	0-1.5		X	Yes	Dual Output Remote Sensing	560.00
806AM	0-20	0-2.0		X	Yes	Remote Sensing Remote Programming	350.00
810A	0-50	0-7.5		X	Yes	Remote Sensing	895.00
812C	0-32	0-10		X	No	Remote Sensing	550.00
855	0-18	0-1.5	X	X	Yes	Can be connected in series or parallel	175.00
885	0-40	0-0.5	X	X	Yes	Continuously Variable Current Limit	185.00
880	0-100	0-1.0	X	X	Yes	Wide Voltage Span	375.00

Write on your letterhead for new, illustrated catalog describing the complete H-Lab line.



**HARRISON
LABORATORIES, INC.**

45 Industrial Road • Berkeley Heights, New Jersey

*TRADEMARK

See us at the IRE Show—Booth No. 1429 & 1431

CIRCLE 87 ON READER-SERVICE CARD

NEW PRODUCTS AT THE IRE SHOW

VHF Preamplifier

473

Bandwidth is 80 mc



Stable, reliable, low-noise circuitry is used in the RF52 vhf preamplifier. As an rf preamplifier, it provides sufficient gain to overcome mixer and post-amplifier noise in broadband intercept, noise-study or panoramic display receivers. Bandwidth is 80 mc, peak to peak; ripple less than 0.5 db, f_0 160 mc. Gain is 30 db, and noise figure for matched input is 5.5 db.

LEL Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

See at Show Booth 2106-08.

Controlled Rectifiers

539

Rated at 5 amp



Silicon controlled rectifiers X5RC2 through X5RC40 will switch up to 5 amp over a peak reverse voltage range of 20 to 400 v. Designed for low-power switching and control uses, they enable 1- to 5- μ sec firing with 2 to 5 ma. All units feature hermetically sealed, all-welded construction, and measure about 1.18 in. over-all.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

P&A: \$5 to \$55 ea, 1 to 99; delivery from stock.

See at Show Booth 2901-03.

Crystal Mixer

552

Range is dc to 16 Gc

Model CM-1A coaxial crystal mixer is designed to be used with the firm's series 402 wide-range receiving system. It is a shunt-type mixer for an rf source which presents a very high impedance at the local oscillator and if frequencies. Fre-



MACHINES

TALK!

over commercial telephone circuits equipped with

Rixon's sebit 24 data transceiver



Binary information is processed at 2400/1200/600 bits/sec in a nominal 3-KC voiceband such as a long distance toll circuit. Used for passing high speed data of 3000 w/m teletypes, machines and computers, slow scan TV, facsimile, time division multiplexers and sequential telemetering equipment.

- Built-in signal and test monitor
- Fully transistorized
- Fast acting automatic gain control and self-contained, variable amplitude and delay equalization
- Contains highly stable clock for synchronous detection and regeneration of received data signals
- Low error rate
- highly reliable over non-engineered circuits
- Standard rack mounting

SPECIFICATIONS AVAILABLE ON REQUEST

THE SEBIT 24 WILL BE ON DISPLAY AT OUR BOOTHS 3064-3065 IN THE MARCH IRE SHOW

RIXON

ELECTRONICS, INC.

2414 REEDIE DRIVE
SILVER SPRING, MD.
LOCKWOOD 5-4578

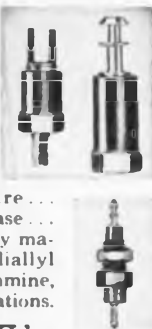
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ELECTRONIC DESIGN • March 15, 1961

Get the Facts About These Cost-Saving Terminals and Components

STANDOFF AND FEED THROUGH TERMINALS

Low cost and high electrical specs. have made these the most popular in the industry. Choice of fork, single and double turret, post... standard, miniature, sub-miniature... molded or metal base... wide variety of body materials, including diallyl phthalate and melamine, and plating combinations.



Request Catalog SFT-1

PUSHLOCK NYLON TIP JACKS



Save time and money regardless of installation method. Just push into cabinet or chassis hole and the one-piece Pushlocks align and self-anchor. Eliminate threads, nuts, lockwashers and vibration problems.

Request literature

MELAMINE JACKS

Very economical, yet designed electrically and mechanically for long, reliable service. Supplied in a wide range of code colors.

Request details



POINTER KNOBS

A military and industrial favorite by reason of price and practicability. Supplied in attractive black, satin finished phenolic.

Request details



WHITSO, INC.

9326 Byron Street, Schiller Park, Illinois
(Chicago Suburb)

CIRCLE 89 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

quency range is dc to 16 Gc. Connectors are type N.

Scientific-Atlanta, Inc., Dept. ED, 2162 Piedmont Road, N.E., Atlanta 9, Ga.
P&A: \$100; 30 days.

See at Show Booth 3936-38.

Multiturn Potentiometer

487

Have 7/8-in. OD



Type S000 multiturn potentiometers are 7/8 in. in diameter. Bushing or servo mount is available. The servo mount uses ball bearings and is built to close tolerances. Resistance element is a precision-drawn alloy wire, wound on an insulated copper core. Resistance and linearity tolerance are $\pm 5\%$, with a resistance range of 25 ohms to 250 K. Power is 3 w at 40 C, derated to zero at 125 C.

International Resistance Co., Dept. ED, 401 N. Broad St., Philadelphia 8, Pa.

Price & Availability: \$10.75 ea; 4-week delivery.

See at Show Booth 2428-32.

Temperature Controller

537

With dc heater



A proportional temperature controller, series TC-202 draws its heater power from the dc line. For missile or aircraft use, the units avoid the weight and power losses involved in dc-to-ac conversion. High-efficiency, switching-type circuitry is used throughout to hold power losses to a minimum. A steady flow of power is maintained to the load, thus holding its temperature constant. The devices are entirely solid state, and are supplied hermetically sealed and potted for military systems.

Harrel, Inc., Dept. ED, 1785 First Ave., New York 28, N.Y.

Availability: 3 to 4 weeks.

See at Show Booth 3948.

NEW HIGH IN A.C. CALIBRATION ↑ ACCURACY



MODEL TV-1

from **HOLT** / *Originators of the
AC Precision Power Source*

THERMAL TRANSFER VOLTMETER N.B.S. CERTIFIABLE

A new AC-DC transfer standard. Transfer measurement is made to a calibrated DC supply of the same voltage as the unknown AC being measured; thus eliminates ratio errors in the high frequency multiplier resistors.

Range — Three decade range multiplier. .5 volt to 1200 volts. Full resolution in 1 volt steps from 1 to 999 volts.

Frequency Response — .5 to 290 volts .02% to 50KC. 300 to 1200 volts .02% to 10KC.

Null Sensitivity — .004%/mm.

Thermocouple — DC reversal error less than .02%. Couples, plug in replaceable, at \$40.00.

Input Resistance — 143 ohm/volt.



AUDIO VOLTAGE STANDARD

MODEL AVS-321

The output is continuously variable in frequency as well as voltage so that complete information about the response of the unit or system under test may be obtained.

Range — 1 to 1000 volts RMS 35 cps to 2 KC. 1 to 300 volts RMS 35 cps to 10 KC. **Accuracy** — Regulated voltage equal to dial setting \pm (0.1% + 2 mv) From 300 to 1000 volts accuracy is \pm 0.25%.

Stability — 30 days. Long-term drift may be corrected by simple adjustment. **Internal Oscillator** — 60 cps, 400 cps or 1000 cps.

Wave Form — **Sinusoidal**: The unit is driven by a low distortion sine wave oscillator. Distortion added by the AVS-321 is less than .1% in the mid band rising to a max. of 0.15%.

For further details write to

HOLT / INSTRUMENT LABORATORIES

OCONTO, WISCONSIN

CIRCLE 90 ON READER-SERVICE CARD

NEW PRODUCTS

AT THE IRE SHOW

IF Amplifier

545

For noise-figure tests



The LA series of laboratory amplifiers, useful in noise-figure testing or general usage, have a gain of 60 or 120 db. Detected output level is indicated on a front-panel meter. Video output and 3-db attenuation are provided, along with coarse and fine gain controls. Bandwidth is 2 or 10 mc; f_o is 30 or 60 mc, noise figure 1.5 db at 30 mc.

LEL Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

See at Show Booth 2106-08.

Silicon Transistors

555

Are stud-mounted

Stud-mounted silicon power transistors 2N1894 through 2N1898 are electrically equal, respectively, to 2N389, 2N424, 2N1660, 2N1661 and 2N1662. The units use standard stud-mounted hardware and mount through a single bolt. Double-ended construction facilitates heat-sinking in multiple assemblies. Ambient temperature range is -65 to $+200$ C.

Raytheon Co., Semiconductor Div., Dept. ED, 200 First Ave., Needham, Mass.

P&A: \$24 to \$60, quantities of 100 to 999; from stock.

See at Show Booth 2613.

Lighted Push-Button

561

Rated at 10 amp

A panel-light indicator combined with a double-pole switch module, the 04-111220 is 7/8 in. square by 3-1/16 in. long. Miniature lamps project light through colored filters onto the display screen, in up to four colors, for a visual indication



*in
50 years...
over
3,500,000,000
capacitors*

For over fifty years, Cornell-Dubilier has specialized in the design, production and distribution of capacitors. William Dubilier is regarded throughout the world as the "Father of the Capacitor Industry." From a modest beginning in 1910, CDE has continued as the leader in this important phase of electronic components pioneering.

Today the many vast and widespread facilities of CDE provide a single source of unmatched capacitor technology. There are more CDE capacitors in use today than any other make—every conceivable known type, style and class—fabricated and sold by CDE in every part of the world.

Designs still unborn are being conceived and developed in CDE's Research Center... particularly "High Reliability" components for the most advanced applications of the Electronics Age.

Be it ceramics, mica, electrolytics, tantalum, film, paper, metalized or types yet unknown, CDE can be depended upon to meet the needs of the Electronics Industry... today and in the future.

CDE also produces relays, semiconductors, filters, delay lines, pulse networks, packaged circuits and systems, test instruments, vibrators and converters, and antenna rotors... all allied electronic devices frequently associated with capacitor technology.

When you have been around for 50 years there are reasons... uncompromising quality of materials, meticulous care in production, exhaustive testing and a compelling "Urge to Serve."

Look to CDE every time you look for Capacitors. Cornell-Dubilier Electronics Division, Federal Pacific Electric Company, 50 Paris Street, Newark 1, N. J.

SEE YOU AT THE IRE SHOW! BOOTHS 2721-25



highly reliable electronic components and systems

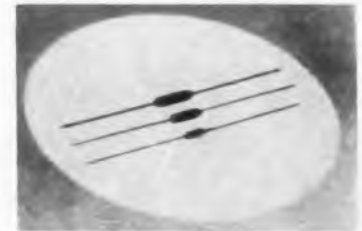
of circuit conditions. The screen is pushed to actuate a pair of switches, each rated at 5 amp, 30 v dc, 2 circuits, or one 10-amp circuit. Mechanical life of the switches is in excess of 20 million cycles.

Illinois Tool Works, Licon Div., Dept. ED, 6606 W. Dakin St., Chicago 34, Ill.

See at Show Booth 1506.

Coated Resistors 540

In 1/8- and 1/4-w sizes



Epoxy-coated deposited-carbon resistors, in 1/8-w and 1/4-w sizes, extend the M-coat line of precision resistors. Values are 10 ohms to 499 K for the 1/8 w, and 10 ohms to 2 meg for the 1/4 w. Temperature coefficient is -55 to 150 C. The resistance element is a carbon film deposited on a ceramic body and terminated with silver. The devices withstand 30 cycles of MIL moisture testing.

International Resistance Co., Dept. ED, 401 N. Broad St., Philadelphia 8, Pa.

Price & Availability: \$0.13 up; 3-week delivery.

See at Show Booth 2428-32.

Isolation Amplifier 553

Is all-transistorized

Model SIA-1 synchro isolation amplifier is an all-transistorized, high-input impedance feedback power amplifier which permits the operation of as many as 10 indicators from one synchro transmitter. Accuracy, using size 23 torque receivers at 1 to 1 ratio, is ± 1 deg; with 36 to 1 ratio indicators, the system accuracy is ± 0.03 deg.

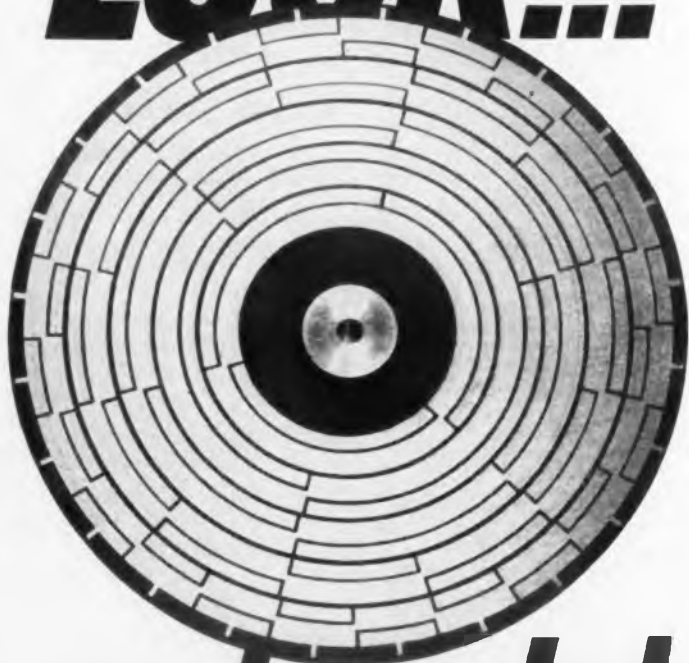
Scientific-Atlanta, Inc., Dept. ED, 2162 Piedmont Road, N.E., Atlanta, Ga.

P&A: \$350; 60 days.

See at Show Booth 3936-38.

◀ CIRCLE 92 ON READER-SERVICE CARD

LOOK...



no hands!

This printed circuit disc is the "face" of a clock that tells time in digital code

... or any code your computer, control system, or data processing device needs to keep it properly in touch with the world of real time.—A. W. Haydon is a company of infinite variation when it comes to such analog-to-digital converters, or "binary encoders". Time periods range from seconds to weeks. Sizes range from miniature to large. They come sealed, enclosed or open, with AC, DC, or pulse drive, and with an imposing variety of accessory equipment.—The model shown is for commercial use. It provides a discrete signal for each two-minute interval over a 28-day period. It is used, among other places, in an automatic parking lot ticket computing system.—This and several other time code generators are described in Technical Brochure SP9-2. It's yours for the asking. Similar solid-state devices can be supplied by our Culver City, Calif., facility.



AWH **HAYDON**
THE **COMPANY**

227 North Elm Street, Waterbury 20, Connecticut

CIRCLE 93 ON READER-SERVICE CARD

NEW PRODUCTS AT THE IRE SHOW

Static Inverter 557

Output is 2,500 w

Static inverter model 433S converts battery power to three-phase, 400-cps power. Construction is all silicon semiconductors and temperature range is -20 to $+54$ C. Voltage regulation is $\pm 0.75\%$; frequency regulation is $\pm 0.5\%$. An output of 2,500 w is achieved with no moving parts.

Varo Manufacturing Co., Inc., Dept. ED, 2201 Walnut St., Garland, Tex.

See at Show Booth 1733.

Inverter-Converter 556

Output is 750 w

Model 4318 inverter-converter converts missile dc power to eight dc and ac outputs. Output is 750 w with voltage regulation of $\pm 10\%$. Noise and ripple on dc outputs is

less than 5%. Package size is 12.4 x 7.9 x 4.3 in. Weight is less than 20 lb. Fluoro-chemical cooling is used for minimum size and weight.

Varo Manufacturing Co., Inc., Dept. ED, 2201 Walnut St., Garland, Tex.

See at Show Booth 1733.

Power Supply 534

Has dual range



Model 1046 MA capacitor-discharge power supply is designed to provide extremely critical watt-sec-

DON'T MISS THIS



**Miniaturized
1-MC PRECISION
CRYSTAL OSCILLATOR**
with transistorized,
proportional-controlled oven

see it at I.R.E. Show
BOOTH 1439

REEVES-HOFFMAN
DIVISION OF DYNAMICS CORPORATION OF AMERICA
CARLISLE, PENNSYLVANIA

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ond, de stored energy for precision metal-to-metal joining applications such as: strain gage assembly; deposited film bonding; and electronic circuitry junctions. Dual-range permits a capacity of 0.004 to 1.3 w/sec and a high range of 0.004 to 1.3 w/sec. Max repetition rate is 50 welds per min at maximum discharge; 150 welds per min at minimum discharge.

Unitek Corp., Weldmatic Div., Dept. ED, 950 Royal Oaks Drive, Monrovia, Calif.

See at Show Booth 4527.

Bolometer Detector 551

Range is 1 mc to 1 Gc

Model BD-1 coaxial bolometer detector mount is a miniaturized coaxial component for broadband detection of rf power. Usable frequency range is 1 mc to 1 Gc.

Scientific-Atlanta, Inc., Dept. ED.

2162 Piedmont Road, N.E., Atlanta, Ga.

P&A: 560; 30 days.

See at Show Booth 3936-38.

RF Amplifier 547

Bandwidth is 100 mc



The 1F50 rf amplifier covers a bandwidth of 100 mc at 150-mc center frequency. It is suitable for use in fast-pulse radar systems, countermeasures, intercept equipment and radio astronomy applications.

LEL Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

See at Show Booth 2106-08.



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at IRE SHOW

BOOTHS 3702-4-6

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New Signal Generator 144H has exceptional frequency coverage and electronic calibrated incremental frequency control—a popular feature borrowed from our 1066 series FM generators. The highly accurate level monitoring is by protected thermocouple which cannot be overloaded. A full-view dial, ALC and two crystal checks contribute to accuracy and ease of use.

Freq: 10Kc to 72Mc; 8 bands
Stability: .002% /10 minutes
Output: .1 μ V to 2V \pm .5db. ALC
 Δ f: calibrated, .01 to 1% of f_c
AM: 0-80%, 20cps to 20Kc \pm 1db
Price: \$1190



1/4% LCR BRIDGE MODEL 1313

This new Universal Bridge adds to the wide variety from which an engineer must choose. But Model 1313 has both 1/4% accuracy and direct readout; combines exceptional discrimination with ease of use. Detector AGC, variable frequency of operation, functional styling are all plus features.

L: 1 μ H to 110H, 7 decades
C: 1 μ F to 110 μ F, 7 decades
R: .01 Ω to 110M Ω , 8 Decades
Accuracy: 1/4%
Discrimination: 5000 div'ns / Decade
Frequency: 1Kc, 10 Kc, 100 cps to 20Kc with ext. osc.
Readout: Direct—no multiplying factors



Make no Mistake—Measure with MARCONI 1313.

MISSILE COMMAND SIG GEN MODEL 1066B/2

Marconi 1066 series FM signal generators are in use wherever FM equipment is designed or maintained. Because it was designed for this specific job, new 1066B/2 precisely meets requirements for aligning Range Command Receivers. It has freq. accuracy .01%, wide deviation, handles 100Kc modulation with multiple tones, and measures peak deviations.

Frequency: 400-550 Mc
Accuracy: .01% at 1Mc points
Output: .1 μ V to 1V into 52 Ω
FM: 0-300Kc
 Δ f: Frequency calibrated, 0-100Kc
Mod. Freq. 100cps—100Kc



MARCONI
INSTRUMENTS



111 CEDAR LANE • ENGLEWOOD, NEW JERSEY

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NEW PRODUCTS AT THE IRE SHOW

Printed-Circuit Connector

455

Is right-angle type



Series WC right-angle printed circuit connectors employ either a removable crimp-type receptacle or a dual-terminal receptacle that accepts taper pins. Both mate with standard W series plugs that contain right-angle pin contacts for dip-soldering to printed-circuit boards.

Winchester Electronics Inc., Dept. ED, Willard Road, Norwalk, Conn.

See at Show Booth 2121-23.

VHF Preamplifier

456

Bandwidth is 80 mc



Stable, reliable, low-noise circuitry is used in the RF52 vhf preamplifier. As an rf preamplifier, it provides sufficient gain to overcome mixer and post-amplifier noise in broadband intercept, noise-study or panoramic display receivers. Bandwidth is 80 mc, peak to peak; ripple less than 0.5 db, f_0 160 mc. Gain is 30 db, and noise figure for matched input is 5.5 db.

LEL Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

See at Show Booth 2106-08.

Resistive Networks

554

For dc to 500 mc

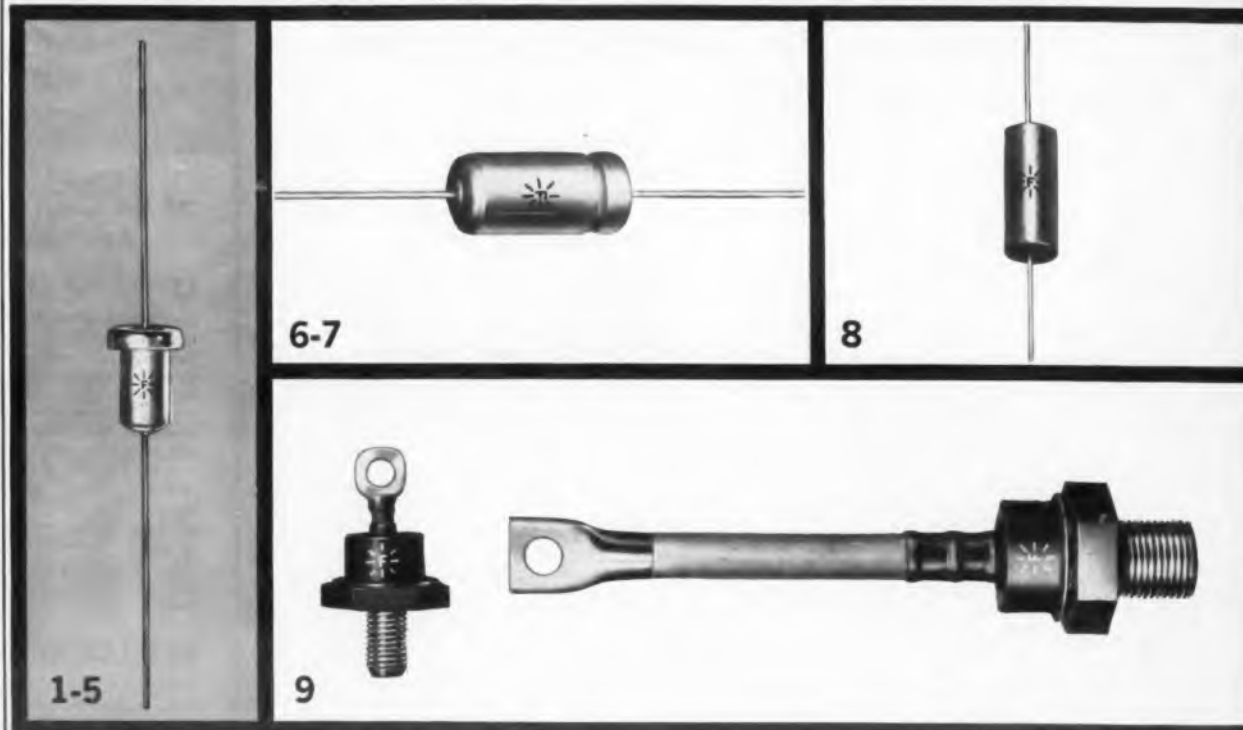
Series RN coaxial resistive networks are designed for impedance matching, attenuation or line termination. Frequency range is dc to 500 mc. Connectors are type BNC.

Scientific-Atlanta, Inc., Dept. ED, 2162 Piedmont Road, N.E., Atlanta 9, Ga.

Price: \$6 to \$12.

See at Show Booth 3936-38.

FANSTEEL HIGH RELIABILITY



FANSTEEL TANTALUM CAPACITORS

In 1949, Fansteel introduced the first commercially available miniature, porous tantalum electrolytic capacitor. This capacitor was the result of more than 25 years of research into the film forming properties of tantalum and techniques for refining and fabricating the metal. Today, Fansteel's complete line of tantalum capacitors includes, in addition to the original PP type (with improved shock and vibration resistant properties), high temperature tantalum capacitors, pre-tested capacitors with certified reliability and solid tantalum types. From this broad line, it is possible to select a capacitor to meet virtually every requirement.

1. GOLD-CAP® TANTALUM CAPACITORS

Pre-tested for reliability with test results certified in writing. Gold-Cap Tantalum Capacitors are available in a wide range of ratings— $2 \mu f$ to $330 \mu f$ —6V to 100V (-55° up to $+125^\circ C$) and are supplied with a standard tolerance rating of $\pm 10\%$.

2. PP TANTALUM CAPACITORS

Most widely used of all tantalum electrolytic capacitors. Meets MIL-C-3965B for vibration Grade 3 capacitors. Excellent low temperature characteristics—operating range -55° to $+85^\circ C$ at full rated voltage. Fansteel PP Tantalum Capacitors have outstanding frequency stability, negligible electrical leakage and are shock and vibration resistant. Capacity tolerance of $\pm 10\%$ is standard for Grade 1 PP capacitors.

3. HP TANTALUM CAPACITORS

For high temperature applications. Fansteel HP Tantalum Capacitors offer reliability and unexcelled stability over a -55° to $+125^\circ C$ ambient temperature range. In addition, HP types are able to withstand severe vibration and impact shock. Grade 1 HP capacitors have a standard capacity tolerance of $\pm 10\%$.

4. All types of CL-44 and CL-45, conforming to MIL-C-3965B, are also available.

5. BLU-CAP® TANTALUM CAPACITORS

These economical units are designed to bring the benefits of tantalum capacitors to any commercial or military application where wider capacity tolerances (-15% , $+75\%$) are permissible.

6. SP TANTALUM CAPACITORS

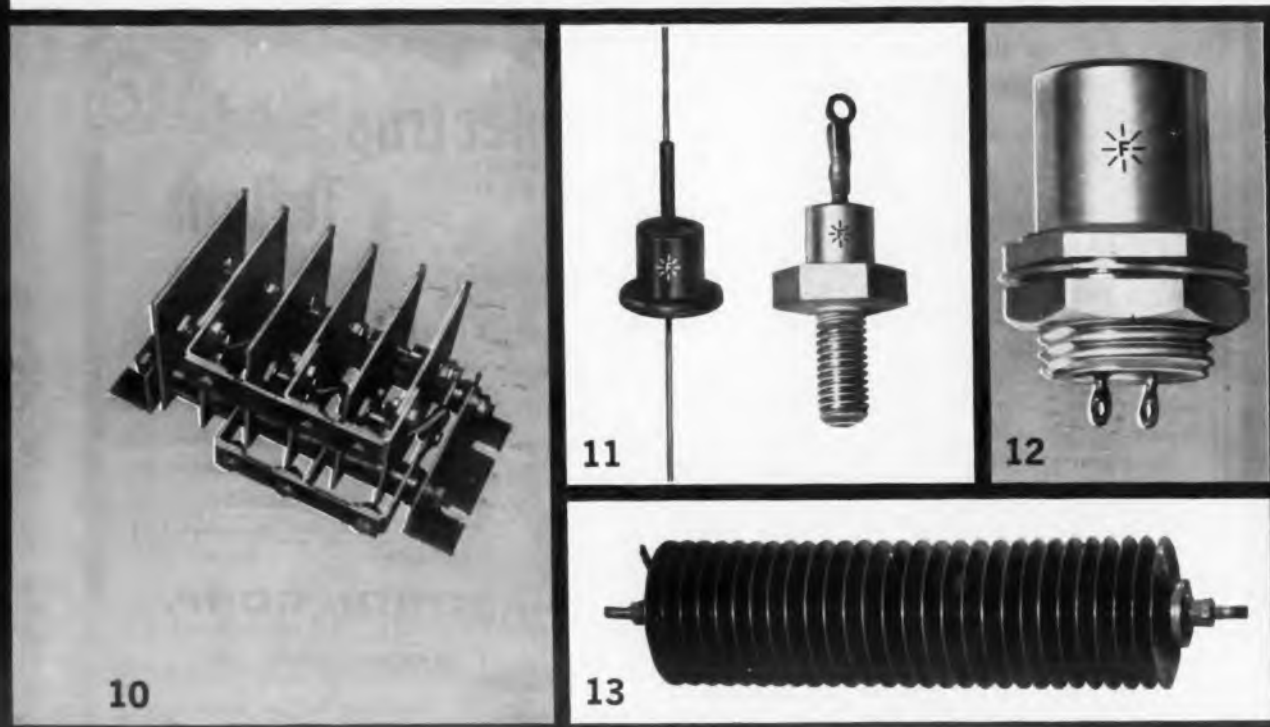
Fansteel SP Tantalum Electrolytic Capacitors offer same capacity ratings as the PP with the advantage of cylindrical cases.

7. All types of CL-64 and CL-65, conforming to MIL-C-3965B, are also available.

8. STA SOLID TANTALUM CAPACITORS

Unsurpassed performance reliability at operating temperatures up to $125^\circ C$. Hermetically sealed case affords full protection against the various environments encountered in use. A wide variety of ratings, consolidated

ELECTRONIC COMPONENTS



into four convenient sizes, cover the most complete line of solid tantalum capacitors available. Built to meet requirements of MIL-C-26655A.

FANSTEEL RECTIFIERS

Fansteel has been actively engaged in the development, engineering and production of dependable rectifiers since 1924, when Balkite Tantalum Rectifiers were introduced. As early as 1932, Fansteel conducted exploratory research work in selenium, as well as other types of metallic rectifiers. This extensive background has enabled Fansteel to continually broaden its line of rectifiers, offering designers and industrial users a full line of highly reliable components.

9. SILICON POWER RECTIFIER CELLS

Available in 20, 35, 50, 70, 160 and 240 Ampere Ratings.

10. SILICON RECTIFIER STACKS

These units provide a highly reliable d-c source for a wide range of power applications. Normally supplied in a single phase center tap, single phase bridge or three phase bridge configurations. Special assemblies can be built to specifications. (Unit illustrated has output rating of 700 volts at 147 kw.).

*Trade Mark
0312-101



Fansteel Metallurgical Corporation, North Chicago, Illinois, U.S.A.

WHERE RELIABILITY DICTATES STANDARDS

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11. NEW! FANSTEEL SILICON ZENER VOLTAGE REGULATOR CELLS

- 1- and 10-watt power dissipation ratings
- Designed and process-selected to give sharp Zener characteristics and low dynamic resistance over entire operating current range
- Hermetically sealed
- All-welded, shock-proof cell

12. NEW! SILICON ZENER VOLTAGE REFERENCE ELEMENTS

- For applications from -55°C to $+165^{\circ}\text{C}$
- High voltage stability
- Rugged construction

13. SELENIUM RECTIFIER STACKS

Practically unlimited life with no maintenance—instantaneous power with negligible leakage. Over 400,000 different stack combinations readily available in a broad range of power ratings. Selenium is still a practical semiconductor used by many designers where peak reverse voltages are troublesome.

Get more information on these new Fansteel Zener Diodes and other Fansteel components at the IRE Show. Visit us in Booth 4021-4022.

Static Inverter

533

Frequency is 400 cps $\pm 0.1\%$



Static inverter model 4333 converts 28 v dc to 400-cps power. Frequency is maintained at 400 cps $\pm 0.1\%$. Output voltage is regulated to 26 v ac $\pm 1\%$. Weight is less than 3 lb; size is 6.1 x 2.9 x 1.6 in.

Varo Manufacturing Co., Inc., Dept. ED, 2201 Walnut St., Garland, Tex.

See at Show Booth 1733.

Cathode-Ray Tubes

549

Two types

Type SC-3016 is a flat-face crt, 1-1/8 in. in diam, with low-power heater, electrostatic focus and deflection and has an over-all length of 6-in. The electron gun employs a 1.5-v, 140-ma heater-cathode assembly. Type SC-3042 is a flat-face, 5-in., high resolution crt with electrostatic deflection and focus. Designed as a mono-accelerator, it is for applications where line widths less than 0.010-in. are required.

Sylvania Electric Products, Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.

See at Show Booth 2322-32 and 2415-25.

AC-DC Relay

548

With 15-amp contacts



Designed for stability of adjustment, long life, and reliability, this ac-dc power relay has heavy-duty, silver-alloy contacts rated at 15 amp. It may be supplied spdt or dpdt, for ac and dc operation. Voltage is 6, 12, 24, and 115 v. Over-all dimensions are 1-15/32 x 1-7/8 x 1-5/32.

Magnecraft Electric Co., Dept. ED, 3350D W. Grand Ave., Chicago 51, Ill.

Price: \$5.90 to \$6.40 ea.

See at Show Booth 2513.

105

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Package semiconductors, re-
sistors, switches, relays, etc.

- Printed or decorated up to 4 colors on crystal clear, transparent or opaque colors
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NEW PRODUCTS AT THE IRE SHOW

Tube Components

457

Are glass-bonded mica



Wire assemblies, grid assemblies, deflection plates and other custom-molded functional tube members are made from metalized Mykroy 789, a glass-bonded synthetic mica. The material has a maximum temperature of 810 F continuous, with less than 3 mils distortion, and will not out-gas. Because of its high surface and volume resistivity, the material is suitable for tube bases and sockets.

Electronic Mechanics, Inc., Dept. ED, 101 Clifton Blvd., Clifton, N.J.

See at Show Booth 4201.

Silicon Rectifiers

538

Rated at 1.8 amp



Rectified dc output currents up to 1.8 amp per cell, along with reverse leakage of 500 μ a at rated piv at 150 C, are available in a diffused-junction top-hat rectifier series. Types X10B1 through X10B6 operate over a peak reverse voltage range from 100 to 600 v. Forward voltage drop is 1.10 v max at rated current at 25 C; surge capability is 40 amp peak at 0.01 sec. Operating temperature range is -65 to 175 C.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

P&A: \$0.50 to \$1.50 ea, 1 to 99; stock.

See at Show Booth 2901-03.

Coaxial Rotary Joint

550

Range is dc to 16 Gc

Model RJ 2 coaxial rotary joint is designed for both low- and high-speed continuous rotary mo-

breakthrough! electroplated Teflon*

Revolutionary new process offers:

- Full range of electroformable metals
- Unlimited variety of Teflon shapes
- No loss of Teflon's electrical properties
- Completely solderable platings
- Hermetic seal without adhesives
- Many new design possibilities

*DuPont Trade Mark

Inquire:

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417 BRUCKNER BLVD., NEW YORK 54, N. Y.

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MODEL
200AB

PRICE
\$449.00



- ⊙ 2° absolute accuracy
- ⊙ Readings not affected by noise and harmonics
- ⊙ Frequency range 15 CPS - 30KC
- ⊙ Accuracy to .01 degree with simple circuit techniques
- ⊙ High sensitivity on input & reference channels
- ⊙ Can measure in-phase & quadrature voltage component

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March 20-23, 1961

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2 to 12 positions!



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3 Walcott Ave., Lawrence 21, Mass.

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WANT THE "IMPOSSIBLE" IN ELECTRONIC PARTS OF METAL TUBING?



Look how H&H is meeting the 'most unheard-of demands for a large electronic tube manufacturer! The parts, pictured above, are volume produced to tolerances up to $\pm .0005$ in. with wall thicknesses of .005 in.! We form, not machine, to meet rigid specs more closely, cut costs to the bone. We can produce in Kovar, Rodar, No. 42 Alloy, A-nickel, stainless steel, Beryllium, copper, practically any metal you need! Write for literature, or send blueprint with quantities desired.

Write, too, for information on any small metal tubular part . . . from .01 in. to 1/2 in., of any commercial alloy for any application. Just send sketch or blueprint of part you need.



H & H MACHINE COMPANY, INC.

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Specialists in the design, tooling and fabrication of small tubular metal parts

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tion between coaxial transmission lines. Specifications are: frequency range, dc to 16 Gc; nominal impedance, 50 ohms; max vswr, 1.15 to 1 to 10 Gc, 1.60 to 1 to 16 Gc; insertion loss, less than 0.1 db.

Scientific-Atlanta, Inc., Dept. ED, 2162 Piedmont Road, N.E., Atlanta 9, Ga.

Price: \$125.

See at Show Booth 3936-38.

Amplifier-Converter

462

Noise figure is 6 db



The RF-51 is an rf-if assembly comprising a broadband vhf amplifier and a converter to if, with coaxial if output. Used with separate local oscillator, the RF51 is useful as a receiver front end for countermeasures, radio astronomy or noise-survey purposes. Typical specifications are: f_o , 300 mc, rf bandwidth, 70 mc ± 1 db; if output frequency, 70 mc; if bandwidth, 3 mc, and overall noise figure, 6 db.

LEL Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

See at Show Booth 2106-08.

Dynamic Analyzer

470

For power supplies



Power supply analyzer PSA-100 measures static and dynamic output regulation and impedance of regulated and unregulated power supplies. Impedance may be measured at frequencies from 1/2 cps to 150 kc. Testing of power supplies can be performed from 28 v dc to 250 v dc. Completely isolated, the unit may be used to test positive or negative supplies.

Telecomputing Corp., Dept. ED, 915 N. Citrus Ave., Los Angeles, Calif.

See at Show Booth 2126.

In RF Connectors

GREMAR

superiority can be

demonstrated on 3 counts!



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*Q. E. D. = *Quod erat demonstrandum*
(what was to be proved)

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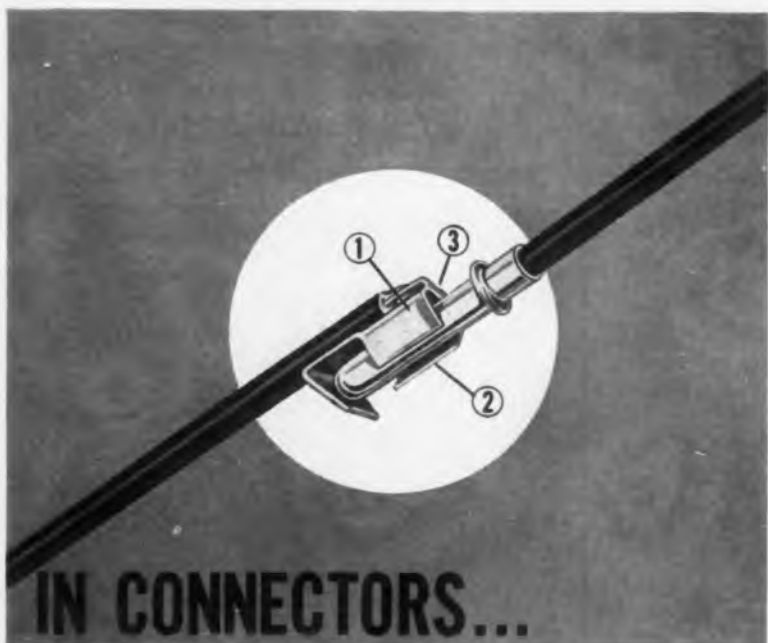
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MANUFACTURING COMPANY, INC.

RELIABILITY THROUGH QUALITY CONTROL

Dept. B Wakefield, Mass. CRystal 9-4580

See us at Booth #2811 IRE Show
CIRCLE 104 ON READER-SERVICE CARD



IN CONNECTORS...

**it's the
CONTACT
that counts!**

3 positive contact surfaces on each Alden top-connected contact give you:

- More reliable electrical contact
- More secure mechanical grip
- Minimum electrical resistance

Each lead has individual strain relief because wire is doubled back through contact tab. Punch press contact design permits rapid heat transfer — eliminates unreliable cold solder joints as in screw machine contacts. Danger of insulation pull back is eliminated by bringing wire insulation right into molded clip pocket.

These unique Alden molding techniques in connector design drastically reduce the number of parts required and make possible multi-contact connectors of amazing basic simplicity and reliability.

Resilient Alden contacts can be included in any type of molded insulation for any combination of contacts. Hundreds of standard off-the-shelf designs are quickly available — with or without leads — or as part of unit-molded cables.

Our Customer Department will work closely with you on any connecting or cabling problems. A letter with description or sketch will enable us to provide recommendations or samples at once.



New, flameproof, high voltage connectors now available in high-density, flame-retardant polyethylene. Light, compact connectors for applications up to 30 KVDC and up to 250° F without distortion.



First major advance in connector reliability since potting offers fool-proof, tamper-proof connections for trouble-free operation. Alden "IMI" connectors and cables (wires, contacts, or other inserts) are integrally molded in a single hot shot of insulation so that material forming the connectors and covering the wires forms a single continuous, bonded insulation.



Standard assembled connectors in non-interchangeable layouts with from 2 to 11 contacts; miniature connectors, plain or shielded, for carrying power or signal; miniature plugs and sockets; signal connectors; and CRT connectors are all available for fast delivery.

ALDEN

PRODUCTS COMPANY
3139 North Main St., Brockton, Mass.

See you at Booths 1613 and 1615

CIRCLE 105 ON READER-SERVICE CARD

NEW PRODUCTS AT THE IRE SHOW

Coil Winder

370

For toroidal TV coils



The model TVW winds TV vertical deflection coils toroidally. A two-section core is mounted on separate holding fixtures with a common arbor, ensuring positive symmetry of cosine winding. Wire range is 25 to 29, standard. Up to 12 layers may be wound. The width of layers is independently adjustable from 8 to 120 deg. Winding speed is 0 to 600 rpm.

Universal Manufacturing Co., Inc., Dept. ED, 1168 Grove St., Irvington 11, N.J.

See at Show Booth 4004-05.

4PDT Relay

399

Rated at 10 amp



The Type H 4pdt, 10-amp miniature relay is made to operate under extreme environmental conditions. Rating is at 26.5 v dc, resistive. Rotary armature has glass-coated cylindrical contact actuators. Operating voltages range from 1.2 to 190 v dc; coil resistance, from 1 to 8,750 ohms. Operating temperature is -65 to 125 C. The relay withstands vibration of 30 g to 2 kc and shock to 50 g. An ac version operates at 115 v, 60 to 400 cps. A variety of mounting styles is available.

Westinghouse Air Brake Co., Union Switch & Signal Div., Dept. ED, Pittsburgh 18, Pa.

See at Show Booth 2122-24.

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CIRCLE 120 ON READER-SERVICE CARD ➤

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SMALL WONDERS



THE ONLY COMPLETE LINE OF MICROMINIATURE RELAYS FEATURING BALANCED ROTARY ARMATURE CONSTRUCTION

The continual research and development efforts of Hi-G in advanced relay design is evidenced in the line of microminiature relays shown above. This is the **only complete** line of microminiature relays incorporating balanced armature construction, proven the best approach for resistance to extremes of vibration and shock, exceeding all present military specifications. When thinking **small** becomes a **big** problem, call Hi-G. See reverse side for relay specifications.

Hi-G
INC.
WINDSOR LOCKS, CONN

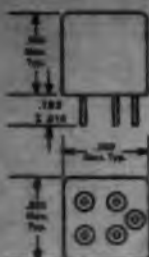
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THE ONLY COMPLETE LINE OF BALANCED ROTARY RELAYS

MICROMINIATURE



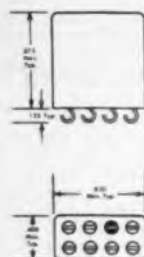
C
SERIES
1PDT
DC (Type 1C)



Contacts: 1 ampere resistive at 32VDC
Sensitivity: 100 to 500MW
Terminals: Hook, Plug-In, 1.5" and 3" leads
Mounting: Bracket, Strap, Stud



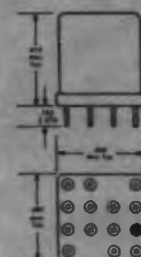
B
SERIES
1 or 2PDT
DC (Type B)
AC (Type BR)



Contacts: 2 amperes resistive at 32VDC
Sensitivity: 300MW at pull-in at 25°C, 2PDT,
or 150MW, 1PDT
Terminals: Hook, Plug-In, 1.5" and 3" leads
Mounting: Bracket, Strap, Stud



4B
SERIES
4PDT
DC (Type 4B)
AC (Type 4BR)

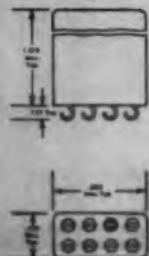


Contacts: 2 amperes resistive at 32VDC
Sensitivity: 400 to 700MW
Terminals: Hook, Plug-In, 1.5" and 3" leads
Mounting: Bracket, Strap, Stud

SENSITIVE



BC
SERIES
1 or 2PDT
SENSITIVE
DC (Type BC)
AC (Type BCR)



Contacts: 2 amperes resistive at 32VDC
Sensitivity: 40MW std. at pull-in at 25°C, 2PDT,
or 25MW for 1PDT
Terminals: Hook, Plug-In, 1.5" and 3" leads
Mounting: Bracket, Strap, Stud



LBC
SERIES
1 or 2PDT
SENSITIVE
LATCH
DC (Type LBC)



Contacts: 2 amperes resistive at 32VDC
Sensitivity: 40MW std. at pull-in at 25°C, 2PDT,
or 25MW, 1PDT
Terminals: Hook, Plug-In, 1.5" and 3" leads
Mounting: Bracket, Strap, Stud



LB
SERIES
1 or 2PDT
LATCH
DC (Type LB)



Contacts: 2 amperes resistive at 32VDC
Sensitivity: 300MW at pull-in at 25°C, 2PDT,
or 150MW, 1PDT
Terminals: Hook, Plug-In, 1.5" and 3" leads
Mounting: Bracket, Strap, Stud

Hi-G INC., BRADLEY FIELD, WINDSOR LOCKS, CONNECTICUT



Printed in U.S.A.

Oscilloscope

649

With 0.2-nsec rise time

The model 707 oscilloscope has both single-transient and repetitive signal capabilities. Rise time is 0.2 nsec; bandwidth is dc to 2 Gc. Repetition rate is 100 kc. The unit features an illuminated, parallax-free reticle, high sensitivity, and ease of operation. Accessories include camera system, spark gaps, and photoflash equipment.

Edgerton, Germeshausen & Grier, Inc., Dept. ED, 160 Brookline Ave., Boston 15, Mass.

See at Show Booth 3244.

Microminiature Relay 630

1s dpdt



Applicable military specifications are met or exceeded by this dpdt microminiature relay. Contact specification is 2 amp dc at 26-1/2 v with a maximum ambient of 125 C. A variety of headers and mountings is available. The sealed relay measures 0.800 x 0.875 x 0.400 in. Weight does not exceed 0.4 oz.

Guardian Electric Manufacturing Co., Inc., Dept. ED, 1550 W. Carroll Ave., Chicago 7, Ill.

See at Show Booth 2502-04.

Magnet Wire

373

For high temperature use

Type ML magnet wire is rated for 180 C service or better; tests have shown a life in excess of 10,000 hr at 240 C. Cut-through resistance is in excess of 400 C. Dielectric strength is 3,400 v per mil dry and 1,900 v per mil wet. It is available in AWG sizes 20 through 44.

Tensolite Insulated Wire Co., Inc., Dept. ED, W. Main St., Tarrytown, N.Y.

See at Show Booth 4330.

CIRCLE 107 ON READER-SERVICE CARD ►

◀ CIRCLE 120 ON READER-SERVICE CARD



We Can Make Precision Ceramic-to-Metal Assemblies for Your Stock or Special Requirements

Or your right is a specialized ceramic-to-metal assembly that we make in small quantity. This vacuum tight assembly includes several thicknesses of metal, two sizes of ceramic envelopes, brazed together with close dimensional tolerances.

On your left are some of our stock terminal insulators. They are made in large runs for economical, off-the-shelf delivery. We also have customers who require large runs of ceramic-to-metal assemblies to meet their own production demands.

Coors furnishes either metalized ceramic parts ready for brazing by the customer, or complete ceramic-to-metal assemblies in sizes up to 10" OD by 12" length. High temperature subsequent brazes can be made up to 1500° F. Braze bond strengths are from 9,000 to 12,000 PSI. Coors offers a variety of alumina or beryllia ceramic materials for use in your metalized assemblies.

If you need ceramic-to-metal assemblies, in quantity or prototype, get in touch with us here in

Golden, contact the Coors regional sales manager nearest you, or write for new bulletin.

REGIONAL SALES MANAGERS

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Midwest.....John E. Marozek
FR 2-7100 - Chicago, Ill.
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Coors

Alumina Ceramics

COORS PORCELAIN COMPANY • 600 NINTH STREET, GOLDEN, COLORADO

NEW PRODUCTS AT THE IRE SHOW

AC Power Supply 659 Output is 25 va



Meeting all military specifications for ground support equipment, this ac supply has an output of 25 va at 350 to 450 cps. Amplitude and frequency stability are 0.1%; regulation is 1%, no load to full load. Output voltage is variable from 0 to 130 v. All controls are external; frequency and amplitude may be remotely controlled. Circuit breakers are used for overload protection.

Industrial Test Equipment Co.,
Dept. ED, 55 E. 11th St., New York
3, N. Y.

Availability: 30-day delivery.
See at Show Booth 3613.

Toggle Switch 367 With leaf action



A short-frame toggle switch, the series 23000 uses a leaf-type action for reliability and long life. It operates as a three-position toggle switch or a two-position switch with momentary or locking action. Silver contacts are rated at 3 amp, 120 v ac noninductive; palladium contacts are available. The switch accommodates multiple circuits. It mounts on 3/4-in. centers.

Switchcraft, Inc., Dept. ED, 5555
N. Elston Ave., Chicago 30, Ill.
See at Show Booth 2825.

WHO CAN SHOW YOU A 220 MC FREQUENCY METER WITH THESE FEATURES?

- * All Solid State 10 MC Counter Section
- * All Solid State Time Interval Plug-in
- * Power Consumption 125 Watts
- * Decade Count-down Time Base
- * Two Year Warranty
Except for Converter Tubes
- * Rugged Unitized
Construction



Model
737AN
with
inline
readout.

Move it anywhere you want with ease. Rack Mounting simpler, too.

Only CMC can! Only CMC's Frequency-Period Meter offers solid state reliability and 48 pound compactness.

DO ALL THESE JOBS:

- Measure frequency dc to 220 mc
- Measure time interval 0.1 microsecond to 10^7 seconds
- Measure period to 0.1 microsecond
- Count dc to 10 mc

Now - See how the CMC 737A compares with its two closest competitors

	CMC Model 737A	Company A 220 mc unit	Company B 220 mc unit
CIRCUITRY	All solid state counter section	100% vacuum tube	100% vacuum tube
TOTAL NUMBER OF VACUUM TUBES	13	91	75
WEIGHT	Net 48 lbs.	Net 118 lbs.	Net 115 lbs.
SIZE	14" H x 17" W x 13" D (1.8 cu. ft.)	21 1/4" H x 20" W x 23 1/2" D (5.8 cu. ft.)	20" H x 20" W x 19" D (4.4 cu. ft.)
POWER	125 watts	600 watts	380 watts
TIME BASE	Decade count-down type; no divider adjustment	Multi-vibrator type; requires frequent adjustment	
WARRANTY PERIOD	2 years	1 year	1 year
PRICE (basic unit with vertical decade display)	\$2400	\$2150	\$2275
(converter plug-ins)	\$250 each	\$250 each	\$250 each
(TIM plug-in)	\$300 each	\$175 each	Included

WHAT IT IS

CMC's Model 737A Frequency Meter combines an all solid state 10 mc digital counter and a vacuum tube heterodyne converter. Three converter plug-ins are currently available with more on the way. Model 731A plug-in extends the 10 mc range to 100 mc and Model 732A covers 100 mc to 220 mc. The third available plug-in, Model 751A, is an all solid state 0.1 microsecond to 10^7 second time interval section.

LOW POWER - A KEY ADVANTAGE

The complete instrument uses only 125 watts of power which reduces operating temperatures, prolongs component life, and assures long trouble-free operation. Even at 10 mc, transistors are well derated. Because of this inherent reliability, CMC offers a two year free service warranty except for converter tubes - the first manufacturer to offer this extended guarantee.

THESE FEATURES, TOO

Automatic decimal point * Inline readout available as standard option * Stability, 2 parts in 10^7 standard, 5 parts in 10^8 special. * Accuracy, ± 1 count \pm oscillator stability * Sensitivity, 0.25 v rms * Standardize against WWV * Remote programming without special regard to cable length, type of cable, or impedance matching * Printer output to drive digital recording equipment, punches, inline readout and other data handling gear, \$80.00 extra.

AND HERE'S 100% SOLID STATE RELIABILITY

CMC offers a complete line of transistorized digital instrumentation including universal counter-timers, time interval meters, frequency-period counters, printers and preset counter-controllers. Here are two models especially suited for applications where high reliability and flexibility of function are key factors. These units can also be remotely programmed by simply closing contacts.

Model 727A Universal Counter-Timer



Using only 50 watts, Model 727A measures dc to 10 megacycles and 0.1 μ sec to 10^7 seconds. Three input channels. Decade count-down time base. Price \$2750.

Model 726A Universal Counter-Timer



Only 5 1/4 inches high and weighing just 25 pounds, Model 726A measures dc to 1.2 mc and 1.0 μ sec to 10^8 sec. Three input channels. Decade count-down time base. Power consumption 40 watts; price, \$1800.

FOR MORE INFORMATION - contact your CMC representative for a demonstration, or write for new technical bulletins. Please address Dept. 36

CMC

Computer Measurements Company

A DIVISION OF PACIFIC INDUSTRIES, INC.

12970 Bradley Avenue • Sylmar, California
Phone: EMpire 7-2161

To see the complete solid state line of digital instrumentation, visit us at the IRE Show-Booth #3226-28.

Servo Actuator

662

Has 8-msec response



Designed for controlling missile flight surfaces, this servo actuator has a response time of 8 msec. Each flight control surface is directly connected to its own actuator. Weight savings of up to 50% over hydraulic systems are claimed, in addition to the elimination of plumbing and accessories. A constant-speed, miniaturized motor is used, with a clutch for left or right action.

American Electronics, Inc., Dept. ED, 1725 W. 6th St., Los Angeles 17, Calif.

See at Show Booth 1327.

Star Tracker

527

Has electronic scanning



The Star Tracker contains an optical system, a phototube and electronic circuitry. It will track radiant sources in the visible and near-infrared regions down to levels equivalent to a sixth magnitude star. Angular resolution is 9 sec of arc. Optical lens aperture is 1 in., focal length is 4 in., instantaneous field of view is 30 min of arc. Sweep frequency is 400 cps, tracking bandwidth is 2.7 cps.

ITT Laboratories, Dept. ED, 500 Washington Ave., Nutley 10, N.J.

See at Show Booth 2510-14.

◀ CIRCLE 108 ON READER-SERVICE CARD



...TOWARDS INFINITY

Micro MINIATURIZATION

The startling miniaturization being achieved in electronic circuits has, until recently, posed problems in interconnections. Lending themselves toward the solutions are AMPHENOL's *new and available* "Micro" family of connectors.

Micro-miniature flat forms, flexible printed wiring, modules, and other devices all can be reliably interconnected with AMPHENOL Micro Edge, Micro Min or Micro Mod connectors.

Connector contact centers are .075" or .050"—and smaller centers are being developed.

Write for complete literature



Micro Edge



Micro Min



Micro Mod

AMPHENOL CONNECTOR DIVISION



1830 S. 54TH AVE. • CHICAGO 50, ILLINOIS
Amphenol-Borg Electronics Corporation

NEW PRODUCTS AT THE IRE SHOW

DC Power Supply 633

Provides 0 to 25 amp

Output of the model 814A power supply is continuously variable from 0 to 36 v, 0 to 25 amp dc. Regulation is 0.03% in constant voltage mode, 0.3% in constant current mode. Chopper stabilization for tighter regulation is optional. Ripple and noise are less than 1 mv rms or less than 25 ma rms. Voltmeter and ammeter are provided. Panel height of the rack-mounting supply is 7 in.

Harrison Laboratories, Inc., Dept. ED, 45 Industrial Road, Berkeley Heights, N.J.

Price & Availability: \$775; 30 to 60 days.

See at Show Booth 1825.

Cathode-Ray Tube 653

With bonded shield



An industrial cathode-ray tube, the 5-in. type SC-3076 has a permanent, built-in reference scale on an integral reflection-free safety panel. The tube offers maximum image visibility, wide-angle viewing, decreased reflection, breakage protection, and simple cleaning.

Sylvania Electric Products Inc., Dept. ED, 730 Third Ave., New York 17, N. Y.

See at Show Booth 2322-32, 2415-25.

DC Power Supply 632

Constant voltage or current

Model 855B supplies 0 to 18 v, 0 to 1.5 amp dc continuously variable. Line and load regulation are 0.03% or 5 mv, and 0.05% or 750 μ a.

◀ CIRCLE 109 ON READER-SERVICE CARD
ELECTRONIC DESIGN • March 15, 1961

Ripple and noise are less than 250 μ v or 250 μ a rms. Units may be connected in series or parallel; remote error sensing, with remote current and voltage programming, are provided. The 11-lb supply measures 7-13/16 x 5-1/16 x 8-1/2 in.

Harrison Laboratories, Inc., Dept. ED, 45 Industrial Road, Berkeley Heights, N.J.

Price & Availability: \$169; 10 to 30 days.

See at Show Booth 1825.

Wire Stripper 535

For 32 to 12 AWG wire



Model 810A automatic wire-stripper has quick-change devices designed to reduce set-up times. It cuts and strips 32 to 12 AWG wire in lengths from 1-in. to 300 ft at speeds up to 8,000 pieces per hr. It may be used to strip Teflon, fiber glass, asbestos as well as PVC and other soft insulations.

Eubanks Engineering Co., Dept. ED, 260 N. Allen Ave., Pasadena, Calif.

See at Show Booth 4036.

Crystal Units 650

In small size

Said to be the smallest ever produced, these crystal units are 0.280 in. square by 0.075 in. thick. Crystals are vacuum-sealed in hard glass. Range is 1 to 200 mc. Crystal units are also available in HC-6/U size, range 1 to 200 mc, and in the HC-18/U size, with a range of 4 to 200 mc. Long-term frequency stability 5 times better than metal types is claimed.

McCoy Electronics Co., Dept. ED, Mount Holly Springs, Pa.

Availability: 30 to 45 days, sample quantities.

See at Show Booth 2215.

CIRCLE 110 ON READER-SERVICE CARD >

NEW B/A MODEL NC-1

Performs
transistor tests
up to 50 amps
at peak power levels!



Only the Baird-Atomic NC-1 offers you the advantages of a direct reading, variable duty cycle test set for non-destructive measurement of medium and high-power transistors.

Check these important features:

- Minimizes heat sink requirements
- Under optimum conditions, requires only 6/10ths of 1% of the input power used in conventional DC current tests
- Permits 750 watts max. power with max. current of 50A or max. voltage of 250V
- Provides DC meter readings of V_{BE} , I_B , V_{CE} and I_C — common emitter configuration under pulse conditions
- Measures leakage currents, I_{CO} and I_{EO} , by standard techniques
- Allows breakdown measurements to be performed under variable bias conditions
- Evaluates switching capabilities of device under dynamic conditions

The Baird-Atomic Model NC-1 applies suitable pulse drive signals to the transistor under test and then peak detects the resulting current pulses at the same measuring value as steady state DC. Because the average pulse signal power is considerably lower than that of steady state DC, less stress is put on the transistor. This permits power tests to be made at a level many times that of rated device dissipation.

Write today for additional information and name of your nearby Baird-Atomic representative.



BAIRD-ATOMIC, INC.

33 university road · cambridge 38, mass.

BAIRD-ATOMIC HAS THE MOST COMPLETE LINE OF TRANSISTOR TEST EQUIPMENT

See us at Booths 3216-3218 IRE Show, New York

NEW PRODUCTS AT THE IRE SHOW

LCR Bridge

657

Has 1/4% accuracy



Universal bridge model 1313 measures inductance to 110 h, capacitance to 110 μ f, and resistance to 110 meg. Accuracy is 1/4% on all measurements. The main balance control has 140 discrete steps, eliminating the usual balance potentiometer. Readout is direct. Measurements may be made at 1 and 10 kc with an internal oscillator, or throughout the audio range with external source and detector. An interpolation control adjusts for final balance.

Marconi Instruments, Dept. ED, 111 Cedar Lane, Englewood, N. J.

Price & Availability: \$595; May delivery.

See at Show Booth 3702-6.

RF Power Source

651

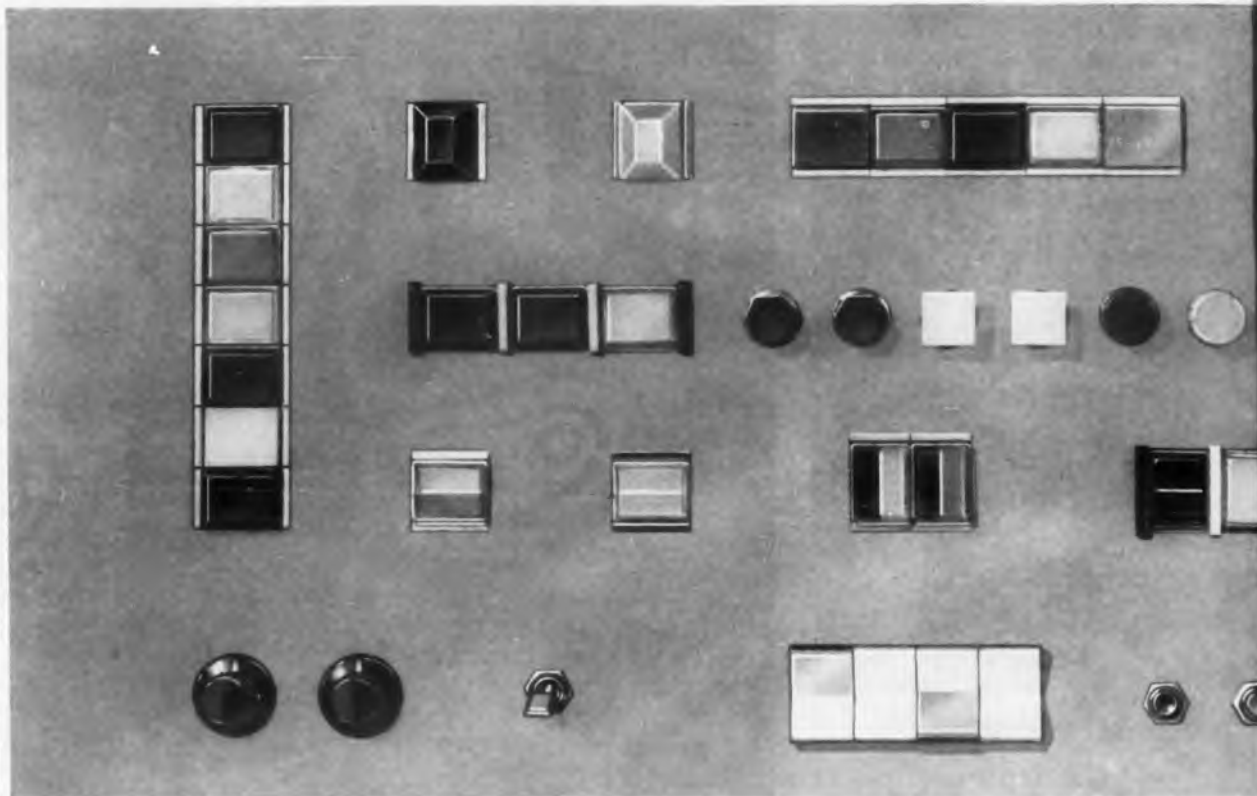
For calibration



A test set for rf calibration, model 1223 is an accurate, stable source of rf power for the calibration of rf power measuring equipment. The set has 6 crystal-controlled power sources with output frequencies of 30, 100, 300, 400, 500, and 1,300 mc. Output power is 5 to 125 w, in 6 steps; levels are adjustable to $\pm 5\%$. Frequency stability is $\pm 0.01\%$. Power is monitored to an accuracy of $\pm 1\%$. Cabinet measures 67 x 44 x 20 in.

Philco, Sierra Electronic Div., Dept. ED, 3885 Bohannon Drive, Menlo Park, Calif.

See at Show Booth 3031-32.

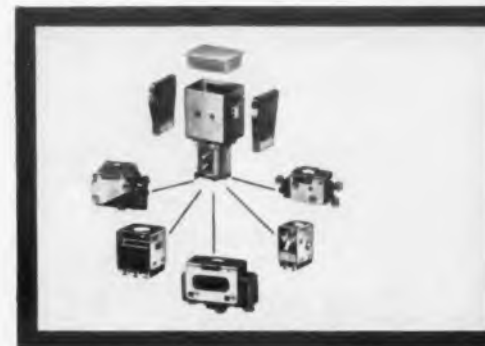


(Actual Size)

NEW

"302 PB" Miniaturized Lighted Push-Button Switch

Indicator and switch unit with momentary action—actuated only while the button is depressed—both combined in less than one cubic inch. The "302 PB" Series conforms to the requirements of MIL-S-6743, MIL-S-6744 and MIL-E-5272A. Write for Data Sheet 182.



SEE US AT THE IRE SHOW NEW YORK,
MARCH 20-23 • BOOTHS 2204-2206

MICRO SWITCH . . . FREEPORT, ILLINOIS
A Division of Honeywell

In Canada: Honeywell Controls, Limited, Toronto 17, Ontario

H Honeywell
MICRO SWITCH Precision Switches

ELECTRONIC DESIGN • March 15, 1961

H
HONEYWELL**MICRO SWITCH Precision Switches**

MICRO SWITCH HAS MORE ANSWERS FOR CUSTOMIZING YOUR CONTROL PANELS!



Modular
"Series 2"



"50 PB" lighted
push-button assembly



Rocker
actuator switch



"6 AT"
toggle switch



"13 AT" toggle
with tab indicator



"17 AS" rotary
selector switch



"2 PB" push-button
switch assembly

MORE SWITCH DESIGNS, MORE FLEXIBILITY IN THE MICRO SWITCH PUSH-BUTTON LINES

When you want to design a control panel precisely tailored to your equipment and absolutely reliable, start with MICRO SWITCH. You'll find the wider selection fits your ideas, rather than your ideas having to fit the selection.

New "302 PB" Miniaturized Lighted Push-Button Switches have lamps designed for infinite service life. They give double-pole double-throw switching and 2-color indication in a unit requiring only one cubic inch of panel space.

Modular "Series 2" Lighted Push-Button Switches offer customized combinations of eight

different basic switches and dozens of colored indicators—and they snap together without tools. New truncated display screens add dimensional visibility.

MICRO SWITCH also makes the "Series 50 PB" lighted push-button switches as well as hundreds of different toggle switches and assemblies. Everything you need for customizing control panels. See the Yellow Pages for the nearby MICRO SWITCH Branch Office. Write for illustrated catalogs on push-button and toggle switches for control panels and machine control stations.

CIRCLE 111 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

Tracking Relay

661

With magnetic action



The model 1073 combines load current contact aiding and magnetic contact aiding, providing reliable contact and lock-in with 5 simple parts. As the instrument pointer reaches the control point, a magnetic pull-in provides snap action sufficient to overcome contact films, even at low contact voltages. Magnetic tracking permits relay adjustment to close tolerances.

Daystrom, Inc., Weston Instruments Div., Dept. ED, 614 Frelinghuysen Ave., Newark 12, N. J.

See at Show Booth 1708-10, 1809.

Digital Transducers

623

Provide direct input



For direct use with digital computers, these transducers have a true digital output. The input forcing function is a primary energy source such as pressure, temperature, or rate of acceleration. Time base outputs are modulated by pulse duration, pulse position, or pulse frequency. Pressure ranges from 5 to 8,000 psi may be supplied. Input power is 115 v, 60 cps; 115 v and 26 v, 400 cps can be used. Size is 2 in. diameter by 2 in. long. Linearity error is $\pm 0.5\%$; repeatability accuracy is 0.2%. The device meets requirements of MIL-5272C.

DeJur-Amsco Corp., Dept. ED, Northern Blvd. at 45th St., Long Island City 1, N. Y.

See at Show Booth 2307-09.

Don't forget to mail your renewal form to continue receiving ELECTRONIC DESIGN.

115

HIGH POWER MATCHED PULSE COMPONENTS



Pulse Forming Networks



Pulse Transformers



Charging Reactors



Oscillator Filament
Transformers

FEATURES

- Stable performance at High Temperatures
- Widest Range and combination of Electrical parameters
- Oil filled units hermetically sealed in welded seam cases
- Designed to meet exact system requirements
- Meets and exceeds all Mil requirements

Axel Pulse components are designed for use in Industrial, Military and Research application where electronic equipments demand a specific energy impulse of accurate shape and duration. All Axel Pulse Components have a high reliability and are designed to meet minimum space and weight requirements.



AXEL ELECTRONICS, INC.
134-20 Jamaica Ave., Jamaica 18, N. Y.

High Voltage Capacitors, Pulse Magnetic Components,
Pulse Networks, Pulse Packages, R.F. Suppression Filters.

CIRCLE 112 ON READER-SERVICE CARD

NEW PRODUCTS AT THE IRE SHOW

Coil Forms

627

Glass-bonded mica



Coil forms of Mykroy 761 and 750 are suitable for induction coils, relays, solenoids, potentiometers, and resistors. The material does not outgas through 350 C; fraying and dust particles are avoided. Special potentiometer grades have expansion coefficients matching those of resistance wire. Mykroy conforms to MIL-I-10A L442 because it does not absorb moisture, has a loss factor of less than 0.016 at 1 meg, and has a dielectric strength of 350 v per mil.

Electronic Mechanics, Inc., Dept. ED, 101 Clifton Blvd., Clifton, N. J.

See at Show Booth 4201.

Distortion Detector

641

For ac harmonic content



Used in conjunction with a vacuum-tube voltmeter, this filter permits accurate measurement of ac harmonic distortion, eliminating the need for a distortion analyzer. The harmonic content can be viewed on an oscilloscope. Stock frequencies are 400, 800, and 1,000 cps; 50-cps to 50-kc units are available on order. Input impedance is 50 K, and range is 0.05% to 20% total harmonic distortion. Filters measure 5-3/4 x 3 x 2 in.

Ortho Filter Corp. Div., Ortho Industries Inc., Dept. ED, 7 Paterson St., Paterson, N. J.

Price & Availability: \$47.25; immediate delivery.

See at Show Booth 1626.

Have you sent us your subscription renewal form?

SPACE, TIME and DR. KARPLUS

$$\frac{\partial}{\partial t} \rightarrow \Delta$$

Enthusiasm & Equipment for analog computing and model building have been purveyed by Philbrick Researches since 1946. The processes synthesized and studied by such techniques as these are generally the sort described by *total differential equations*.

When Field Problems place *partial differential equations* on the stage, the analog impresario recasts them as the former kind by lumping in space. As to time, though he may scale it, he is loath to lump it. Transient fields are transformed by him into models which are Discrete in Space, but Continuous in Time.

Numerical solution of field problems, whether carried out by a Giant Digital Brain or by a tiny human one, proceeds by transforming to *difference equations*. Everything is made discrete: even the dependent variables of the field.

An intermediate technique is recommended by Dr. Walter J. Karplus*, which is called DSDT: for Discrete Space and Discrete Time. He retains the continuity and convenience of analog voltage for field variables, but formulates the solution in a novel manner with *difference equations*. The Karplus method† is compatible with analog equipment of the kind we make and sell, and we should naturally be happy to send data on the subject to responsible enquirers.

*Associate Professor, University of California, Los Angeles

†Philbrick Researches is licensed exclusively by Dr. Karplus to apply his DSDT invention.

GEORGE A.

PHILBRICK
RESEARCHES, INC.

127 Clarendon Street, Boston 16, Mass.

CIRCLE 113 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

DC Power Supply 634

Variable 0 to 40 v

A constant voltage or constant current power supply, model 865B is continuously variable from 0 to 40 v at 0 to 0.5 amp. Ripple and noise are less than 200 μ v rms or less than 100 μ a. Units may be connected in series or parallel. Transient recovery time is less than 50 μ sec. Overload protection is provided by current and voltage limiting. Regulation is 0.01% in constant voltage operation, 0.05% in constant current operation.

Harrison Laboratories, Inc., Dept. ED, 45 Industrial Road, Berkeley Heights, N. J.

Price & Availability: \$169; 10 to 30 days.

See at Show Booth 1825.

Coil Analyzer 625

Reads error to 0.1%

A high-reliability instrument for checking the number of turns on a variety of coils, model 165 compares an internal universal standard against production coils. Error information is rapidly provided to within 0.1%. In-line digital readout is given on a tabulator-type push-button board with a 5-digit maximum.

Deluxe Coils, Inc., Central Engineering Div., Dept. ED, Wabash, Ind.

See at Show Booth 2933.

4-Pole Relay 629

Is approved type

A 4-pole relay rated at 10 amp, this hermetically sealed unit carries military standard approval. Operating temperature range is -65 to 120 C. It withstands vibration of 20 g to 500 cps, 15 g from 500 cps to 1 kc, and 10 g from 1 kc to 2 kc. Standard coil voltage is 24 to 28 v dc. Special units with internal rectification networks are available for ac to 400 cps. Terminals may be screw-type or potted lead.

Guardian Electric Manufacturing Co., Dept. ED, 1550 W. Carroll Ave., Chicago 7, Ill.

See at Show Booth 2502-04.

CIRCLE 114 ON READER-SERVICE CARD ►

Sealed Contact Relays... for contamination-free operation ...positive on-off switching



CLAREED solves the vexing problem of contact contamination. Its sealed, gold-plated contacts operate indefinitely in an in-built ideal environment, give positive on-off switching for up to millions of cycles. It is a relay you can install and forget.

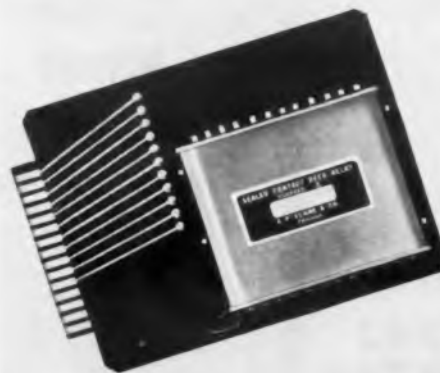
This maintenance-free operation makes CLAREED sealed contact relays ideal components for such critical applications as transistor drives, computers, data processing equipment and many other high-speed devices.

CLAREED design is simplicity itself—a pair of magnetically operated contacts, hermetically sealed in an atmosphere of inert gas within a glass capsule. Compact size permits almost unheard-of flexibility of assembly and application.

Typical space-saving Clareed Relay Assemblies



This cylindrical can contains one, two or three CLAREED switch capsules which form the core of a common coil. Numerous variations of this design are possible to meet customer requirements.



CLAREED relay consists of 12 switch capsules enclosed in a rectangular container and mounted on printed circuit board. Varied coils and contact arrangements available.



Here is a CLAREED relay module for printed circuits. Quick, convenient mounting on your own prototypes or assembly line. High component density. Sturdy steel cover provides magnetic shielding.

C. P. CLARE & CO.

*Relays and Related
Control Components*

If you use relays, it will pay you to know all about CLAREED relays... an entirely new concept in relay design. To obtain Bulletin CPC-10, address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Limited, 840 Caledonia Road, Toronto 19, Ontario. Cable Address: CLARELAY.

The Leaders Specify **ALPHLEX** ZIPPER TUBING



- constant flexibility
- cuts time and labor
- outer jacket is replaceable
- wire changing is simplified
- eliminates costly jacket extrusion
- immediate delivery from your local Alpha distributor

For all these benefits, Alphlex Zipper Tubing is used by such OEM leaders as IBM, IT&T, Librascope, Lockheed, Martin, Sperry Rand and Government agencies. Write for free Alphlex Catalog Z-2.



The new Alphlex Closing Tool (above) designed to save you time, labor and money in your cable production requirements is free with each order of 1,000 feet of Zipper Tubing.

TYPES OF ZIPPER TUBING	
ZIP-31	fabricated from .020" polyvinyl sheet made from MIL-I-631C materials. All purpose type for general applications to 105°C. Standard colors: Clear, Black, Yellow.
ZIP-31M	heavy duty construction. Similar to ZIP-31 type except nominal wall thickness of .040". Standard colors: Clear, Black.
ZIP-44	polyvinyl sheet made from MIL-I-7444B materials. Extremely flexible; for aircraft and low-temperature uses to -67°C. Standard colors: Clear (amber), Black.
ZIP-44M	heavy duty construction. Similar to ZIP-44 type except nominal wall thickness of .040". Standard colors: Clear (amber), Black.
ZIP-50	"sandwich" of aluminum foil laminated between two sheets of polyvinyl. For 100% RF shielding applications to 105°C. Standard color: Silver Grey.
ZIP-90	polyvinyl bonded to woven fibreglass sheet per MIL-I-3190A. For rough usage, abrasion resistance, and high temperature uses to 130°C. Standard color: Black.

All types available in inside diameters from 1/4" to 2" in increments of 1/8"; and from 2" to 4" in increments of 1/4".
Alphlex Zipper Tubing covered by Patents #RE24,613 and #2,558,267 and other patents.

ZIPPER SPECIFICATIONS FOR ALL TYPES OF ALPHLEX ZIPPER TUBING

Material	Polyvinyl Chloride
Track Thickness (when closed)	.005"
Dielectric Strength, V/mil	759
Tensile Strength P.S.I.	3810
Ultimate Elongation	255%
Operating Temperature, Upper Limit	100°C
Cold Brittleness	-86°C
Fungus-proof	will not support fungus
Flammability	self-extinguishing
Lateral Pull Strength (unsealed)	42.7 pounds/inch
Lateral Pull Strength (permanently sealed)	90.6 pounds/inch
Standard Colors	Black, Clear, Yellow

ALPHA WIRE CORPORATION

200 Varick Street, New York 14, N. Y.

Pacific Division: 1871 So. Orange Dr., Los Angeles 19, Calif.

Subsidiary of LORAL Electronics Corporation



CIRCLE 231 ON READER-SERVICE CARD

NEW PRODUCTS AT THE IRE SHOW

Panel Meters

652

With longer scale



Scales of the Prince line of panel meters are said to be 20% to 40% longer than in similar meters. Accuracy of all models is $\pm 2\%$. A threaded mount is used for quick installation. The shielded meters require no adjustment on magnetic or nonmagnetic panels. Sizes are 2-1/2, 3-1/2, and 4 in.

Yokogawa Electric Works, Inc., Dept. ED, 40 Worth St., New York 13, N. Y.

Price & Availability: \$12; 2 to 3 weeks.

See at Show Booth 3940.

FM Generator

656

Range is 400 to 550 mc



Designed for testing command receivers, the model 1066B/2 fm generator has a range of 400 to 550 mc. Carrier frequency can be set to any 1-mc channel and multiple-tone modulation to 300 kc deviation can be applied. The generator has a calibrated fine frequency control for bandwidth measurements, and a modulation compression circuit for constant fm deviation. A mutual inductance piston attenuator of low vswr is used for rf level control.

Marconi Instruments, Dept. ED, 111 Cedar Lane, Englewood, N. J.

Price & Availability: \$3,000; April delivery.

See at Show Booth 3702-6.

Don't forget to mail your renewal form to continue receiving **ELECTRONIC DESIGN**.

ELECTRONIC DESIGN • March 15, 1961

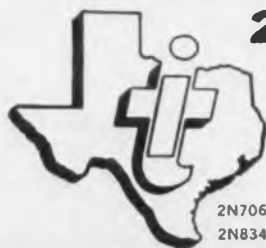
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2N743
2N744



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CIRCLE 233 ON READER-SERVICE CARD

UHF Oscillator

Is electronically swept



A uhf electronically swept oscillator, model 400 covers a frequency range of 500 mc to 1,100 mc. Output frequency is read directly from the frequency dial calibrated to $\pm 1\%$ of reading. The unit is capable of amplitude, pulse or frequency modulation. Sweep rates are adjustable from 0.01 to 100 cps. Sweep width is continuously adjustable. An internal square wave (400 to 1,200 cps) is provided for ease in making reflectometer, slotted line and antenna measurements.

Menlo Park Engineering, Dept. ED, 711 Hamilton Ave., Menlo Park, Calif.

See at Show Booth 3843.

Push-Button Switches

Single-station type



Push-pull switches of the 15000 series may be used in push-to-lock, push-to-release, or momentary functions. The illuminated, single-station units have a square push-button with side as well as front illumination. The nonilluminated switches in series 5000 have a similar action, and use round or square buttons. Both types offer long electrical and mechanical life because of the heavy-duty, long-frame, leaf-type switching action. Switches mount on 5/8-in. centers. Lamp voltages are 6 v, 28 v, and neon (115 v ac).

Switchcraft, Inc., Dept. ED, 5555 N. Elston Ave., Chicago 30, Ill.

See at Show Booth 2825.

Solid Tantalum Capacitor

419

Type TAD is a miniature, dry-electrolyte tantalum capacitor made to meet or exceed MIL-C-26655A. Operating temperatures range from -80 to 125 C, with low leakage current and dissipation factor. Units are available in a wide range of capacitances, voltages, and tolerances.

Pyramid Electric Co., Dept. ED, Orange St., Darlington, S. C.

See at Show Booth 1212.

SLASH COMPONENT REQUIREMENTS

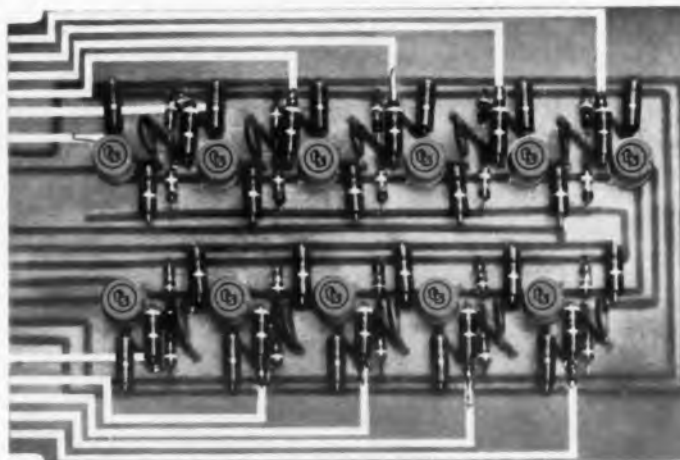
with

Dynaquad

new Tung-Sol 4-layer PNP Bistable Transistor

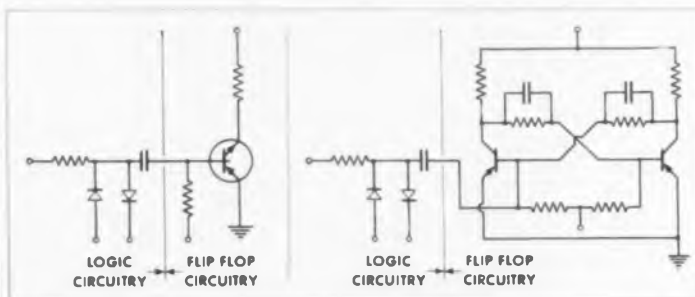


TO-5



Here is a shift register panel which demonstrates the enormous component savings and the substantial reduction in backboard wiring and circuit complexity that can be achieved through the use of Tung-Sol Dynaquad transistors. This component advantage is typical of the assembly economy (especially with printed circuitry) that can be realized in many other applications, including: computer memory and readout; core drivers; relay activators; sweep generators; and high energy switching. For full technical details write: Tung-Sol Electric Inc., Newark 4, New Jersey.

1 printed circuit board assembly performs the job of 3. 10-bit shift register designed with Tung-Sol Dynaquad transistors. Just one assembly is required where 3 are necessary when designed with conventional components.



7 components replace 14. Comparison of a single stage of the 10-bit shift register designed with Dynaquad transistors (left) and conventional components (right) shows the circuit simplicity and component reduction obtained with Tung-Sol's new germanium multilayer alloyed junction transistor.

	2N1066	2N1067	2N1068
Typical electrical characteristics and ratings.			
Pc	collector dissipation at 25°C		120 MW
BVces	collector breakdown voltage		50 volts
Ics	sustaining current		15 Ma
ib (on)	base turn-on current		0.1 Ma

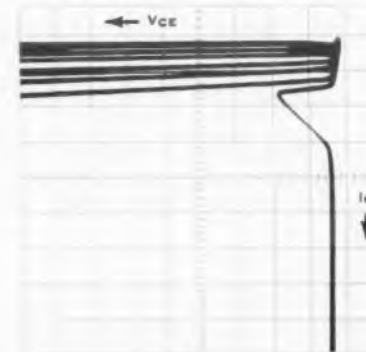
Technical assistance is available through: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Tex.; Denver, Colo.; Detroit, Mich.; Irvington, N.J.; Melrose Park, Ill.; Newark, N.J.; Philadelphia, Pa.; Seattle, Wash. In CANADA: Abbey Electronics, Toronto, Ont.



TUNG-SOL®

see Tung-Sol Dynaquad Transistors
at the IRE show booth Nos. 2334-2336, 2427-2429

CIRCLE 234 ON READER-SERVICE CARD



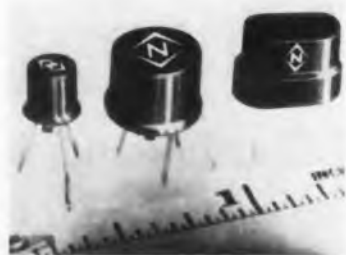
Dynaquad is a three-terminal device featuring regenerative switching characteristics. One terminal—the base—serves as the control gate for initiation of the regenerative action. It permits turn-on and turn-off by bursts of drive power. In this way, a small signal controls large amounts of energy in a ratio not approached by conventional 3-layer junction transistors. Trace shows Dynaquad collector characteristics with base current turn-on.

NEW PRODUCTS AT THE IRE SHOW

Silicon Transistors

640

Are mesa type



Several types of silicon mesa transistors are available at the price of grown-junction transistors. In TO-18 packages are pnp amplifier types, and npn switching and medium power series. In both TO-5 and TO-18 packages are a pnp alloy series, and an inverted switch offering low saturation drop and low leakage current.

National Semiconductor Corp., Dept. ED,
Sugar Hollow Road, Danbury, Conn.

See at Show Booth 1929.

AM Generator

658

Tunes 10 kc to 72 mc



Useful in tests and measurements, the model 144H am generator covers a frequency range of 10 kc to 72 mc. It has a precisely calibrated fine frequency control, automatic level control, and output voltage accuracy to 0.5 db. Carrier frequency drift does not exceed 0.002% in a 10-min period.

Marconi Instruments, Dept. ED, 111 Cedar Lane, Englewood, N. J.

Price & Availability: \$1,190; April delivery.

See at Show Booth 3702-6.

Accuracy Is Our Policy . . .

A few errors appeared in Part 3 of Y. J. Lubkin's series, "All-Pass Networks," *ED*, Feb. 15, 1961, pp 44-47. In the middle of the last column on p 45, the coefficient of ω^3 was improperly given as $-t_d/720$. The coefficient is actually $-t_d^3/720$. Two paragraphs later, the coefficients of ω^5 for the all-pass and Pierce sections respec-

THE NEW SHOCKLEY



This is a
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of the new
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4-layer
diode.
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in electrical
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specifications
have been
made
along with
the
development
of this new
package

SD

ACTUAL SIZE

4-LAYER DIODE

Type E SHOCKLEY 4-layer "glass" diode

- Carries 150 milliamperes steady dc
- Carries 10 amperes peak pulse
- Power rating 150 milliwatts
- Improved temperature stability
- Reduced size
105 diameter x .270 length (maximum)
- Reduced weight
7 grains
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MIC LINE diodes are shock tested at 1,500 G's for 0.5 ms and vibration tested at 20 G's from 30 to 2,000 cps.
- Lower prices
For COMMERCIAL applications in quantities over 5,000 the price has been reduced 40%

• Fast switching of voltages from 20 volts to 200 volts

These are some of the proven applications for Shockley 4 layer diodes.

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| pulse generators | inverters |
| pulse modulators | telephone switching |
| pulse amplifiers | relay driving |
| time delay circuits | multivibrators |
| alarm circuits | squib firing |
| magnetic core driving | emergency power transfer |
| ring counters | |



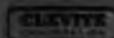
TYPE E 4 LAYER DIODES ARE NOW AVAILABLE
IN PRODUCTION QUANTITIES

Local stocks of Shockley 4 Layer Diodes are maintained by many of our representatives; you'll find them listed in EDC and EEM.

Our engineering sales representatives or our engineers in Palo Alto are ready to discuss applications with you... please write or call whenever you have questions. In the meantime, may we send you specifications and prices?

Shockley TRANSISTOR

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CIRCLE 118 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

tively should be $-t_d^3/720$ and $-t_d^3/480$.

On p 47, Eq. 18 should have ϕ_y rather than ϕ_n . Eq. 21 should have $p-1$ rather than p as the superscript under the root sign. In Fig. 4, the dotted Pierce curve is for $M = 0.0833$ rather than 0.833.

Film Resistors

642

In high values



Film resistors in the HR 1000 series are available in values from 10^7 to 10^{12} ohms, with tolerances from 1% to 10%. Stability is 2% per year at room temperature. Diameter is 3/16 in., length is 1 in.; leads are 1-1/2 in. long. Maximum voltage is 1 kv. Applications include geiger and scintillation counters, phototube circuits, radar equipment, and others.

Pyrofilm Resistor Co., Inc., Dept. ED, U. S. Highway 46, Parsippany, N. J.
P&A: \$4.50 to \$2.70 ea; 2 to 4 weeks.

See at Show Booth 2104.

Component Tester

660

Rate is 4,000 per hour



The TCS-AB4 is designed for high-speed, automatic testing of electronic components. All parts to be tested are lead-taped, and remain on the tape during the entire testing cycle. Tests are made with predetermined limits on a go/no-go basis; any unit out of tolerance is rejected by shearing off the leads. Testing rate is in excess of 4,000 units per hour. The tester may be operated by unskilled personnel.

Industrial Instruments Inc., Dept. ED, 89 Commerce Road, Cedar Grove, N. J.

See at Show Booth 3225-27.

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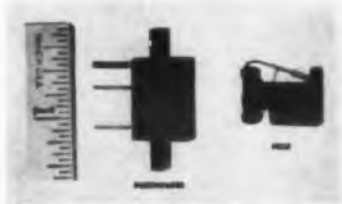
121

NEW PRODUCTS AT THE IRE SHOW

Miniature Fuses

636

With fuse holders



GMT fuses and HLT holder permit multiple mounting of fuses in small areas. Fuseholders mount on 1/4-in. centers. A flag gives visual indication of a blown fuse. Flag is color coded to identify ampere size of fuse. The holder is designed so that fuses may not be incorrectly inserted. Fuses are available in ratings to 10 amp.

Bussman Manufacturing Div., McGraw-Edison Co., Dept. ED, University at Jefferson, St. Louis 7, Mo.

See at Show Booth 2740.

Portable Oscillator

529

Completely transistorized



Model 204B portable oscillator is fully transistorized and battery operated. Frequency range is from 5 cps to 500 kc. Balanced and unbalanced loads, referenced above or below ground can be driven by this unit. The output is flat within $\pm 3\%$ at any setting.

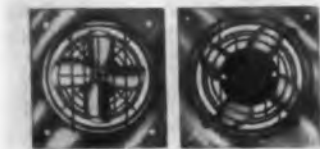
Hewlett-Packard Co., Dept. ED, 1501 Page Mill Road, Palo Alto, Calif.

See at Show Booth 3205-15.

Propeller Fans

638

For rack ventilation



Specifically designed to ventilate electronic cabinets, these self-contained propeller fans are available in two types. Model IPB65W10 (air push

A shining example of Ampex leadership!





Again, Ampex has advanced the boundaries of magnetic recording, with computer and analog tapes that set new standards of excellence for the industry.

The shining surface of Ampex tape is mirror-smooth. It glides directly over the recording head—no nonmagnetic layer in-between. Improved head contact means consistently uniform output and brilliant resolution. The revolutionary Ampex binder formulation and the exclusive Ferro-sheen process give Ampex Computer Tape the lowest coefficient of friction of any tape with far less headwear and oxide build-up.

Thus, Ampex offers the first truly **clean** error-free tapes for instrumentation, the first digital and analog tapes to give you long life and optimum performance **without compromising either!** Recent wear tests by an independent company using Ampex's 833 Long Wear—High Output Computer Tape, showed that the first permanent drop-out was not encountered until the tape had passed through the handler more than 400,000 times! In fact, Ampex tape wears 10 times longer than other tapes with comparable magnetic properties.

Rigorous quality control standards assure you error-free tape, that lives up to high Ampex standards. Every reel of Ampex Computer Tape is individually tested. Evaluation of magnetic properties include: Uniformity of Output, Intrinsic Coercivity (H_{ci}), Retentivity (B_r), and squareness Factor ($\frac{B_r}{H_m}$). There are more than 100 quality checks, from raw material to finished product.

Ampex has pioneered in giving the magnetic recording industry the finest equipment possible. New Ampex Computer and Instrumentation Tapes live up to the same high Ampex standards. No matter what your application—data acquisition, reduction or control programming—you will get the most out of your recorder with clean-running Ampex tapes.

Write for specifications and literature.



**Ampex Magnetic Tape Products
Orr Industries Company**

Division of Ampex Corporation • Opelika, Alabama

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ELECTRONIC DESIGN • March 15, 1961

over motor) and model 1PB65Y10 (air pull over motor) may be mounted for vertical or horizontal operation. Either model may be easily installed in a round or square opening. Both sides of the propeller are protected with heavy guards. Motor is shaded pole type, operating on 115 v, 50 to 60 cps, single phase.

McLean Engineering Laboratories, Dept. ED, Princeton, N. J.

P&A: \$20 ea, in quantity; immediate shipment.

See at Show Booth 1264.

Operational Amplifier

639

Is rack-mounted



Mounting in 3-1/2 in. of rack space, model 505A dc operational amplifier has response to 5 kc, with an open loop gain of 5,000. The self-contained unit operates directly from 115-v, 60-cps line. Dual inputs are provided; output current is 8 ma, bipolar. Front panel is laid out in a block diagram with standard binding posts for input, feedback, and output appropriately located.

Micro Gee Products, Inc., Dept. ED, 6319 W. Slauson Ave., Culver City, Calif.

P&A: From \$295 to \$250 ea; immediate delivery.

See at Show Booth 3842.

Transistor Counters

536

In four models



These transistor counters are available in four models: 5212A; 5512A; 5232A and 5532A. They are 3-1/2 in. high and are suitable for rack-mounting or bench use. Maximum counting rates are 300 kc and 1.2 mc with a choice of column or in-line readout. Dual use of decade dividers permits multiple-period average measurements.

Hewlett-Packard Co., Dept. ED, 1501 Page Mill Road, Palo Alto, Calif.

See at Show Booth 3205-15.

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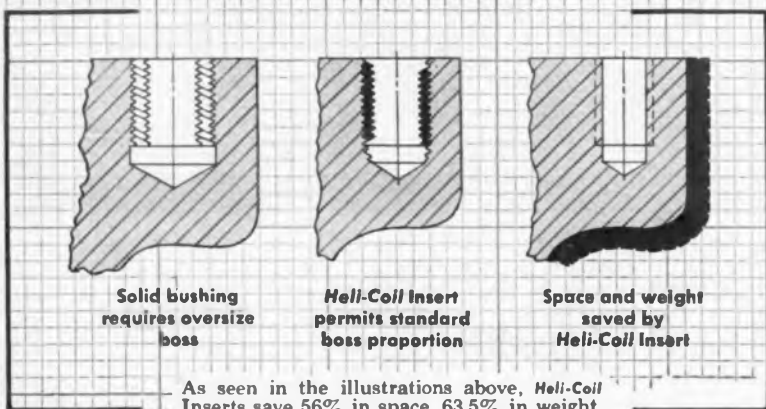
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NO OTHER TYPE OF INSERT OFFERS SUCH SAVINGS!

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Permanently protects threads against wear, stripping, corrosion, galling, seizing, vibration, and shock. Made of 18-8 stainless steel wire, this precision-formed Heli-Coil Insert has a tensile strength of approximately 200,000 psi. Conforms to military standards and all commercial and industrial thread forms.

Heli-Coil Screw-Lock Insert eliminates lock wiring and lock nuts



This one-piece wire Screw-Lock Insert provides all the thread protection of the Standard Insert, PLUS an exclusive resilient internal locking feature that eliminates clumsy protruding lock nuts, lock wiring and other supplementary locking devices. It saves cost, space and weight — permits simple streamlined design in standard bosses. Meets military and N.A.S. specifications for locking torque and vibration.

The Heli-Coil line of products includes: inserts and related taps, hand tools, power inserting tools, automated tooling, and gages. Tables of boss radius and weight comparison are available. Write for complete details and design data.



HELI-COIL CORPORATION

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NEW PRODUCTS

Crystal Filter

514

For single sideband



Using 14 piezoelectric crystals, the SBU-175B single-sideband filter has a passband from 300 cps to 3.2 kc at a carrier frequency of 1.75 mc. Lower-sideband and carrier-frequency rejection are 70 db; insertion loss is 5 db. Passband ripple is ± 0.5 db. Operating temperature range is -55 to 85 C.

Electronic Laboratories Corp., Dept. ED, 4221 Spencer St., Torrance, Calif.

Availability: 6 to 10 weeks for sample quantities.

Stacking Modules

723

For subsystem circuits



These electronic packages for modular subsystem circuits are designed primarily for military electronics use. The modules stack to form complete systems. The top of the stack is fitted with an adapter cap for connections to all modules.

Modular Electronics Co., Dept. ED, 12941 Prospect Ave., Santa Ana, Calif.

Price: \$35 and up.

Utility Microscope

426

10 to 40 times

Model AO utility microscope provides magnifications of 10X, 20X, and 40X. Working distance remains 4 in. at all magnifications. Field is erect and unreversed.

American Optical Co., Dept. ED, Buffalo 15, N.Y.

Price: \$110 for 3 powers.

Availability: 30 days.

Relays by Stromberg- Carlson



Telephone-type quality • reliability durability

TYPE A: general-purpose. Up to 20 Form "A" spring combinations.

TYPE B: gang type. Up to 60 Form "A" spring combinations.

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TYPE C: two on one frame. Ideal where space is tight.

TYPE E: characteristics of Type A, plus universal mounting. Interchangeable with other makes.

Types A, B, and E are available in high-voltage models. Our assembly know-how is available to guide you in your specific application. If you desire, we can also provide wired mounting assemblies.

Details on request from these Stromberg-Carlson offices: Atlanta—750 Ponce de Leon Place N.E.; Chicago—564 W. Adams Street; Kansas City (Mo.)—2017 Grand Avenue; Rochester—1040 University Avenue; San Francisco—1805 Rollins Road.

STROMBERG-CARLSON
A DIVISION OF
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Program Timer

418

Up to 20 circuits



The type 540 cycling timer provides timed-sequence control of up to 20 independent load circuits. Cycle speeds range from 1 sec to 11 days. Switch points are adjustable for each circuit from 2% to 98% of full cycle time; accuracy is within $\pm 0.5\%$ of full cycle time. Snap-acting spdt switches are rated for 10 amp at 115 v noninductive. Motors operate at 50 or 60 cps, 115 v at 400 cps, or 6 to 28 v dc.

Cramer Controls Corp., Dept. ED, Centerbrook, Conn.

Pulse Transformers 356

From 0.5 to 10 mh



Kit PTK-1 contains six ferrite-core pulse transformers with primary inductances from 0.5 to 10 mh. All have turns ratios of 3:2:1, with rise times less than 0.1 μ sec. A 7-pin plug-in base is used. The operating temperature range is -55 to 105 C. The transformers will withstand 500 v, and are encapsulated in epoxy resin.

Hamilton Watch Co., Electronics Div., Dept. ED, Lancaster, Pa.
Price: \$25.

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THE COMPLETE LINE OF INTERMEDIATE AND HIGH POWER SILICON TRANSISTORS

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IRE: BOOTH 1326

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Standard To Sub-Miniature

in PUSH BUTTON SWITCHES



Dependable Push Button Switches by Grayhill

- Snap Action
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- Lighted
- Push-Pull
- Single Pole Double Throw

—Ratings from 1 10 ampere to 10 amperes—
for commercial or military applications—
custom engineered models for special applications.
These top quality Push Button Switches are
available with a wide variety of accessories,
such as decorative mounting nuts, range of col-
ored button caps, lockwashers, etc.

Special return springs, contacts and other
variations of the standard model are available
on special order.

✓ Switch
✓ Test
✓ Connect
with
GRAYHILL



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Booth No. 2801—IRE Show

"PIONEERS IN MINIATURIZATION"
CIRCLE 127 ON READER-SERVICE CARD

126

NEW PRODUCTS

Digital Module

420

Has four inverters



Based on diode-NOR logic, each DN-1 card has four transistor circuits which can be connected as flip-flops, one-shots, and logic gates. The cards can be simply connected to form any digital logic. Each transistor output can drive 10 inputs at rates from 0 to 200 kc. Standard levels are 0 and -12 v. Boards measure 4-3/8 by 4-1/2 in. Compatible system elements are available.

Computer Logic Corp., Dept. ED, 11800 W. Olympic Blvd., Los Angeles 64, Calif.

Shaft-Angle Encoder

385

In size 11



An 8-bit shaft-angle encoder, model AD11-085 is 1 in. in diameter and less than 1.4 in. long. The size 11 unit weighs 1.8 oz, including silicon isolation diodes and 15 in. of wire leads. It has a minimum life of 2 million revolutions at 100 rpm and meets military specifications for extreme environment. Driving torque is less than 0.3 oz-in.; resolution is 1.4 deg.

Litton Systems, Inc., Dept. ED, 5500 Canoga Ave., Woodland Hills, Calif.

Delay Line

518

Variable, tapped

When this variable tapped delay line is terminated in its characteristic impedance, it can be tapped at any of the intermediate time delays with negligible reflections from the unused por-



MODEL
4005
with



CONSTANT VOLTAGE CONSTANT CURRENT with PROGRAMMABLE CROSSOVER

\$143⁵⁰

F.O.B.
FACTORY

Other Models
Available
Write For
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•TM

Model 4005 is a 1-40 volt, 500 ma, regulated DC power supply incorporating AMBITROL.® The AMBITROL.® circuit will switch automatically to either voltage regulation or current regulation at any point predetermined by the operator, with continuous control of voltage or current to .05%.

Power Designs inc.

1700 SHAMES DRIVE
WESTBURY, NEW YORK
Edgewood 3-6200 (LD Area Code 516)
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Natvar

ISOGLAS
and
ISOLASTANE

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ROLLS
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FOR CONTINUOUS
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UP TO 155° C.

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- toughness and scuff resistance
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- flexibility at low temperatures
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Also available laminated with other insulating materials for slot lining, coil supports, and phase insulation. Ask for Data Sheet and Samples.

NATVAR CORPORATION

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**10 mc-
1,000 mc
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Response
with new
INCREDUCTOR®
Wideband RF
Transformer**



Other packaging available

FREQUENCY RESPONSE within $\pm 1/2$ db over 20 mc—500 mc frequency range and $\pm 1/2$ db from 10 mc—1,000 mc.

AVERAGE INSERTION LOSS 1 db between 20 mc—500 mc and 2 db between 10 mc—1,000 mc.

SIZE $1\frac{5}{16}$ " x $2\frac{1}{4}$ " x $1\frac{3}{16}$ ". Hermetically sealed.

AVAILABLE IMPEDANCE RATIOS presently 200 ohms balanced to 50 ohms unbalanced. Other ratios to be announced.

TYPICAL APPLICATIONS Antenna matching. Input and Output matching of broad band push-pull for single ended amplifiers.

MILITARY SPECIFICATIONS On special order.

We invite you to write for INCREDUCTOR® Wideband RF Transformer Technical Bulletin No. 460.

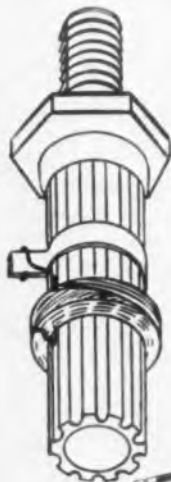


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CIRCLE 131 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

tions. All or any of the taps may be used with proper load termination impedance. Model VDLT-2221 has 500-ohm impedance; model VDLT-2224 has 1,000-ohm impedance. Case measures 4.275 x 2.6 x 2.95 in.

Dresser Electronics, HST Div., Pacific Components Facility, Dept. ED, 18151 Napa St., Northridge, Calif.

Ultraviolet Detector

450

Weights 4.57 oz.



Model M-306 electron multiplier detects vacuum ultraviolet photons, soft X-rays and charged particles. It produces a current gain in excess of 10 million with applied potential of 2 kv. Power dissipation is less than 0.1 w. It will operate in vacuum and can be exposed to air. The multiplier will withstand missile environments. Volume is 3.85 cu in.; weight, 4.57 oz.

The Bendix Corp., Research Laboratories Div., Dept. ED, Northwestern & 10-1/2 Mile Road, Southfield, Mich.

Transistor Tester

501

For in-circuit use



Using an ac bridge principle to null impedance, this device measures ac Beta with an accuracy of $\pm 5\%$. The solid-state transistor tester will also measure transistor input resistance and base-emitter circuit impedance. Weight is 7-3/4 lb; size is 6-1/2 x 9 x 10-3/4 in.

The Hickock Electrical Instrument Co., Dept. ED, 10514 Dupont Ave., Cleveland 8, Ohio.

Price: \$129.50.

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SILICON
RECTIFIERS**
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127

■ A production reality based on 20 years of crystal engineering experience...

Miniature Wide Band-Pass Crystal Filters Delivered In Quantity...To Specification

Filters just recently considered as "state of the art" are now a *production* reality. In addition to its many stock narrow band filters, Midland offers prototype and production quantities of practical Miniature Wide Band Filters in the .5 to 30 mc range. These filters are of exceptional quality.

They are essentially free from unwanted spurious modes which have previously limited the realization of many types of wide band filters. Small quantities for engineering evaluation are available *immediately* from stock. Consultation is available at any time to potential filter users.

Shown below are specifications for ten of our stock wide band filters, as well as actual characteristic response curves. These filters are actually being delivered to major weapons system manufacturers in quantities — to specification.

THESE ARE NOT LABORATORY CURIOSITIES OR IN PROTOTYPE DEVELOPMENT STAGE

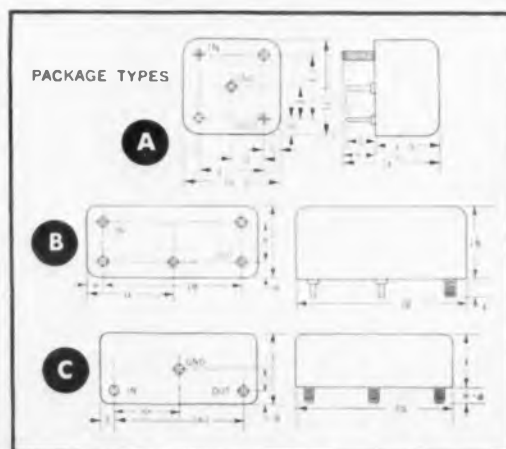
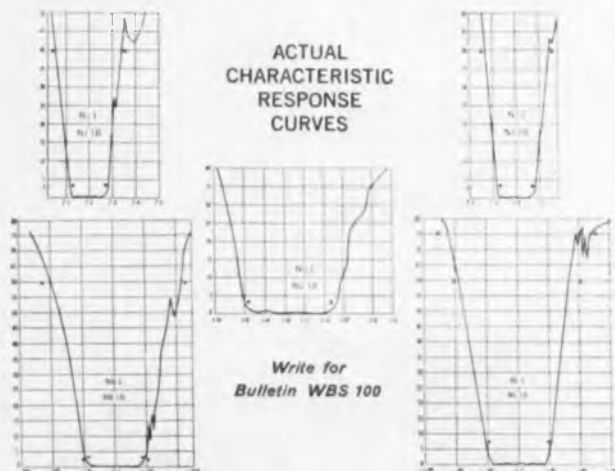
Type	Center Freq.	3db Bandwidth Minimum	40db Bandwidth Max.	60db Bandwidth Max.	75db Bandwidth Max.	Ultimate Discrim. Minimum	Insertion Loss Max.	Impedance ohms	Inband Ripple Max.	Package Type
NJ-1	7.2MC	160KC	300KC			60db	6db	13K	1db	A
NJ-1B	7.2MC	160KC	300KC			60db	6db	13K	.5db	B
NJ-2	7.4MC	160KC	300KC			60db	6db	13K	1db	A
NJ-2B	7.4MC	160KC	300KC			60db	6db	13K	.5db	B
NG-1	5.09MC	160KC	350KC			60db	8db	20K	1db	A
NG-1B	5.09MC	160KC	350KC			60db	6db	20K	1db	B
NB-1	10.7MC	200KC		450KC		75db	12db	50	1db	A
NB-1B	10.7MC	200KC		450KC		85db	8db	50	.5db	B
RL-1	11.5MC	80KC		160KC	200KC	85db	6db	50	.5db	C
RL-1B	11.5MC	80KC		160KC	200KC	90db	5db	50	.5db	B

Operating Temp.: -55°C to +90°C

Shock: 100g

Vibration: 15g to 2KC

Units hermetically sealed



A limited number of opportunities for filter and communications engineers and technicians are available. Write Mr. Robert A. Crawford, Chief Engineer, Filter Division.

Midland

MANUFACTURING COMPANY • 3155 Fiberglas Road, Kansas City 15, Kansas

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DIVISION OF PACIFIC INDUSTRIES, INC.

CIRCLE 133 ON READER-SERVICE CARD

MID 1-61

128

NEW PRODUCTS

Magnetic Drum

364

12-in. diam



Built to military specifications, the M-1250 magnetic memory drum is 12 in. in diameter. The 50-track, 300-ke drum has a capacity of 133 bits per in. Motor is 110 v, 60 cps, 1 phase for either 3,600 or 1,800 rpm. The sealed drum can be supplied with inert gas or with desiccator.

Digital Development Corp., Dept. ED, 7541 Eads Ave., La Jolla, Calif.

Price: \$6,000 to \$9,000.

Diode Tester

741

Measures stored charge



The model DRT-40 diode tester measures diode turn-off time for limited turn-off current conditions, and enables switching characteristics to be investigated on conventional oscilloscopes. Measurement of diode's stored charge can be measured with the DRT-40 and an oscilloscope to an accuracy of 5%.

Computer Control Co., Inc., Dept. ED, 983 Concord St., Framingham, Mass.

Price: \$285.

Availability: 4 to 8 weeks.

Diversity Combiner

505

For telemetry



Used as accessory equipment to improve

ELECTRONIC DESIGN • March 15, 1961

signal-to-noise ratios for telemetering systems, this diversity combiner is designed to handle most types of signals with bandwidths up to 5 mc. Signal-to-noise improvement may be as high as 6 db. Model OR-DD has two, three, and four-channel configurations. Input-signal dynamic changes may be greater than 80 db. The combiner weighs 35 lb and measures 19 x 7 x 16 in.

Gulton Industries, Inc., Dept. ED, 212 Durham Ave., Metuchen, N.J.

Price: \$3,200 up.

Germanium Transistors

510

Noise is db max



Types 2N1175 and 2N1175A are pnp germanium alloy transistors for applications requiring high gain and low noise. Type 2N1175A has a maximum broadband noise figure of 6 db, from 15 cps to 1 kc. Collector cut-off current rating is 6 μ a with a collector-to-base voltage of 30 v. Operating temperature range is -65 to 85 C.

General Electric Co., Semiconductor Products Dept., Dept. ED, Kelley Bldg., Liverpool, N.Y. Price: 2N1175, \$1.05 ea; 2N1175A, \$1.30 ea, in production quantities.

Drum Tester

358

For general checkout



The model MD-100 magnetic drum checkout system offers clock recording, clock smoothing, origin and work-track recording, and test-pattern recording. A clock track may be recorded around the drum with up to 16,883 bits, in either the non-return-to-zero or in the Manchester method.

FMA, Inc., Engineering Dept., Dept. ED, 142 Nevada St., El Segundo, Calif.

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You can now get rectifiers that are guaranteed for 18 months to operate at a certified level of performance. If any Syntron rectifier does not perform as certified you will get an immediate replacement without cost.*

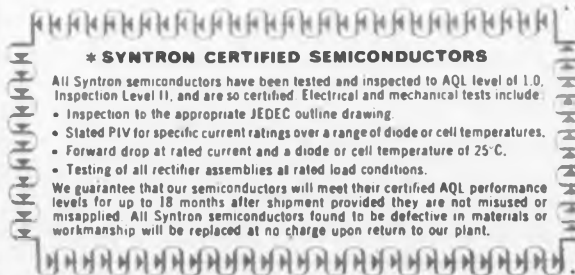
Advantages: you know the rectifier you choose is exactly right for the application. The variables of quality, service life, and reliability are eliminated from design considerations. And you minimize or eliminate time-consuming inspections on production quantity shipments.

Some of the precise tests that make certification and guarantee possible: physical inspection to JEDEC drawing specifications, electrical tests of specific current ratings, tests for forward drop at rated current with cell temperature at 25°C, extensive testing of all assemblies at rated load conditions. Of course, there are a host of others.

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SYNTRON

certified SEMICONDUCTORS



* SYNTRON CERTIFIED SEMICONDUCTORS

All Syntron semiconductors have been tested and inspected to AQL level of 1.0, Inspection Level II, and are so certified. Electrical and mechanical tests include:

- Inspection to the appropriate JEDEC outline drawing.
- Stated PIV for specific current ratings over a range of diode or cell temperatures.
- Forward drop at rated current and a diode or cell temperature of 25°C.
- Testing of all rectifier assemblies at rated load conditions.

We guarantee that our semiconductors will meet their certified AQL performance levels for up to 18 months after shipment provided they are not misused or misapplied. All Syntron semiconductors found to be defective in materials or workmanship will be replaced at no charge upon return to our plant.

SYNTRON COMPANY, Semiconductor Div., Dept. ED-3, Homer City, Pa.

Please send me Silicon and Selenium Rectifier Data (Catalog 100) and Semiconductor Certification (Bulletin 200).

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title _____
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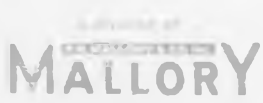
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From Philadelphia Bronze & Brass, you're sure of getting OFHC copper forged accurately to your specifications, from certified grade material guaranteed at least 98% IACS conductivity. Recommended as a source of OFHC copper and related alloys by American Metal Climax, Inc., PB&B can give you expert service on forgings, both open and closed die. Our large stocks assure prompt delivery.

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Non-ferrous forgings, castings and fabrications *Registered Trade Mark—American Metal Climax, Inc.

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NEW PRODUCTS

Tape Reader

368

Photoelectric type



The model 350 punched paper tape reader handles 5-, 7-, or 8-level tape at 350 characters per sec. The solid-state, photoelectric device uses windows to maintain a smooth reading surface. It can be programmed to operate start/stop a character at a time, or can react to a stop code. The 34-lb reader measures 9 x 11-1/2 x 10 in.

Control Data Corp., Dept. ED, 501 Park Ave., Minneapolis 15, Minn.

Availability: From stock in small quantities.

Two-Pen Recorder

359

Graphs two functions

The two pens of this recorder simultaneously graph on a single chart any information that can be expressed as current or voltage. The two functions are plotted side by side on the 6-in. chart. The recorder is guaranteed for 2 yr.

The Esterline-Angus Instrument Co., Dept. ED, 1201 Main St., Speedway, Ind.

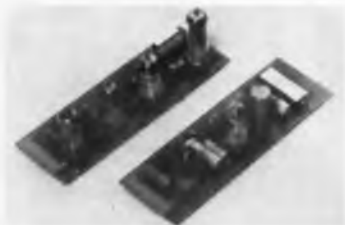
Price: About \$600.

Availability: July 1.

Operational DC Amplifier

440

Chopper-stabilized



This chopper-stabilized dc amplifier has an output of ± 100 v with a 10-K load. It will operate at 75-ma positive output and pulses to 200 ma. The output can be short-circuited without damage. Gain is 125,000 from 5 to 500 cps and 10^6 at dc. The dc amplifier and the chopper amplifier are mounted on separate epoxy-glass circuit boards and may be used individually.

American Brake Shoe Co., Raymond Atchely Div., Dept. ED, 2339 Cotner Ave., Los Angeles 64, Calif.



AO TRACEMASTER PAPER TAKE-UP STORES ENTIRE 1000 Ft. RECORD!

The AO Tracemaster offers a superior paper take-up mechanism that stores complete 1000 ft. record on one roll. Automatic braking device assures constant correct tension (even at full 500 mm/sec. chart speed) to maintain wrinkle-free chart surface for writing notes, interpreting or measuring record.

Convenient, built-in paper cutter permits you to cut the record cleanly and quickly at any point . . . free end can be replaced on take-up spool in just a few seconds.

This outstanding convenience and performance of the paper take-up mechanism is typical of every detail of the AO Tracemaster . . . just one more example of the high standards of precision manufacturing that make it the world's finest 8-channel direct writing recorder. Send for complete information . . . now!

American Optical Company

Instrument Division • Buffalo 15, New York

Ultrasonic Microphone 702

For remote control

Designed for remote control applications, this ultrasonic microphone has a tuned sensitivity of -54 db. Resonant frequency is 40 kc; bandwidth is 4 kc max. The unit is 1-in. in diameter and 1-in long.

Gulton Industries, Component Sales, Dept. ED, 212 Durham Ave., Metuchen, N.J.

Price: About \$12.

Availability: 30-day delivery.

Compact Transformers

366

For panel mounting



Type SXO transformers are designed to conserve space in panel installations. They are particularly suited for use with rectifier and lighting loads and related applications. The transformers have preformed coil bases and heavy insulating channels between core and coil. Screw terminals are used. The series is made for 50 or 60 cps in 15 ratings from 0.050 to 10 kva. All models meet or exceed NEMA standards.

Hevi-Duty Electric Co., Transformer Div., Dept. ED, 3002 W. Burleigh, Milwaukee 1, Wis.

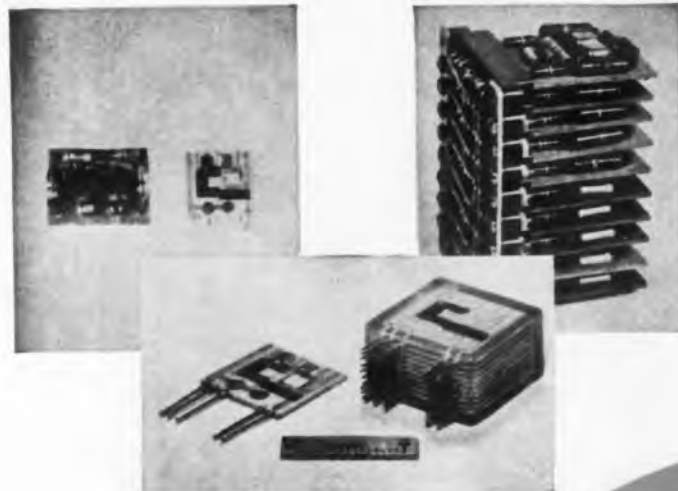
Trimming Potentiometer

369

Slide-wire type

A slide-wire resistor, model 0271 is 0.250 in. in diameter and 1.325 in. long, including the threaded end for panel mounting. It is rated at 1/4 w at 50 C, derating to 0 at 125 C. Resistance range is 3 to 17 ohms; temperature range is -55 to 125 C. It is sealed against humidity.

Edcliff Instruments, Con-Elco Div., Dept. ED, 1711 S. Mountain Ave., Monrovia, Calif.



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NEW PRODUCTS

Cycling Timers

526

Range is 5 sec to 30 hr



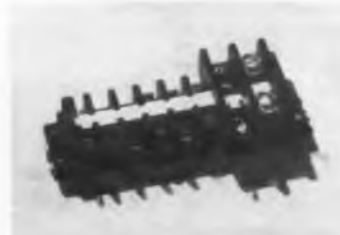
Type 553 cycling timers have a range of 5 sec to 30 hr. They are designed to operate under severe environmental conditions. Hermetically sealed units are made with 60- or 400-cps motors. One to five load switches, rated 5 amp at 125 or 250 v ac, may be used. Actuating cams are accurate to 1 deg at the operating point.

Cramer Controls Corp., Electromechanical Div., Dept. ED, Centerbrook, Conn.

Terminal Boards

357

Mixed types



Sectional terminal boards CR151A are available with box, screw, saddle-clamp, and combination terminals. Current ratings range from 25 to 125 amp. Boards are supplied in pre-assembled form or in building-block kits. A marking strip is supplied. Screw terminal boards are also made in 4-, 6-, and 12-point units. They are rated to 30 amp, 600 v max.

General Electric Co., General Purpose Control Dept., Dept. ED, Bloomington, Ill.

Digital Buffer

379

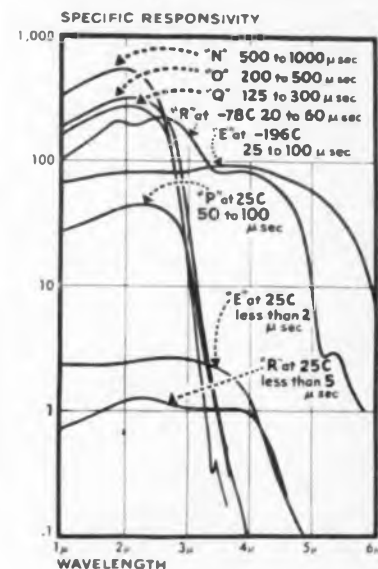
And storage unit



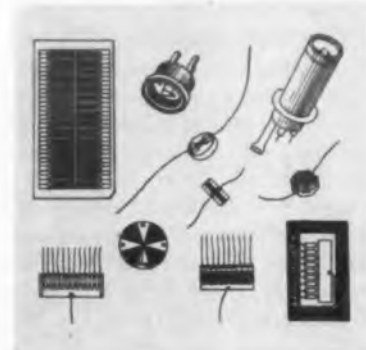
The model 1520 digital buffer storage unit provides isolation and storage between digital meas-

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-for the 1 μ to 6 μ infrared



a wide-open choice in spectral responsivity and time constant



a wide open choice of physical forms —large, small, complex shapes, multiple arrays, "immersed," Dewar-housed—ingenuity is the only limit, almost

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ELECTRONIC DESIGN • March 15, 1961

uring instruments and output devices. It accepts decimal or binary-coded decimal information and gives isolated decimal contact closure output. Data input transfer time is as low as 100 μ sec. Storage capacity is 8 decimal digits.

Auto Data, Dept. ED, Box 9146, San Diego, Calif.

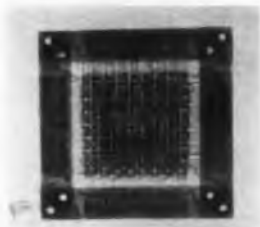
Price: \$1,475 up.

Availability: 30 to 45 days.

Memory Frames

428

For commercial uses



Tailored to meet requirements for low-cost memory systems specified for business computers, these memory frames may be assembled in 10 frame configurations. Four sizes of printed-circuit strips are made, using any of several types of 50-mil and 80-mil ferrite cores. Base material can be glass epoxy, paper phenolic, or other suitable material; solder-plated circuitry is used.

Lockheed Electronics Co., Dept. ED, 6201 E. Randolph St., Los Angeles 22, Calif.

Flash Power Supply

360

Up to 20 kw/sec



Designed to produce the highest possible peak light intensity from xenon or krypton gas discharge lamps, this flash power supply operates from 0 to 5 kv dc. Output power is 1 to 20 kw/sec. Low-impedance circuitry provides peak light intensities higher than those obtainable with photo-flash devices. Input is 115 v, 60 cps.

Electro Powerpacs, Inc., Dept. ED, 5 Hadley St., Cambridge 40, Mass.

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THIS DVM IS EXPLOSION PROOF!



Cubic announces the first digital voltmeter that may be used in any explosive atmosphere. The new Model 2100 is ideal for use around aircraft or missiles that are being fueled, in pipeline pumping stations, refineries, chemical processing plants, munitions factories and all other environments formerly considered "off-limits" for a DVM. It has already been chosen for use on Polaris-armed submarines.

Other Features of the Model 2100: shockproof — withstands up to 50G shock; waterproof — can operate underwater; corrosion-proof — can't be damaged by salt spray or chemicals; specifications equal or exceed those of all high performance meters. Write for descriptive literature to Dept. ED-102, Industrial Division, Cubic Corporation, San Diego 11, Calif.

Visit us at the I.R.E. Show... Booth No. 3111

Cubic manufactures a complete line of quality digital instruments, including a-c and d-c voltmeters, ohmmeters, ratiometers, scanners and printer controls.



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133

Bendix

MONTROSE DIVISION

D.C. MOTORS



OPTIONAL FEATURES

- MOTOR SPEEDS—7500 rpm, 9000 rpm, 12000 rpm. Other speeds available on request.
- GEAR RATIOS—5:1, 8.33:1, 20:1, 25:1, 80:1, 500:1, 1600:1.
- INPUT VOLTAGE—6 to 50 volts d.c. Standard models 12 and 26.5 volts d.c.
- GOVERNOR CONTROL RANGE—7500-14000 rpm.
- DUTY—3 watt continuous.
- BRUSH LIFE—to 450 hrs.

ENVIRONMENTAL CHARACTERISTICS

- TEMPERATURE— -65° F. to 200° F., standard models.
 -65° C. to 200° C., special models.
- VIBRATION—20 to 2000 cps at 16 g's.
- SHOCK AND ACCELERATION—30 g's.
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Montrose Division

SOUTH MONTROSE, PA.



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NEW PRODUCTS

Flush Circuitry

Size to 10 x 10 in.



Printed circuitry may be compressed flush with the laminate to avoid interference with rotating elements. The operation is done after etching, in sizes up to 10 x 10 in. Work has been done on glass epoxy and other laminates.

Kenmore Sales Co., Dept. ED, Industrial Park, Lowell, Mass.

Capacitance Bridge

Resolution is 0.1 pf



A solid-state capacitance bridge, model 101 has a resolution of 0.1 pf, and an accuracy of 0.001% of full scale. Range extends to 1,000 pf. Test frequency is 200 kc. It is available in console or rack model with panel height of 7 in.

Dynatron Laboratories, Dept. ED, 71 Glenn Drive, Camarillo, Calif.

Price: \$570 rack, \$590 console.

Cadmium Sulphide Cell

Sensitive top and side



The cadmium sulphide area in the ORP 50 cell is positioned at a 45-deg angle, making the device sensitive on top and side. The all-glass cell

386



Punched Paper Tape Accessories

A complete line of quality punched tape processing components ... adaptable to all systems.



TAPE SPLICER NO. 219
Edits, Mends, Corrects.



SINGLE LINE TAPE READER NO. 220
Reads up to 60 lines per second. 5, 6, 7 or 8 hole tapes.



TAPE-ARD READER NO. 171
Reads 80 bits of information simultaneously.

Manual TAPE-ARD PUNCH NO. 173
Tape punch (uncoded)



TAPE-ARD DUPLICATOR NO. 174
(shown below punch)
For automatically duplicating punched tapes use Duplicator No. 174, Tape Reader No. 171, and Tape-ard Punch No. 173.



TAPE-ARD HANDLING UNIT NO. 194
Handles 200 feet of one inch tape, no rewinding necessary.

Write for full information



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- Computing Solar Temperatures

These new developments in the semiconductor field are especially sensitive to infra-red radiation. Cetron's careful production control insures reliable performance characteristics in all of your photo cell requirements.

Cetron engineers are always available to help in your tube requirements—just write, wire or phone.

**YOUR DEPENDABLE SOURCE FOR
RECTIFIER, THYRATRON AND PHOTO TUBES**

CETRON
**ELECTRONIC
CORPORATION**



715 Hamilton Street • Geneva, Illinois
CIRCLE 143 ON READER-SERVICE CARD

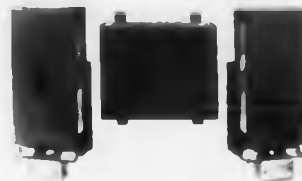
ELECTRONIC DESIGN • March 15, 1961

is hermetically sealed, and can be used for industrial and entertainment applications. Dissipation is 250 mw max; average cell current is 10 ma. Diameter is 0.63 in., length 1.42 in.

Amperex Electronic Corp., Semiconductor and Special Purpose Tube Div., Dept. ED, 230 Duffy Ave., Hicksville, N.Y.

Photoelectric Protector 422

Beam width is 17 in.



Modulated-light projectors are used in this line of photoelectric protective equipment, designed for direct mounting on industrial machines. The devices stop machine operation when the beam is interrupted. Standard beam widths are 7, 12, and 17 in.; control units operate when 2 in. or more are interrupted. Projector and receiver may be located up to 15 ft apart.

The Clark Controller Co., Dept. ED, 1146 E. 152nd St., Cleveland 10, Ohio.

Size 11 Synchro 525

For aircraft instruments



Designed for use in aircraft instruments, the model 1085 synchro may also be servo driven for positioning potentiometers and servo instruments. Input is 26 v at 400 cps; power consumption is 0.4 w. Output is 11.8 v max. Repeater positioning error is less than 30 minutes. Weight is 2-3/4 oz; length is 1.6 in. The synchro is also made in 115-v type.

MEMCOR, Courter Products Div., Dept. ED, Boyne City, Mich.
Price: \$23 ea. 1,000 units.

Don't forget to mail your renewal form to continue receiving ELECTRONIC DESIGN.

**INERTIAL
QUALITY**

**SINGLE AND
2 AXIS ACCELEROMETERS**



Highly precise and accurate, Kearfott's accelerometers are pendulous devices which sense airframe acceleration forces acting on them.

A pendulum utilizing a unique Hooke's joint suspension displaces as a function of acceleration. An AC pickoff signal is rectified and applied to voice coils restoring the pendulum to null. The DC required for restoration is proportional to acceleration. Typical characteristics for these units include range of ± 25 g's, scale factor of 5.0 ma/g, linearity of $\pm 0.005\%$ and threshold of 2×10^{-7} g's.

CHARACTERISTICS:

	SINGLE AXIS F2401	SINGLE AXIS 429037	TWO AXIS 326778-1
TYPE NO.	F2401	429037	326778-1
Range of Measurement	$\pm 20g$	$\pm 25g$	See above
Scale Factor (output)	5.0000 ma/g	5.0000 ma/g	
Operating Temperature	155 F ± 5 F*	50 F and +160 F	
Threshold	$5 \times 10^{-7}g$	Less than $2 \times 10^{-7}g$	
Zero Stability	± 0.05 milliradian	$\pm .00005g$ day to day	
Vibration	Up to $\pm 10g$ peak from 20 to 2000 cps	Up to $\pm 5g$ peak from 20 to 2000 cps	
Storage Temp.	-65°F to +200°F	-60°F to +170°F	
Scale Factor Variation	$\pm .01\%$ randomness	$\pm .01\%$ randomness	
Excitation	6 volts, 3860 cps**	6 volts, 4000 cps**	3.4 volts, 4000 cps***
Natural Freq.	180 cps	210 cps	160 cps
Freq. Resp.	Flat to 250 cps	Flat to 160 cps	Flat to 100 cps
Shock	60 g's	30 g's	30 g's
Weight	4 oz.	7 oz.	2 lbs.

*Available for 180°F.

**Carrier frequency to 100 Kc may be used.

***When tested with Kearfott A3501-01 amplifier.

Write for complete data



**KEARFOTT DIVISION
GENERAL PRECISION, INC.**

Little Falls, New Jersey

CIRCLE 144 ON READER-SERVICE CARD



...and now for the sealing test!

If the pots you need *must* function in a dust or sand environment, you could build 'em yourself to make sure they stay clean! But before you move heaven and earth while testing your creation, exactly what have you planned, to give you a tight seal, yet low torque? And if that isn't enough of a problem, how do you keep foreign matter out of the bearings?

But why move heaven and earth, mostly earth, to test your own dirt-free pot, when Ace has the pots with the dust-free features? Special O-rings seal sand, dust and other foreign matter eliminating abrasion damage. Our wound nylon packing delivers excellent sealing with *lowest* torque. Also, a special silicone-type grease, located in shaft pockets, captures foreign particles before they ever get a chance to do any damage. So if grit's a problem for you, come to Ace for the answer. See your ACErep!



This 3" AIA Acepot (shown 1/3-scale), meeting all MIL spec's on sealing, incorporates these exclusive anti-dirt and dirt-trapping features. Mandrels are also fungicide-varnished, to insure long life.

See us at I.R.E. Booth 1912-1914

ACE ELECTRONICS ASSOCIATES, INC.
99 Dover Street, Somerville 44, Mass.
SOMerset 6-5130 TMA SMVL 181 West. Union WUX

Acepot® Acotrim® Acoset® Aceohm® *Reg. Appl. for
CIRCLE 145 ON READER-SERVICE CARD

NEW PRODUCTS

DC Amplifier

372

Is chopper-stabilized



Model 458B/N is a chopper-stabilized, single-ended, wideband dc amplifier. The general-purpose unit has gain steps from 100 to $-1,000$, and accuracies from $\pm 0.001\%$ to $\pm 1.0\%$. Bandwidth is dc to 40 kc. Output capability is ± 45 v dc into a 10-K load, and 25 v ac rms into 1 K or more.

Cohu Electronics, Inc., Kin Tel Div., Dept. ED, 5725 Kearny Villa Road, San Diego 12, Calif.

Price: \$1,225.

Availability: 1-week delivery.

Pulse Generator

730

Has risetime of 0.3 nsec



Model 303A has rise times of 0.3 nsec, a minimum pulse width of 0.7 nsec and built-in calibrated widths of 5, 10 and 20 nsec. Calibrated amplitudes are to ± 100 v into 50 ohms with adjustable leading edge damping and a separate trigger output. Repetition rates are variable from 20 to approximately 300 pps.

Lumatron Electronics, Inc., Dept. ED, New Hyde Park, N.Y.

Price: \$490.

Availability: Two to three weeks.

Timing Relay

410

Is dc static type

Type TD-4 dc static timing relay is for directional-distance relaying. Operating voltages are 48, 125 or 250 v dc. The unit provides timing

“ Say,
what's this
I hear
about LFE
making
read/write
heads for
magnetic drums
and
tape?”

“They have been
making them
for years
for their own
systems!
Now they're
available
to the industry.
Why don't you
write for
further info?”

LFE

LABORATORY FOR ELECTRONICS
MAGNETIC DEVICES OPERATIONS
COMPUTER PRODUCTS DIVISION
1079 COMMONWEALTH AVENUE

BOSTON 15, MASS.

DEPT. E-24

Please send me complete data on
your magnetic read/write heads.

Name _____

Title _____

Company _____

Division _____

Address _____

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ELECTRONIC DESIGN • March 15, 1961



tubular capacitors

*ultra-high precision
with a
NEW DEGREE
of
RELIABILITY*



SOUTHERN ELECTRONICS CORP. has long been a leader in the design and manufacture of high-precision tubular capacitors, and has pioneered in supplying them for critical applications in computers, missiles, communications and other high-grade military and commercial equipment. They are made to the same standards as our high-precision polystyrene capacitors so widely accepted for military applications.

SEC tubular capacitors are manufactured under unusually critical quality control standards, resulting in tolerances as low as 0.5% in most values, and hermetic sealing guarantees accuracy over wide environmental changes.

SEC tubulars are available in a wide range of tolerances to meet your needs, from 100 mmfd. to any higher value in polystyrene, mylar, metallized mylar, teflon and dual-dielectrics.

All SEC tubular capacitors meet or exceed the most rigid MIL-SPECS.

In addition, we manufacture a complete line of tubular capacitors for commercial applications. Let us know your requirements.

Write today for detailed technical data and general catalog.



See our new sub-miniature Polystyrene capacitor at the IRE Show, Booth 2217, N. Y. Coliseum.

**SOUTHERN
ELECTRONICS**
Corporation

150 WEST CYPRESS AVENUE
BURBANK, CALIFORNIA

CIRCLE 147 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

within the range of 1/10 to 3 sec. Accuracy is $\pm 3\%$ of setting within the following limits: supply voltage variation, -20% to $+10\%$ of normal battery voltage; ambient temperature changes of -20 to $+40$ C; rms value of ac ripple, 7% of applied dc voltage.

Westinghouse Electric Corp., Dept. ED, P.O. Box 2099, Pittsburgh 30, Pa.

RF Attenuators

477

Can be ganged



These attenuators use two or more standard turret attenuators ganged in tandem with a common dial-control and shaft. Model TAA50 consists of two 0- to 50-db attenuators with 10-db steps. It can provide up to 50-db attenuation to each of two circuits or 100 db in 20-db steps to a single circuit. Connectors are BNC type.

Telonic Industries, Inc., Dept. ED, Beech Grove, Ind.

Price: \$160 for the TAA50.

Availability: 30 days.

Servo Motor

508

In size 5



The J126-06 size 5 servo motor is 1 1/2-in. in diameter and 0.968-in. long. Operating voltage is 26 v. phase 1, and 36 v. phase 2. Frequency is 400 cps. No-load speed is 9,500 rpm; stall torque is 0.12 in. per oz. The 0.68-oz motor operates in a temperature range from -54 to 125 C. Time constant is 0.020 sec. It is available in a variety of shaft configurations; the control phase is designed for operation by transistor servo amplifiers.

Kearfott Div., General Precision, Inc., Dept. ED, 1150 McBride Ave., Little Falls, N.J.

This is the time of our annual subscription renewal; Return your card to us.



COAXIAL BROAD BAND FERRITE ISOLATORS

IN SIZES FOR EVERY APPLICATION

Now—from Kearfott, a new and broader line of Ferrite Isolators to satisfy the most exacting requirements of band width and isolation. Combining low unit loss characteristics with compactness and light weight, this new series of Kearfott Coaxial Isolators is available from present stock. Immediate selection and faster delivery is assured . . . precision performance proven.

A FEW OF THE TYPICAL SPECIFICATIONS				
MODEL	FREQUENCY	ISOLATION	INSERTION LOSS	VSWR
C991100-402	1.2—2.6 KMC	10 DB Min.	1.0 DB Max.	1.20
C992100-405	2.0—2.5 KMC	30 DB Min.	.8 DB Max.	1.20
C992100-404	2.0—4.0 KMC	10 DB Min.	1.0 DB Max.	1.20
C992100-407	3.0—3.5 KMC	35 DB Min.	.8 DB Max.	1.20
C993100-401	4.0—8.0 KMC	10 DB Min.	1.0 DB Max.	1.20
C994100-403	7.0—9.0 KMC	25 DB Min.	.8 DB Max.	1.20

Complete information on these or all of the models is available by directing inquiries to: 14844 Oxnard Street, Van Nuys, California, or the sales office in your area.

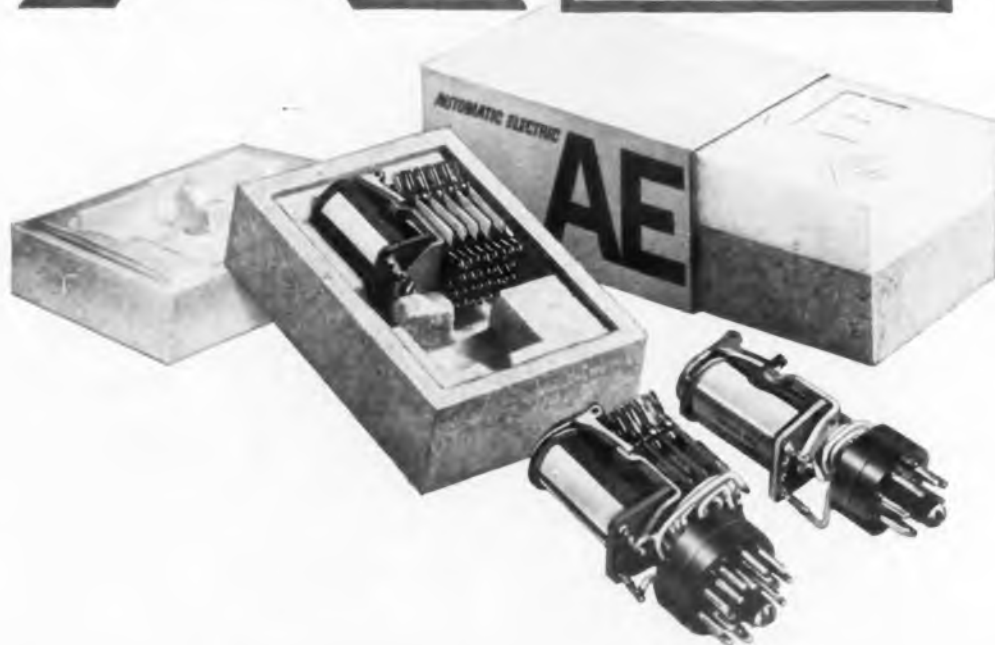


**KEARFOTT DIVISION
GENERAL PRECISION, INC.**

Little Falls, New Jersey

SALES OFFICES SEATTLE, WASH. VAN NUYS, CALIF. PHOENIX, ARIZ. DAYTON, OHIO CLIFTON, N.J.
PALO ALTO, CALIF. SAN DIEGO, CALIF. DALLAS, TEX. CHICAGO, ILL. WASHINGTON, D.C.
CIRCLE 148 ON READER-SERVICE CARD

AE



TO THE ENGINEER who wants his "circuit jewelry" intact

AE takes great pains in preparing its Class E relays for a well-adjusted life in the world of automatic control. To make sure that they reach you in the same happy state, we're now shipping them in a special protective package molded to shape from featherweight polystyrene foam.

The two sections of the case have identical multiform cavities. When put together, they form a snug fit for any Class E relay assembly. The possibility of relay damage in packing, in transit or in removal is virtually eliminated. To facilitate production, the containers can be fed directly to your assembly

line; relays remain protected and accessible.

As for Class E relays, you can have them with the usual solder terminals, "Taper-Tabs," end-mounted printed circuit terminals, wire-wrap, prewired octal plugs, screw terminals or other special forms to fit your needs.

Our circuit engineers will be happy to work with you in applying Class E relays to your designs. They'll also be glad to tackle any control problems you may have.

Want details? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. And be sure to ask for Circular 1702-E, "Relays for Industry."

**AE
CAN
DO**



AUTOMATIC ELECTRIC

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS



CIRCLE 149 ON READER-SERVICE CARD

NEW PRODUCTS

Flow Meter

511

With removable tube



This flow meter has a removable flow tube for easy sterilization. It is used for sanitary flow measurement of conductive liquids. Calibration is unaffected by changes in temperature, conductivity, viscosity, pressure, or density. The flow tube may be sterilized by autoclaving, gas, or germicide. Metering accuracy is $\pm 1\%$ of full scale, repeatability is within $\pm 0.5\%$. Flow range is 0 to 1 liter per min or higher.

The Foxboro Co., Dept. ED, Foxboro, Mass.

Induction Motors

704

With 24-slot stators



Smoother, more constant torque and quiet operation is claimed for these 26-frame, 3-in. OD induction motors. A 24-slot stator is used, with porous bronze or ball bearings. Shaft diameter is 1-2 in. The four-pole motors are made in ratings to 1/20 hp; two-pole units, to 1/10 hp. Length is between 3-11/16 and 5-7/16 in. The motors have Mylar insulation.

Howard Industries, Inc., Dept. 31, Dept. ED, Racine, Wis.

Silicone Rubber Products

401

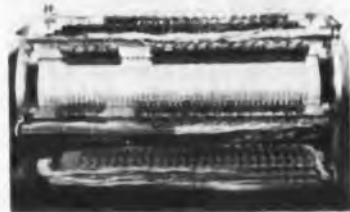
Silicone rubber is available bonded to metals, plastics, and other rubbers. Some products are O-ring seals, tubing, bellows, extrusions, grommets, and silicone-covered metal strip.

Minor Rubber Co., Inc., Dept. ED, Ackerman St., Bloomfield, N. J.

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Magnetic Drum

For conveyor sorting



The Dynastat magnetic memory drum is suited to sorting operations in connection with materials-handling conveyor systems. Information may be manually or automatically inserted, and is available at any drum speed. High-power output of the read heads eliminates the necessity of sensitive amplifiers. Output is 1.5 v dc into a 1-K load. The drum stores 200 bits per channel.

Consolidated Controls Corp., Dept. ED, Bethel, Conn.

Price: \$300 per channel.

Plugboard Systems

With 160 to 5,120 contacts

These six plugboard programming systems are made in sizes ranging from 160 to 5,120 contacts. They are complete with lightweight, removable plugboards and a complete line of plugwires. Boards are silk-screened to order. Single, dual, and shielded plugwires come in numerous lengths, with manual or fixed tips.

MAC Panel Co., OEM Division, Dept. ED, Springfield Ave., High Point, N. C.

Price: From \$60 to \$1,100.

Availability: Immediate.

Partial Motors

From 1/40 to 300 hp



Selection of a partial motor during the early stages of design allows more compact and lighter products. Cost is 10 to 35% less than that of a complete motor. Available in partial-design modifications are motors from 1/40 to 300 hp ac.

Howell Electric Motors Co., Dept. ED, Howell, Mich.

742

KEARFOTT SIZE 5 COMPONENTS

FOR SERVO SYSTEM MINIATURIZATION

SHOWN ACTUAL SIZE



A complete family of Size 5 components for every servo system function is now available from Kearfott. This series offers the system designer complete latitude in miniaturization of his second-generation systems, with the performance and reliability heretofore found only in much larger units.

Stainless steel housings, shafts and bearings protect the units against environmental extremes and contribute to stability under shock, vibration, and temperature fluctuations. • Standard 26-v, 400 cps excitation. • Synchro and resolver accuracy ± 10 min. • Operating temperature range -55° to $+125^{\circ}\text{C}$. Computer-designed for optimum performance.

CHARACTERISTICS

SYNCHROS

	VOLTAGE (400 cps)	CURRENT (amps)	IMPEDANCE		T.R.	NULL (mv)	ERROR (min)
			INPUT	OUTPUT			
Transmitter CJO 0565 100	26	.045	576 /74.7	94.2 /71.4	.454	34	10
Control Transformer Low Z-CJO 0555 100	11.8	0408	250 /73	1085 /72	1.765	34	10
High Z-CJO 055 900	11.8	0202	550 /74	2390 /73	1.765	34	10
Differential CJO 0595 100	11.8	0408	250 /72	313 /69.8	1.154	34	10
Resolver Low Z-CJO 0585 100	26	0485	537 /64.7	677 /74	1.0	34	10
High Z-CJO 0589 100	26	0145	1795 /68.1	2210 /76	1.0	34	10

Weight: 0.90 oz; Length: 1.250 in.

SERVO MOTORS

	J126-06	J126-02
No-Load Speed	9800 rpm	9800 rpm
Stall Torque	0.10 in. oz	0.10 in. oz
Rotor Moment of Inertia	0.175 gm cm ²	0.175 gm cm ²
Voltage $\phi 1 / \phi 2$ (400 cps)	26 /36-CT	26 /26
Power Input /Phase	1.7 w	1.7 w
Duty	continuous at stall	

MOTOR GENERATORS

MOTOR	CJ40812001	CJO0812650	CJO0813200
Voltage $\phi 1 / \phi 2$ (400 cps)	26 /36-CT	26 /36-CT	26 /26
Power / ϕ	1.5 w	1.5 w	1.5 w
No-Load Speed	8000 rpm	8000 rpm	8000 rpm
Stall Torque	0.10 in. oz	0.10 in. oz	0.10 in. oz
GENERATOR			
Voltage (400 cps)	26 v	26 v	26 v
Power	1.5 w	1.5 w	2.0 w
Volts /1000 RPM	0.1 v	0.1 v	0.5 v
Null	1.3 mv	10 mv	6.7 mv

Weight: 1.05 oz; Length: 1.507 in.

SYNCHRONOUS MOTOR

	CJO 0172 200
Pull-In Torque	0.06 in. oz
Pull-Out Torque	0.10 in. oz
Pull-Out Power	4 w
Length	1.24 in.

GEARHEADS, BRAKES, CLUTCHES

Size 5 gearheads range in reduction ratios from 20:1 to 1019:1 for servomotors and motor tachometers above. In addition, Size 6 clutches, brakes, and brake-clutches are available.

Write for complete data

KEARFOTT DIVISION
Little Falls, New Jersey



GENERAL PRECISION, INC.
Other Divisions: GPL, Librascope, Link



meet one of the few things **CIRCO ultrasonics** can't clean!

Grimy gamins we gladly relegate to patient mothers. However, there's little else that Circosonics® can't clean—and clean absolutely!

From gears to glass, from clocks to printed circuits, from meters to missiles—the proven applications for Circo ultrasonic units are almost limitless.

Fact is, wherever absolute cleanliness is a must, or where cleanliness has created a production problem, there's a need for Circosonics—the amazing units that actually blast dirt loose in seconds, yet never harm your product.

Chances are there's an application for Circosonics in your business. Whether you need a bench model, or a huge custom-designed conveyorized system, Circo engineers can recommend the specific Circosonic unit to solve your problem. For Circo offers the widest line of ultrasonic cleaning units to be found.

You'll clean up with Circo—in precision cleaning, economy, speed and quality.



Mighty meter cleaner!

Circo Ultrasonic Model BC 125 quickly, absolutely cleans delicate meter parts requiring cleanliness to tens of microns. Vast savings in disassembly and hand labor are realized.



Custom-built Circo conveyorized degreaser chalks-up big savings for Purolator Products, Inc., Wayne, Mich. Linked-up with the production line it super-cleans filter parts and speeds them on their way in record time at lowest per unit cost.

Clean up with **CIRCO**
CIRCO CORPORATION
ULTRASONICS • WASHERS • DEGREASERS
Solvents

51 TERMINAL AVENUE

CLARK, NEW JERSEY

CIRCLE 151 ON READER-SERVICE CARD

NEW PRODUCTS

Crystal Can Relay

446

With special mounting



Designed for missile and aircraft uses, this 4pdt crystal can relay mounts at the center of gravity. It is rated at 2-amp, 28-v resistive, and provides 100,000 operations per min. Type AR withstands 20 g vibration at 2 kc, and 50 g shock. Coil voltage is 6 to 115 v dc. Operating temperature range is -65 to 125 C. A two-pole unit is also made.

Branson Corp., Dept. ED, P. O. Box 234, Whippany, N.J.

Availability: From stock.

HF Galvanometer

403

This light-beam recording galvanometer has a natural frequency of 13,000 cps. It is one of the 212 series of galvanometers, which have high sensitivity and 2% linearity in most frequency ranges for deflections to 8 in. peak-to-peak.

Century Electronics & Instruments, Inc., Dept. ED, P.O. Box 6216, Pine Square Station, Tulsa 10, Okla.

Quartz Accelerometer

431

Has static response



Short-term static response of these quartz accelerometers enables measurement of high- and low-frequency components of shock signals without zero shift. Calibration is done by static methods. Operating temperature range is -250 to 350 C; sensitivity is constant from -250 to 200 C. Model 802 has a range of 20,000 g, and a natural frequency of 100 kc. Model 812 has sensitivity of 100 mv per g. Model 810 operates to 50,000 g.

Kistler Instrument Corp., Dept. ED, North Tonawanda, N. Y.



Parts shown 3/8 actual size
BRAND NEW!

GRC GUIDE BOOK for SMALL GEAR USERS

Full Specs for Hundreds of Combinations of One-Piece Die Cast Zinc Alloy—spur gears, gear clusters, pinions, cup gears—with hubs, shafts, spacers or special features—at little or NO tool cost

If you use small gears and pinions, it will pay you to keep this valuable guide book at your fingertips. It shows parts made by GRC's interchangeable unit die system and exclusive single cavity casting techniques; new design flexibility, new assembly shortcuts—reduced production and material costs. Maximum sizes: 1.5/16" O.D. by 1/16" face width—wider faces with smaller diameters.



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this FREE ENGINEERING MANUAL

tells why total 2 solves all
retaining ring
PROBLEMS!

CircOlox

the newly designed die-formed ring in a variety of materials and finishes.

E-RING DESIGN • SPECIAL RING SHAPES • STACKED RINGS



With Ramco's Circolox and Spirolox you have the total 2 designs needed to solve all retaining ring

problems. This Free Engineering Manual brings you the complete total 2 story—write for it today!



RAMSEY CORPORATION a subsidiary of Thompson Ramo Wooldridge Inc.
Box 513, Dept. P, St. Louis 66, Missouri 169

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ELECTRONIC DESIGN • March 15, 1961

*New retainer
brings new benefits!*

In MPB's new R Series instrument bearings, the advanced ribbon type retainer provides acceleration without hang-up . . . reduces starting torque and assures smooth, uniform running torque . . . lengthens service life. R Series bearings are manufactured to ABEC Class 7 tolerances, the precision standard of all MPB miniature bearings. For details on any MPB bearings call your MPB Sales Engineer or write Miniature Precision Bearings, Inc., 14 Precision Park, Keene, N. H.

MPB



Helps you perform miracles in instrumentation

CIRCLE 154 ON READER-SERVICE CARD

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EPOXY?
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Check the
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TRIPLEMATIC[®]
PUMP**

TO METER MIX & DISPENSE
MULTI-COMPONENT RESINS

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PHONE PLYMOUTH 9-1242

CIRCLE 155 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

Panel-Mounted Oscilloscope 445

With 3-in. tube



Model 32APM panel-mounted oscilloscope has built-in power supply and amplifiers. It uses a 3-in. display tube. Sensitivity is 0.1 to 0.25 v rms per in.; frequency response is ± 3 db from 20 cps to 40 kc. Panel is 5-3/8-in. high by 6-in. wide. Depth is 10-1/2 in. Input power is 115 v, 60 or 400 cps.

Building Blocks Electronic Co., Dept. ED,
2172 E. 36th St., Brooklyn 34, N.Y.

Resin Dispenser 454

For small volume



The Micro-shot resin dispenser meters, mixes and dispenses small quantities of two-part resin systems. Shot volume ranges from a fraction of 1 cc to 20 cc. Exact proportions are achieved with each shot. The machine can be operated automatically, can handle both filled and unfilled systems, and offers temperature control for both components.

Automatic Process Controls, Inc., Dept. ED,
1170 Morris Ave., Union, N.J.

Circuit-Card Handle 406

Model II Pul-E-Ze circuit-card handle provides distortion-free insertion or removal of circuit cards and boards. Shock- and short-circuit-resistant, it is made of high-impact plastic, pulls 35 lb. and will not break under normal use.

Products For Industry, Dept. ED, 220 S. Rose
St., Los Angeles 54, Calif.

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DESIGN.**

Only



has it!

... a machine which now makes possible the rapid, automatic continuous organic finishing of electrical and electronic components having coaxial leads.

**THE NEW IMPROVED MODEL HD-3
REMOTE MASKING SPRAY COATER**

The first completely automatic machine for accurate coating of diodes and other small components of varying lengths with sprayable materials at a rate of up to 10,000 per hour, depending on the coating requirements and size of the components. Applies a protective coating or light, tight seal for diodes.

Automation is practical, inasmuch as the coating material is confined by remote masking, **ELIMINATING THE NEED OF SPRAY MASKS, REGISTERING DEVICES AND MASK CLEANING OPERATIONS.** The machine can be adapted to fit individual requirements.

40 loaded trays of axial lead components, after painting, are stacked in a portable magazine.



**Conforming
Matrix
CORPORATION**

841 New York Avenue
Toledo 11, Ohio
Phone RA. 9-3777

CIRCLE 156 ON READER-SERVICE CARD



A PRECISION
POTENTIOMETER
WITH

7"
8

DIAMETER
CONFIGURATION

**BORG'S New
2100 Series
Miniature
Multiturn
Micropot®**



ACTUAL SIZE

MODEL 2131S
Three-Turn Servo Mount

MODEL 2101B
Ten-Turn Bushing Mount

- ✓ Aluminum Housings for Maximum Heat Dissipation
- ✓ Color-Coded Terminals to Identify Slider and Rotation

Reference-Action Data from BORG

CHARACTERISTICS		
	3-Turn	10-Turn
Resistance Range*	10 to 40,000 ohms	25 to 125,000 ohms
Standard Linearity	±.5%	±.5%
Temperature Range	-55°C to +125°C	-55°C to +125°C
Weight	¾ oz.	1 oz.
Diameter	7/8 in.	7/8 in.
Housing Length	.930 in.	1.448 in.
Life (revolutions)	1,000,000	1,000,000

*10 to 50 ohms tolerance ±10%; 100 to 100,000 ohms ±3%;
100,000 to 120,000 ohms ±5%.



It's true. Borg's new 2100 Series Miniature Micropot is only 7/8" in diameter. It is wirewound, multiturn and linear. End caps and housings are aluminum for best possible heat dissipation. Color-coded terminals identify function and are gold plated for perfect solderability. Military specifications for vibration, shock, temperature, humidity, sand and dust are met. Contact your nearest Borg technical representative or distributor now.

WRITE FOR COMPLETE
SPECIFICATIONS AND
INFORMATION

BORG EQUIPMENT DIVISION

Amphenol-Borg Electronics Corporation
Janesville, Wisconsin • Phone Pleasant 4-6616

Micropot Potentiometers • Turns-Counting Microdials • Sub-Fractional Horsepower Motors • Frequency and Time Standards

CIRCLE 157 ON READER-SERVICE CARD

NEW PRODUCTS

DC Power Supplies

384

With transient suppression



These four transient-suppressed, high-current dc power supplies are able to withstand severe and continuous overloads. Input for the DMR series is 90 to 140 v, 60 cps. Outputs range from 0.5 to 36 v at 0 to 15 amp, to 18 to 36 v, 0 to 50 amp dc. Static regulation as low as ±0.1%, load or line, is available with dynamic regulation of 2.0% load and 0.6% line.

Magnetic Research Corp., Armour Stablvolt Div., Dept. ED, 3160 W. El Segundo Blvd., Hawthorne, Calif.

Printed Circuits

400

Printed circuits are available on phenolic, melamine, epoxy, silicon, and Teflon. Plating may be copper, silver, nickel, gold, rhodium, or solder. Printing processes are either silk screen or photo etch.

Komak, Inc., Dept. ED, 2632 W. Cumberland St., Philadelphia 32, Pa.

Converter

714

Analog-to-digital



This analog-to-digital converter called the Transponder, permits direct conversion of transducer signals into digital outputs. It is available in two types: the El-Con which responds to an interrogating pulse with a pulse proportional in duration to the transducer input voltage; the Micro-Con, which responds to a chain pulse interrogation, producing an output pulse train proportional in number of pulses to the transducer input voltage. Accuracies are to 0.1% absolute.

Electro-Logic Corp., Dept. ED, 515 Boccaccio Ave., Venice, Calif.

Tube Tester

451

For all TV and radio tubes



The model 600 tube tester checks all TV and radio tubes, old and new, 10-pin tubes, Nuvisitors, and 12-pin Compactrons. It tests for shorts, grid emission, leakage and gas. Capability is checked under simulated load conditions. Grid emission test is adjustable. Carrying case size is 8-1/2 x 11 x 4-1/2 in.

B & K Manufacturing Co., Dept. ED, 1801 W. Belle Plaine Ave., Chicago 13, Ill.
Price: \$69.95.

Transformers and Reactors

388

Transformers and reactors, with ratings to 40 kv and 1 kva, are made to customer specifications. They may be tested for corona and voltage breakdown in accordance with MIL-T-27A.

Communications Accessories Co., Dept. ED, Lee's Summit, Mo.
Availability: 4 to 8 weeks.

Panel Meter

499

Is surface-mounting



The S35 surface-mounting panel meters have a depth of 1-2 in. The movement uses a printed-circuit coil in conjunction with a thin ceramic-ring magnet. Bearings are sapphire, mounted in silicone rubber. The meters will withstand overloads of 10,000% or more indefinitely. A variety of types and ranges are available. Type S35S is hermetically sealed.

Interlab, Inc., Dept. ED, 116 Kraft Ave., Bronxville, N.Y.
Price: \$12 up.

Don't miss an issue of **ELECTRONIC DESIGN**; Return your renewal card.

ELECTRONIC DESIGN • March 15, 1961



ECONOMY ON WHEELS

With RADATAC I, Radiation's portable, low cost data acquisition system

Selecting data from low-level analog pick-offs and putting them into the right format for entry into a digital computer is frequently the most costly step in a performance evaluation program. RADATAC I (Radiation's Data Acquisition Cart) permits you to take this step directly and rapidly—eliminating much expensive data processing equipment and appreciably reducing computer time.

RADATAC I combines Radiation's Radicon analog/digital converter, Radiplex low-level electronic commutator, and an Ampex tape recorder (with the necessary logic circuitry and power supplies) into a single mobile unit. The system handles up to 48 analog inputs from resistive or thermocouple sources (as low as ± 5 mv full scale) with a resolution of $\pm 10 \mu\text{v}$. After digital conversion, the information is recorded in computer format on magnetic tape. Data formats are available which are directly compatible with most large and medium scale digital computers.

For more complete data on RADATAC I, write to Dept. ED-3R, Radiation Incorporated, Products Division, Melbourne, Florida.

THE ELECTRONICS INDUSTRY ALSO RELIES ON RADIATION FOR...

RADIPLEX 89 — a 48-channel low-level multiplexer with broad data processing applications. Features rugged solid-state circuitry, almost unlimited programming flexibility, unique modular construction for compactness and exceptional ease of operation and maintenance.

RADICORDER — Multistylus recorder provides high-speed instantaneous readout for wide range of data acquisition or processing systems. Eliminates necessity of electronically translating complete data, thereby reduces computer work loads.

TDMS — Telegraph Distortion Monitoring System pin-points type and source of trouble on teletype, data processing and similar communications links without interrupting traffic. Ultra-compact TDMS can replace most test equipment now required for teletype maintenance and monitoring.



RADIATION
INCORPORATED

CIRCLE 158 ON READER-SERVICE CARD

NEW—CONTINUOUS READING METER-RELAY



INDICATES AND CONTROLS...

RIGHT THROUGH SET-POINT...



...AND BEYOND

GIVES CONSTANT CONTROL UPSCALE OR DOWN

API's new Continuous Reading Meter-Relay (CRMR) can do a diversity of control jobs for you. It will monitor and control just about any variable that can be translated to electrical values. It will handle low-level microamp or millivolt signals without amplification. In many applications, the CRMR's high sensitivity will permit simplification of control circuitry. In any application, it will give accurate ($\pm 2\%$ or better), non-cyclic control.

The CRMR is simple. It consists of a D'Arsonval meter with toggle-mounted contacts; a load relay does the control switching. No signal-sampling interrupters are required. Reset is automatic and instantaneous.

Reliability? The CRMR is right now in service on such critical applications as monitoring radiation level.

Our Bulletin S-2-1 shows how the CRMR works, and gives full details on available ranges and prices. The latter, not incidentally, are a lot less than you might expect for so versatile an indicating control.



ASSEMBLY PRODUCTS, INC.

Chesterland 17, Ohio

B.A. 2203

CIRCLE 159 ON READER-SERVICE CARD

NEW PRODUCTS

Wire Tester

377

Range is +80 to -100 F



The WU-100-24 wire and cable tester provides temperature conditions from 80 to -100 F ± 2 deg. The pulldown is accomplished in 60 min. The chamber, measuring 24 x 26 x 72 in. high, is penetrated by a cone-step mandrel for testing on 2-, 3-, 4-1/2-, and 6-in. diam-used. The chamber has interior illumination and a 12 x 12-in. multi-pane window. Power requirement

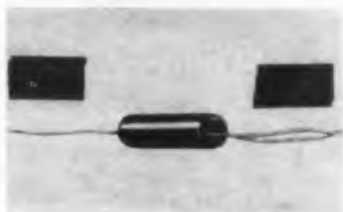
is 230 v, 60 cps, 1 phase.

Cincinnati Sub Zero Products,
Dept. ED, 3932 Reading Road,
Cincinnati 29, Ohio.

Meter Protector

363

For D'Arsonval movements



This meter protector is made for use with any D'Arsonval movement between 0 and 1 ma. Meter degradation is less than 0.6% for movements up to 200 mv with 2 K or more resistance. It provides instantaneous overload protection; when meters. Test load to 1/2 ton may be overload is removed, the protector recovers and meter operation is re-

PLATE or GRID PULSED UHF TRIODE

MACHLETT ML-7698 PLANAR TRIODE
provides 5A plate current.



The Machlett Laboratories offers the designer a new planar triode designed for plate or grid-pulsed operation where high output currents are required. For existing equipment, (or new equipments where plate voltage is limited), where higher power is required, the high plate current capability of the ML-7698 can produce higher output powers.

The ML-7698 employs the new high-emission, arc-resistant Machlett matrix cathode. Conduction cooling. Ceramic envelope.

Plate-Pulsed Oscillator and Amplifier — Class C

Maximum Ratings, Absolute Values

Pulse Length	3 μ sec
Duty Factor	0033
Peak Plate Pulse Supply Voltage	3.5 kv
Grid Bias Voltage	-150 v
Peak Plate Current from Pulse Supply	5.0 Amps
Average Plate Current	13 mA
Average Grid Current	6 mA
Average Plate Dissipation	10 watts
Average Grid Dissipation	2 watts

For full technical data on this or any other Machlett tube type, write:

The Machlett Laboratories, Inc., 1063 Hope Street, Springfield, Conn.

Subsidiary of Raytheon Company

CIRCLE 160 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

turned to normal.

Dynatron Laboratories, Dept. ED, 71 Glenn Drive, Camarillo, Calif.

Price: \$3.50.

Sequence Controller 374

Schedules 8 events



The model TES-1 time-and-event sequencer can schedule up to 8 separate events to occur at time intervals from 100 msec to 5 sec apart. Provision is made for remote starts and emergency reset. Time interval setting is accurate to 5%. The rack-mounting set has a panel

height of 15 in. and operates on 115 v ac.

Atlantic Research Corp., Dept. ED, Alexandria, Va.

Alumina Ceramics 365

In miniature form



Containing up to 97% alumina oxide, these ceramics are made as small as 0.050 in. OD x 0.030 ID x 0.045 in. long. The parts possess high dielectric strength at high frequencies and elevated temperatures.

Diamonite Products Manufacturing Co., Dept. ED, Shreve, Ohio.

CHIP OPENER
RCA
DO NOT PAINT VANE OR SLOT
Chelsea
RESISTOR PWR
GENERAL ELECTRIC
SLIGHTLY APPROVED BY POWER TUBE DEPT. ETL.
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You'll be in good company...
Pressure-Sensitive, Anodized Aluminum Foil
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Certified to meet all MIL Specs.
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FOR FREE SAMPLES and your nearest sales representative, contact . . .

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CIRCLE 161 ON READER-SERVICE CARD

now... analyze **both SSB & AM** transmitters & receivers faster, with uniform sensitivity over entire **100 cps-40 mc** range

AT MINIMUM COST



new — improved

PANORAMIC
SSB-3a
SPECTRUM
ANALYZER

Panoramic adds important NEW design features to the time-proven Model SSB-3! Now, in one convenient, compact package, you get the comprehensive unit you need to set up, adjust, monitor and trouble shoot SSB and AM transmitters and receivers.

GREATER FREQUENCY RANGE New Optional REC-1 Range Converter extends SSB-3a 2 mc-40 mc range down to 100 cps . . . speeds distortion analysis of receiver AF and IF outputs, transmitter bass band.

NEW 2-TONE AF GENERATOR MODEL TTG-2 2 generator frequencies, each selectable from 100 cps-10 kc • Resettable to 3 significant digits • Accuracy: $\pm 1\%$ • Output Levels: each adjustable from 2 to 4 volts into matched 600 ohm load • Output DB Meter • Spurious, hum, etc., less than -60 db. • 100 db precision attenuation in 1 db steps.

FASTER-NEW TUNING HEAD FEATURES RAPID "SIGNAL SEARCH" PLUS PRECISE FINE TUNING.

ALL THESE NEW FEATURES . . . PLUS A SENSITIVE SPECTRUM ANALYZER

Panoramic's Model SB-12aS Panalyzer. Pre-set sweep widths of 150, 500, 2000, 10,000 and 30,000 cps with automatic optimum resolution for fast, easy operation. Continuously variable sweep width up to 100 kc for additional flexibility. 60 db dynamic range. 60 cps hum sidebands measurable to -60 db. High order sweep stability thru AFC network. Precisely calibrated lin & log amplitude scales. Standard 5" CRT with camera mount bezel. Two auxiliary outputs for chart recorder or large screen CRT.

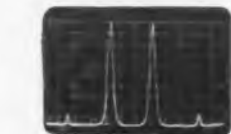
INTERNAL CALIBRATING CIRCUITRY Two RF signal sources simulate two-tone test and check internal distortion and hum of analyzer. Center frequency marker with external AM provisions for sweep width calibrations.

Write, wire, phone **RIGHT NOW** for technical bulletin and prices on the new SSB-3a. Send for our new **CATALOG DIGEST** and ask to be put on our regular mailing list for **The PANORAMIC ANALYZER** featuring application data.

PANORAMIC RADIO PRODUCTS, INC.

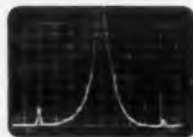
524 So. Fulton Ave., Mount Vernon, N. Y.
Phone: OWens 9-4600
TWX: MT-V-NY-5229

Cables: Panoramic, Mount Vernon N. Y. State



TWO TONE TEST*

Fixed sweep width 2000 cps. Full scale log sideband tones 1.5 kc and 2.1 kc from carrier (not shown). Odd order 1. M. distortion products down 37 db.



HUM TEST*

Indication of one sideband in above photo increased 20 db. Sweep width set to 150 cps reveals hum sidebands down 53 db and 60 db.

*See Panoramic Analyzer No. 3 describing testing techniques, etc., for single sidebands. A copy is yours for the asking.



See the SSB-3a and other equipments — in dynamic action at the I.R.E. Show—Booths 3402-3404.

CIRCLE 162 ON READER-SERVICE CARD



Sec. 2900

A Completely New, Advanced Design

Bruel & Kjaer

TRUE RMS LEVEL RECORDER

(Recording Voltmeter)



- Records all signals DC to 200 kc/s
- Accuracy with True RMS readout
- True RMS Dynamic Range of 75 db
- A Nucleus for Integrated Test Systems

This is a basic instrument for measuring and recording the True RMS, average or peak level of AC signals ranging in frequency from 10 c/s to 200,000 c/s and DC to 10 c/s signals through an internal chopper.

Typical fields in which the Level Recorder finds broad application are calibration or frequency response of transducers and electronic devices, spectrograms for noise or vibration, and reverberation decay curves.

The Level Recorder design concept serves as the heart of the Bruel & Kjaer line of integrated instruments. Smooth running test procedures requiring a minimum of operator attention can be set up by utilizing the recorder's automatic or remote controls and the synchronized tuning drive for companion instruments.

Write for Complete Information • NOW!

Gentlemen:
Please send me
 B & K Brochure on Model 2305
 B & K Complete Line Catalog

Name _____
Company _____
Address _____
City _____ Zone _____ State _____



CIRCLE 163 ON READER-SERVICE CARD

NEW PRODUCTS

Vacuum Recorder

502

Is miniaturized



Suitable for bench or panel installation, this vacuum recorder is 3-5/8-in. wide and 5-5/8-in. high. Miniaturized compensated thermopile vacuum gage circuitry is used. Ranges are 0 to 1,000 micron Hg and 0 to 20 mm Hg. Pressure-sensitive paper and recorder scales are calibrated in absolute pressure units. Power requirement is 115 v, 60 cps.

Hastings-Raydist, Inc., Dept. ED, Hampton, Va.

Price: Under \$300.

1-Kc Oscillator

391

For frequency standard

This frequency standard oscillator provides 1 kc $\pm 0.01\%$ sine-wave output. Input is 25 to 29 v dc; output is 1 to 10 v rms into 600-ohm load, stable to ± 0.5 v rms. Military environmental specifications are met. The 13-oz unit measures 2 x 2 x 3 in.

Lockheed Electronics Co., Avionics & Industrial Products Div., Dept. ED, 6201 E. Randolph St., Los Angeles 22, Calif.

Ratio Bridge

507

Frequency to 10 kc



Model RB-105 ratio bridge has a frequency range to 10 kc. It combines a precision ratio transformer and an electrostatically shielded bridge transformer. Measurements to 1.1111 can be made. Input impedance is 300 K at 10 kc. The bridge is accurate to 0.0025%, and provides 5 decades of transformer switching. Panel height is 5-1/4 in.

Gertsch Products, Inc., Dept. ED, 3211 S. La Cienega Blvd., Los Angeles 16, Calif.

Price: \$550.

Availability: 3-week delivery.

Shaft Encoder

522

With high resolution



The type VS-256E digital shaft encoder, designed for guidance systems, can give resolutions of one part in 2^{14} to 2^{21} in a single turn. Output, in the form of alternate fine and coarse pulse trains, give angular position every 40 msec. Accuracy is maintained at slow rates up to 1 to 4 min per sec without time correction. Power requirement is 400-cps, 2-phase, or 28-v dc.

Data Tech, Dept. ED, 238 Main St., Cambridge 42, Mass.

Geared Servos

421

Ratios to 4,000:1



One model of these gear-train servo packages has two size 8 rotary units, with gear ratios to 1,000:1. It is 1.00-in. wide by 1.812-in. long, and weighs 4 to 6 oz. The other model has gear ratios to 4,000:1, is 1.280-in. wide by 1.90-in. long and weighs 6 to 12 oz.

Clifton Precision Products Co., Inc., Dept. ED, 5050 State Road, Drexel Hill, Pa.

Bank Control Switch

354

The model 110 is a pressure-actuated control switch sensitive to the movement of small parts. Designed to regulate flow rate of parts, it is actuated by 1/3 oz. It operates on 110 or 220 v. The 12-oz switch measures 1-7/16 x 1-13/16 x 3-7/8 in.

Feedall, Inc., Dept. ED, 38399 Pelton Road, Willoughby, Ohio.

Don't forget to mail your renewal form to continue receiving ELECTRONIC DESIGN.

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Milestones in Engineering

The rolling characteristic of round objects—the principle of the wheel—was probably discovered by primitive man watching a stone roll down hill or having a log roll under his foot. The first application of this principle is lost in antiquity. Yet today, countless centuries later, the principle involved remains absolute, fundamental and inviolate.

The discovery of such principles was the foundation for the science of engineering, since engineering is based upon the application of principles rather than theories, on the use of proven truths rather than hypotheses.

As surely as this stands as a basic engineering philosophy, so then does sound engineering result in products and equipment that have one thing in common—dependability!



Typical of the dependability engineered into every North Electric product, the North 100 and 200 Series Relays have a record of dependability established over billions of operations in countless applications. Basically "Telephone Quality" Relays, the North 100 and 200 are fast acting, multi-purpose relays—the 100 Series for general duty application, the 200 Series for heavy duty applications.

For detailed specifications on these relays, write

SEE US IN BOOTH 2125
AT THE IRE SHOW

NORTH ELECTRIC COMPANY

153 S. MARKET ST., GALION, OHIO



CIRCLE 164 ON READER-SERVICE CARD

147

now



STYLE 1001
SPDT



STYLE 1005
SPDT

MIDGET RELAYS for AC or DC Operation

Price Electric Series 1000 Relays Now Feature . . .

- AC or DC Operation
- Solder or Printed Circuit Terminals
- Open or Hermetically Sealed Styles

These versatile, midget, general-purpose relays, formerly available only for DC operation, are now being offered for operation directly on AC. The AC relays, of course, have the same basic features, including small size, light weight, and low cost that made the DC relays pace setters in their fields of application.

Typical Applications

Remote TV tuning, control circuits for commercial appliances, radiosonde, auto headlight dimming, etc.

General Characteristics

Standard Operating Voltages:

3 to 32 VDC; 6 to 120 VAC 60 Cycle.

Maximum Coil Resistance: 13,000 ohms

Sensitivity:

0.05 watt at standard contact rating; 0.3 watt at maximum contact rating for DC relays; 1.2 volt-amperes for AC relays.

Contact Combination: SPDT

Contact Ratings:

Standard 1 amp.; optional ratings, with special construction, to 3 amps. Ratings apply to resistive loads to 26.5 VDC or 115 VAC.

Mechanical Life Expectancy:

10,000,000 operations, minimum

Dielectric Strength: 500 VRMS, minimum

VISIT US AT BOOTH 2409 I.R.E. SHOW

PRICE ELECTRIC CORPORATION

302 Church Street • Frederick, Maryland
MONument 3-5141 • TWX: Fred 565-U

CIRCLE 165 ON READER-SERVICE CARD

NEW PRODUCTS

Setting Control Dial 471

Has 36-to-1 ratio

Designed as a setting control for potentiometers, coils and synchros, the Mini-Dial has a 36-to-1 ratio between setting knob and output shaft. Scales may be either 0 to 360 deg or 0 to 100 divisions. Accuracy is 0.2 deg, a coarse knob provides 1 to 1 turning.

Theta Instrument Corp., Dept. ED, 520 Victor St., Saddle Brook, N.J.

Price: \$50 ea.

Availability: Four weeks.

Recording Voltmeter 459

For true rms

A recording voltmeter, the model 2305 measures true rms, average, or peak level of ac signals from 10 cps to 200 kc, or from dc to 10 cps through an internal chopper. It

operates as a null balancing, electromechanical servo with six linear or logarithmic recording ranges from 10 to 75 db. Tuning drives and controls enable integration with other instruments.

B & K Instruments, Inc., Dept. ED, 3044 W. 106th St., Cleveland 11, Ohio.

Price: \$2,080.

Availability: 60 to 90 days.

2-W Resistor 352

Wirewound, fireproof



The PW-2 axial-lead, wirewound resistor, rated at 2 w, has fireproof, inorganic construction. The as-

WHAT DOES GOOD DESIGN MEAN IN A RACK CABINET

The function of a metal rack cabinet is to accommodate most effectively the instruments it houses. Chassis and components should be stably anchored, well protected and readily accessible for maintenance and repair.

Falstrom Standardized rack cabinets are manufactured from stock tools and dies and easily adaptable to your individual specifications at truly economical cost.

Write, wire or telephone for complete information

FALSTROM COMPANY

171 Falstrom Court, Passaic, N. J. PRescott 7 0013



See us at the I.R.E. Show Booth 4315 - 4317 March 20 - 23

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sembly is sealed in a rectangular ceramic case. Resistance range is 0.24 to 8,200 ohms; standard tolerances are 5 and 10%.

International Resistance Co., Boone Div., Dept. ED, 401 N. Broad St., Philadelphia 8, Pa.

Price: \$52 per 1,000, 10% tolerance.

Availability: 3-week delivery.

Overload Coupling 355

Capacity to 60 ft-lb



This overload protector coupling fits shafts from 3/8 to 1-1/2 in. in diameter, and can be ordered preset to any torque from 1/2 to 60 ft-lb. Setting is maintained to $\pm 5\%$.

The coupling can remain in the disengaged position without heating or binding. It automatically re-engages, in the same position, when overload is corrected.

Holland, Inc., Dept. ED, Navarre, Minn.

Mixing Amplifier 351

With 24 inputs



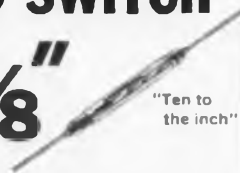
A solid-state audio mixing amplifier, type 5249 is designed for use as a preamplifier in multi-channel recording systems. Six amplifier modules provide 24 input channels and 6 output channels after mixing. Voltage gain from any input to output is 48 db max. Input impedance is 6 K; output impedance is 600 ohms.

ITI Electronics, Inc., Dept. ED, 369 Lexington Ave., Clifton, N. J.

WORLD'S SMALLEST

MAGNETIC REED SWITCH

.095" x 7/8"



"Ten to
the inch"

Ideal for relays, cross-points, computers, scanners, logic elements.

**WORLD DEBUT...I.R.E. SHOW—
Booth #1123**

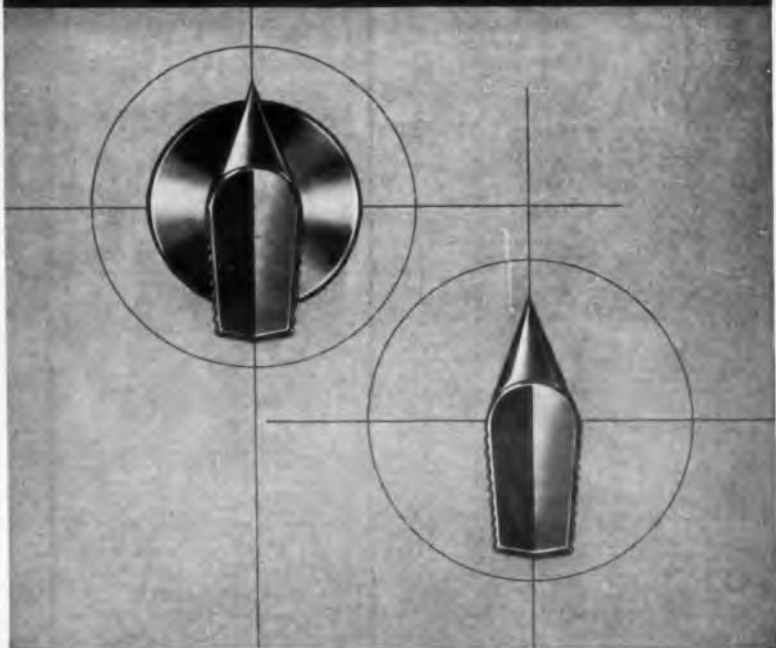
GORDOS
CORPORATION 250 GLENWOOD AVENUE,
BLOOMFIELD, NEW JERSEY

CIRCLE 167 ON READER-SERVICE CARD

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NEW RAYTHEON 90 SERIES

BAR-POINTER KNOBS REDUCE PARALLAX PROBLEMS



Parallax is practically eliminated with these new 90 series Bar-Pointer Knobs made to fulfill human engineering recommendations of the Department of Defense and the U.S. Air Force.

Dial-skirted and bar-pointer designs, in black or gray, fully meet the requirements of MS 91528B. Nonreflective matte finish for military applications. High-gloss finish for industrial equipment that deserves the precision-engineered look.

For more information about 90 series Bar-Pointer Knobs and the most complete line of high quality control knobs, please write: Raytheon, Industrial Components Division, 55 Chapel Street, Newton 58, Massachusetts.

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

RAYTHEON

RAYTHEON COMPANY

INDUSTRIAL COMPONENTS DIVISION
CIRCLE 168 ON READER-SERVICE CARD

Power Control System Users:

Q. Why do the newest universal power control units from Magnetic Amplifiers Division of The Siegler Corporation use G-E Silicon Controlled Rectifiers driven by magnetic gating amplifiers?

A. "General Electric Silicon Controlled Rectifiers provide an almost perfect combination of magnetic amplifier and SCR, making possible exceptionally reliable and efficient control of either a-c or d-c power."



Reliability through solid-state design is achieved in small, light weight power control units developed by Magnetic Amplifiers Division. Another example of advanced equipment design made possible by use of the General Electric SCR.

Features of universal power control units include:

- Precise Control.
- High power units up to 2½ kilowatts at a fraction of size and weight of conventional units.
- Response of entire system within 1 cycle of supply frequency.
- High reliability "designed-in", with no tubes, no moving parts or fragile elements.
- Input circuits designed to accept multiple control signals.

Now lower priced than ever before, the SCR opens new areas for engineering development. *Can you afford to wait any longer?* Write today for application information. Section 23C84, Rectifier Components Dept., General Electric Company, Auburn, N. Y.



GENERAL ELECTRIC

CIRCLE 169 ON READER-SERVICE CARD

Furnace and Oven Users:

Q. Why did BTU Engineering Corporation switch to a stepless temperature control designed around the General Electric Silicon Controlled Rectifier?

A. "The General Electric SCR makes a better control at a lower price. It has all the advantages of the saturable core reactor with none of its limitations of range and power matching requirements, and all the latitude of a magnetic contactor without the see-saw effect, stickiness and noise."

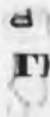


Diffusion furnace used in semiconductor manufacturing, developed by BTU Engineering Corporation, Waltham, Mass. The Stepless Control designed around the General Electric SCR has no moving parts, does not deteriorate with age. It is also fail safe. In the absence of a signal it shuts off the power.

Advantages of the BTU Stepless Control include:

- No costly contactor failures.
- Reliability of a solid state rectifier as the heart of the system.
- It operates "full-on," "full-off" or any point in between with infinitesimally precise control.
- Nearly linear throughout range.
- No matching of imposed load to size of control unit required.

Now lower-priced than ever before, the SCR opens new areas for engineering development. *Can you afford to wait any longer?* Write today for application information. Rectifier Components Department, Section 23C7, General Electric Company, Auburn, New York.



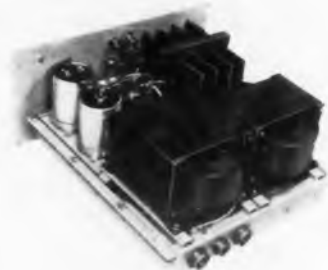
GENERAL ELECTRIC

CIRCLE 170 ON READER-SERVICE CARD

D.C. Power Supply Users:

Q. Why are North Electric Company's new d.c. power supplies designed around G-E Silicon Controlled Rectifiers?

A. "We design our power supplies to meet military specifications, and they have to combine sturdy construction with relatively low weight. General Electric Silicon Controlled Rectifiers give us the advantages of solid state devices with high-speed response, reliability and efficient operation."



A completely solid-state d.c. power supply developed by the Electronics Division of North Electric Company, Galion, Ohio. They can be manufactured for any voltage, with up to 3 K.W. power output. Another example of advanced equipment design made possible by General Electric SCR's.

Features of North Electric's d.c. power supply include:

- Reliability
- High-speed response
- Precision regulation
- Maximum power conversion efficiency
- Reduced weight and package size

Now lower-priced than ever before the SCR opens new areas for engineering development. *Can you afford to wait any longer?* Write today for application information. Section 23C85, Rectifier Components Department, General Electric Company, Auburn, New York.



GENERAL ELECTRIC

CIRCLE 171 ON READER-SERVICE CARD

NEW PRODUCTS

Diode Evaluator

416

Tests 1 to 10



The model 2002 diode evaluator tests up to 10 diodes. Leakage current is measured to 0.1 μ a with $\pm 3\%$ accuracy. Forward resistance is tested at 10 or 50 ma with $\pm 5\%$ accuracy. It provides easy selection of matched diodes. The meter weighs 2 lb and measures 5-5/8 x 6-7/8 x 3 in.

Dynatron Laboratories, Dept. ED, 71 Glenn Drive, Camarillo, Calif.

Price: \$89.

Flexible Couplings

520

In 12 sizes



Miniature flexible couplings are available in 12 sizes, ranging from 5/8 in. OD to 1-5/16 in. OD, with bores from 0.0937 to 0.6875 in. They are rated to transmit 15- to 40-in. per lb of torque at high speeds. There are no moving parts. They will absorb angular misalignment up to 7-1/2 deg, lateral misalignment to 0.015 in., and axial movement up to 0.060 in.

Dial Products Co., Dept. ED, 19 Cottage St., Bayonne, N.J.

Load-Cell Calibrator

404

The model 256 calibrates load-cell transducers from 5,000 lb to 1 million lb within 0.05% of reading. The press is hydraulically operated, arranged to handle tension and compression loads, and has a stroke opening from 0 to 96 in.

Gilmore Industries, Inc., Dept. ED, 13015 Woodland Ave., Cleveland 20, Ohio.

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RF Chokes

417

Are unshielded



The multipurpose, unshielded iron core chokes in the 1700 series are stable at frequencies from 50 kc to 790 kc. Values range from 0.5 mh to 150 mh, in 11 sizes. All coils are rated at 125 ma. The over-all height is 5.8 in. Inductance tolerance is $\pm 5\%$. All chokes are impregnated to resist moisture and fungus.

Delta Coils, Inc., Dept. ED, 1128 Madison Ave., Paterson 3, N.J.

Price: \$0.52 to \$0.22 ea.

Audio Amplifier

390

Weighs 11 oz

This audio-frequency amplifier has a frequency response of 100 cps to 16 kc ± 2 db; distortion is less than 5% at full output. Signal input is 0.1 to 1 v rms; output is 250 mw, 1 to 12.6 v rms min. Power requirement is 24 to 29 v dc at 165 ma. The amplifier weighs 11 oz and measures 2 x 2 x 2 in. Environmental tests are met.

Lockheed Electronics Co., Avionics & Industrial Products Div., Dept. ED, 6201 E. Randolph St., Los Angeles 22, Calif.

Miniature Chopper

383

Has center-tapped coil



Model 36 chopper employs a center-tapped drive coil to facilitate transistor drive in all-transistor circuits. Contacts are spdt, rated for 2 ma at 10 v dc. Drive voltage is 6.3 v, 60 cps. Dwell is 175 deg. average. The chopper withstands vibration to 2,500 cps; operating temperature range is -65 to 100 C.

Airpax Electronics Inc., Cambridge Div., Dept. ED, Cambridge, Md.

Availability: 2 to 3 weeks.

In addition to their "greater-than" conversions at high temperatures, the new Bulova Servo Amplifiers promise maximum flexibility in systems design with a minimum of ounces and inches.

The all-silicon transistors potted in these amplifiers assure continuous operation from -50°C. to $+125^{\circ}\text{C.}$ and provide maximum wattage output per unit volume and weight. Under varied conditions, Bulova

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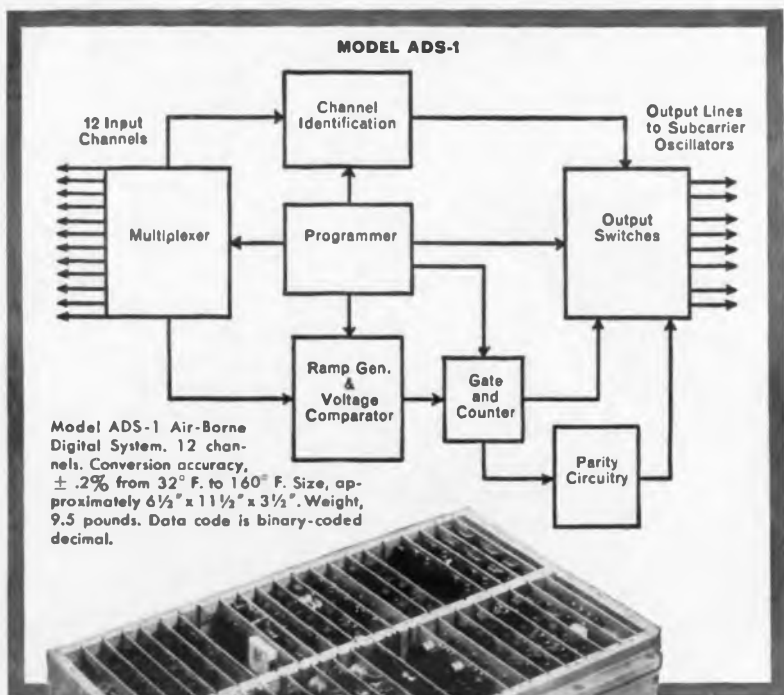
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unit suited to your needs and budget. For additional data write Department 1671, Bulova Electronics, Woodside 77, New York.

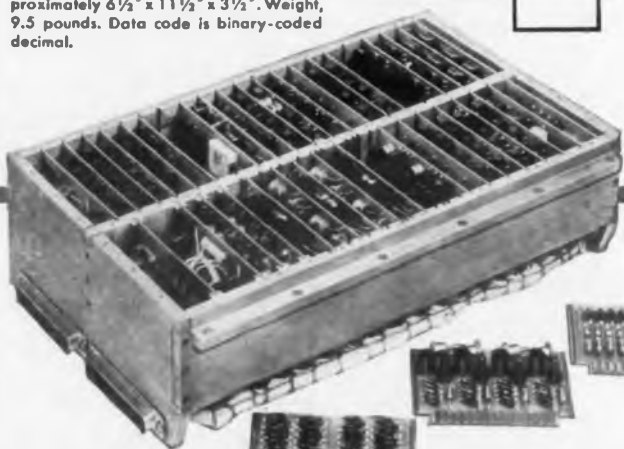
CIRCLE 172 ON READER-SERVICE CARD



DIGITAL DATA SYSTEMS



Model ADS-1 Air-Borne Digital System. 12 channels. Conversion accuracy, $\pm .2\%$ from 32° F. to 160° F. Size, approximately 6½" x 11½" x 3½". Weight, 9.5 pounds. Data code is binary-coded decimal.



See Curtiss-Wright at IRE—Booth 1521-23

An air-borne digital system that is small, rugged, accurate, low in cost

Typical of Curtiss-Wright digital systems is Model ADS-1, designed primarily for missile use. It converts multiplexed analog voltages to a digital equivalent for use with FM-FM Telemetry Systems, magnetic or paper tape recorders. System includes input multiplexing, an analog to digital converter, output switching, channel identification and parity checking. Composed entirely of solid state components, except for 12 electromechanical input switching relays. Ideal also for ground instrumentation, industrial quality control, development laboratories. Special systems custom-designed to meet your specific requirements. Blueprint your problem and let us suggest an answer.

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NEW PRODUCTS

AC Capacitors 461

Metalized-paper type

The MP line of ac starting and running capacitors, made with metalized paper, are self-healing, insensitive to overload, and short-circuit-proof. They are available for permanent and intermittent service, with irregular periods of start and stop, in four voltage ranges up to 720 v. They are made for use with a three-phase motor on a single-phase net.

Robert Bosch Corp., Dept. ED, 40-25 Crescent St., Long Island City 1, N.Y.

Spectral Comparator 490

For low frequencies

This spectral comparator computer compares the frequency and intensity characteristics of the input spectrum with up to 10 stored spectra. The number of matches

for each spectrum is integrated over a selected period and displayed as a percentage. Controls permit a wide range of selection of the intensity limits, threshold values, and integration time.

General Motors Corp., Delco Radio Div., Dept. ED, Kokomo, Ind.

Snap-Action Switch 362

With lever actuator



The series E13-00H is a snap-action switch with a hinged lever actuator requiring low operating force. The switch is supplied normally open or normally closed. spst

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PROCESS GEAR CO.
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or spdt, in a variety of actuation modes and operating forces. The contacts are rated at 15 amp, 125/250 v ac, 3/4 hp.

Cherry Electrical Products Corp., Dept. ED, W. Deerfield Road, Highland Park, Ill.

Price: \$0.32 ea. in 10,000 quantities.

3-Phase Generator 371

Range is 50 to 60,000 cps



The model AG3-030 electronic generator provides 30 va of 3-phase power at 50 to 6,000 cps. Output voltage is 0 to 130 v, regulated to 0.5% no load to full load. Frequency

stability is $\pm 0.25\%$. It consists of a power supply and amplifier chassis, each with a panel height of 7 in. Weight is 105 lb.

Communication Measurements Laboratory, Inc., Dept. ED, 350 Leland Ave., Plainfield, N. J.

Price: \$1,045.

Availability: 6 to 8 weeks.

Hand Tools 488

For microminiature work

This line of hand tools for microminiature electronics and instrument use embodies tip elements from 0.001- to 0.01-in. in size. There are 67 different tool tips, fitting a single handle design. Tips and handles are available singly and in kits. Tips include manipulators, knives, gravers, scales, and others.

Circon Component Corp., Dept. ED, Santa Barbara Municipal Airport, Goleta, Calif.

Price: Handle, \$1.85 ea; tips, \$2.54 up.



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ELECTRONIC DESIGN • March 15, 1961

Specify

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RESISTORS for reliability!

GOLD SEAL CARBON FILM RESISTORS ARE "RELIABILITY TESTED" INDIVIDUALLY

Rugged, Sub-Miniature Gold Seal Carbon Film Resistors are available in three complete lines, standard, moulded and hermetically sealed. With completely uniform carbon coating applied to special ceramic core material, these resistors offer unsurpassed reliability. Calibrated at 25°C to tolerance specified, they are available in plus or minus 1/4%, 1%, 2%, or 5% tolerances. When 2.5 times rated wattage but not more than 2 times max rated voltage is applied for 5 seconds, there is an average change of .05% with max. permanent change of .1%. Subjected to temperature of -65°C for 24 hours and maintained at temperature of +25°C for 24 hours, average change is below .25%. Meet or surpass applicable MIL specs.

DISTRIBUTED NATIONALLY BY AVNET CORPORATION

STANDARD DEPOSITED CARBON RESISTORS (60°C AMBIENT TEMP. AT FULL LOAD)

TYPE	MIL-C (6899-B)	RATING WATT	CONF. VDC MAX.	RESISTANCE RANGE							
				1/4%		1%		5%			
				MIN	MAX	MIN	MAX	MIN	MAX		
S-3	RN-30	2	750	15 Ω	10 Meg	15 Ω	30 Meg	15 Ω	60 Meg	15 Ω	100 Meg
S-1	RN-25	1	500	10 Ω	5 Meg	10 Ω	20 Meg	10 Ω	30 Meg	10 Ω	60 Meg
SX-13		1/2	350	10 Ω	3.9 Meg	10 Ω	10 Meg	10 Ω	15 Meg	10 Ω	20 Meg
SX-12	RN-20	1/2	350	5 Ω	2 Meg	3 Ω	5 Meg	2 Ω	10 Meg	2 Ω	10 Meg
SX-14		1/4	300	5 Ω	1 Meg	2 Ω	2.5 Meg	2 Ω	5 Meg	2 Ω	10 Meg
S-14	RN-10	1/4	300	5 Ω	1 Meg	5 Ω	2.5 Meg	5 Ω	5 Meg	5 Ω	10 Meg
S-14A		1/4	300	5 Ω	1 Meg	5 Ω	2.5 Meg	5 Ω	5 Meg	5 Ω	10 Meg
SX-18		1/8	250	2 Ω	500K	2 Ω	1 Meg	2 Ω	2 Meg	2 Ω	3 Meg
S-18		1/8	250	2 Ω	500K	2 Ω	1 Meg	2 Ω	2 Meg	2 Ω	3 Meg
S-110		1/10	150	20 Ω	250K	20 Ω	250K	20 Ω	500K	20 Ω	500K

MOLDED DEPOSITED CARBON RESISTORS (70°C AMBIENT TEMP. AT FULL LOAD)

SMS-2	RN-80	2	750	15 Ω	10 Meg	15 Ω	50 Meg	15 Ω	60 Meg	15 Ω	100 Meg
SMS-1	RN-75	1	500	10 Ω	5 Meg	10 Ω	20 Meg	10 Ω	30 Meg	10 Ω	60 Meg
SMS-12	RN-70	1/2	350	10 Ω	2 Meg	10 Ω	5 Meg	10 Ω	10 Meg	10 Ω	10 Meg
SMS-14	RN-65	1/4	300	10 Ω	1 Meg	10 Ω	2.5 Meg	10 Ω	5 Meg	10 Ω	10 Meg
SMS-18	RN-60	1/8	250	10 Ω	500K	10 Ω	1 Meg	10 Ω	2 Meg	10 Ω	2 Meg

HERMETICALLY SEALED DEPOSITED CARBON RESISTORS (70°C AMBIENT TEMP. AT FULL LOAD)

SMS-2	RN-80	2	750		50 Ω	20 Meg	50 Ω	20 Meg	50 Ω	20 Meg
SMS-1	RN-75	1	500		10 Ω	10 Meg	10 Ω	10 Meg	10 Ω	10 Meg
SMS-12	RN-70	1/2	350		10 Ω	5 Meg	10 Ω	5 Meg	10 Ω	5 Meg
SMS-14	RN-65	1/4	300		10 Ω	2.5 Meg	10 Ω	2.5 Meg	10 Ω	2.5 Meg
SMS-18	RN-60	1/8	250		10 Ω	1 Meg	10 Ω	1 Meg	10 Ω	1 Meg

WIRE WOUND FIXED RESISTORS ARE AVAILABLE IN TWO SERIES

SERIES M micro-miniature and sub-miniature resistors are non-inductive, vacuum impregnated, absolutely tension-free wound to assure maximum stability, and all connections are microscopically welded. Temperature coefficient is .002% per °C over the range of -65°C to +150°C. Use of a new high-heat epoxy encapsulating material assures high temperature thermo stability. Resistance tolerances are: 1%; .5%; .25%; .1%. Special tolerances may be obtained. Lead size can be varied. Complete environmental tests available. Diameter x length dimensions from .080" x .210" to .210" x .465"; max. wattage from .04 to 25; max. voltage from 50 to 300; max. resistance from 100 K to 2 Meg; and min. resistance from 1 K to .1 ohm.

SERIES 600 are vacuum impregnated, encapsulated and surpass MIL-spec requirements. All Lug types and Radial types have axial mounting hole for #6 screw. Lead wire size #20, other sizes available. Diameter x length dimensions from .250" x .500" to 1.000" x 2.125"; com. wattage from .25 to 2.5; and max. ohms from 2 meg. to 25 meg. Special application resistors per customer specifications.

Reliability is inherent through design and craftsmanship in their manufacture.

Standard or non-standard values available for prompt delivery. Field engineers will gladly assist you with technical recommendations.

For additional data write for descriptive literature.

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CIRCLE 137 ON READER-SERVICE CARD

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	CS-902 (Illustrated)	CXB903	CS-900
Frequency Range	2.7-3.3KMC	5.4-6.7KMC	2.2-2.4KMC
Isolation	20db	20.0db	18db
Insertion Loss	0.4db	0.4db	0.4db
VSWR	1.3:1 Max.	1.3:1 Max.	1.3:1 Max.
Power Handling	5KW Peak 5 Watts Avg.	5KW Peak 5 Watts Avg.	5KW Peak 5 Watts Avg.

TIYPICAL PERFORMANCE - CS902

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CIRCLE 176 ON READER-SERVICE CARD

NEW PRODUCTS

3-Phase Inverter 460

For airborne use

Occupying 112 cu in., this inverter supplies 115-v, 400-cps, 3-phase power from 24 to 32 v dc. Output voltage is regulated to $\pm 2.5\%$; frequency is regulated to $\pm 0.1\%$ for load changes. Motor starting overload capacity is 500%. It can supply full output up to 70,000 ft, at temperatures from -54 to 100 C.

Bogue Electric Manufacturing Co., Dept. ED, 52 Iowa Ave., Paterson 3, N.J.

Stripping Machine 458

For braided shielding

Designed to strip braided wire shielding from coaxial cable and shielded wire, this machine is about 12 times as efficient as hand labor. The model 15 can cut shielding lengths from 1/2 to 1-1/2 in.; the

model 35 cuts lengths from 1/2 to 3-1/4 in. Cutting heads for different diameters are readily interchanged. The bench-mounted stripper operates on 115 v, 60 cps.

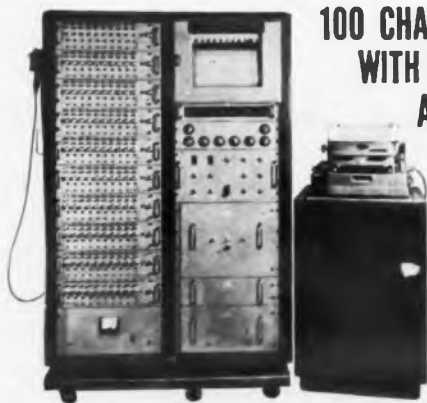
Cadre Industries Corp., Dept. ED, Box 150, Endicott, N.Y.

Compact Relay 375

Mercury-wetted type



The type HGSS provides the same sensitivity, speed, and life of



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ELECTRONIC DESIGN • March 15, 1961

the standard HGS mercury-wetted relay, and is 25/32 in. shorter. A broad range of single-side-stable, bi-stable, or chopper adjustments is available.

C. P. Clare & Co., Dept. ED,
3101 Pratt Blvd., Chicago 45, Ill.
Price: From \$12 to \$5 ea.
Availability: 8 to 9 weeks.

Motor-Generator Set 387

Produces 1,200 cps



Designed for electronic testing, this motor-generator set produces 20 kw at 1,200 cps. The generator is driven by a 40-hp synchronous motor. The alternator rotor has 40 poles and turns at 3,600 rpm. Motor

field can be controlled to produce a leading power factor.

Kato Engineering Co., Dept. ED,
Mankato, Minn.

Cable Connector 376

With strain relief



This miniature connector has cable clamps and strain relief to accommodate a multiconductor cable with shield and strain-relief core. Shell size is No. 14. There are 16 gold-plated No. 20 contacts with solder cup terminations. The aluminum alloy shell has quick-disconnect coupling. Receptacle provides for bulkhead mounting.

Buggie Facility, Burndy Corp.,
Dept. ED, Box 817, Toledo 1,
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CP-70 Style Container

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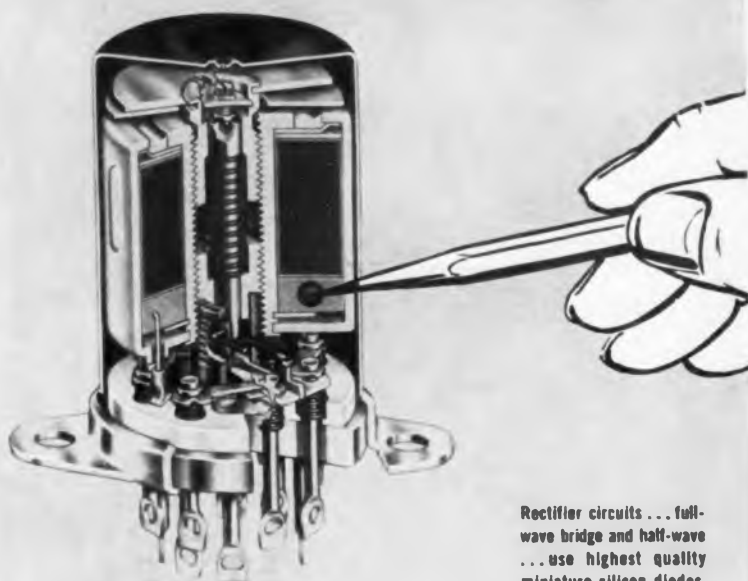
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Relay shown 1½ times actual size

Rectifier circuits . . . full-wave bridge and half-wave . . . use highest quality miniature silicon diodes. Note potted construction.

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These relays are identical in size and weight to Hart's widely specified Series R and S d-c relays and meet the same specifications*. And, thanks to their unique design, they provide the same shock resistance (to 50G), the same vibration resistance (to 20G-2000 cps), and the same performance under temperatures ranging from -65°C to $+125^{\circ}\text{C}$. Contact ratings from dry circuit to 10 amps, 115 volts a-c resistive and 30 volts d-c resistive.

The complete line of "Diamond H" miniature hermetically-sealed relays includes hundreds of models. Contact ratings, pull-in and drop-out times, temperature, vibration and shock ratings, mounting arrangements and other specifications can be varied to meet your particular performance requirements. Ask for descriptive literature and specification list.

*Like the R and S series, they meet the requirements of MIL-R-5757C. Models are also available to fill the requirements of MIL-I-6181.

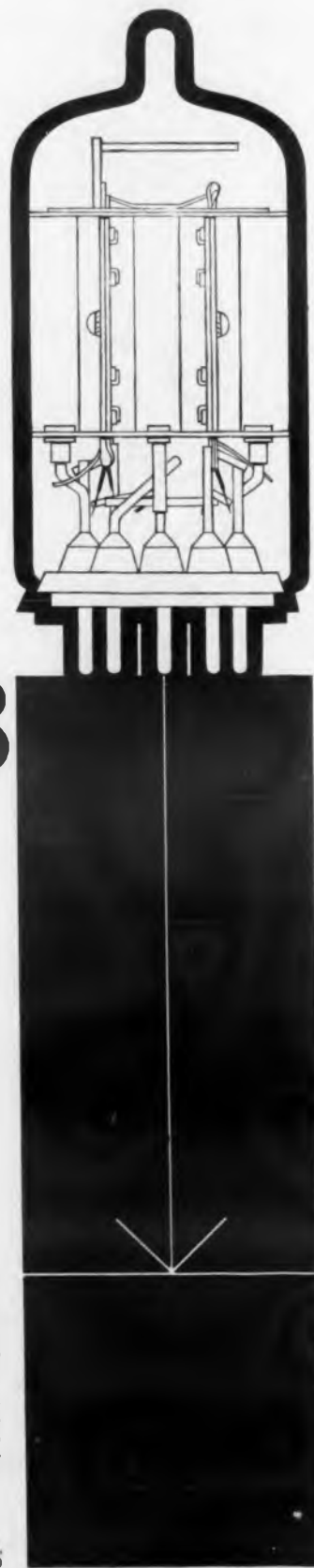
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ECC83

12AX7



high gain double triode

Double Triode having separate cathodes, primarily intended for use as a resistance-coupled amplifier or phase inverter.

characteristics (each section)

V_a	100	250 V
I_a	0.5	1.2 mA
V_g	-1.0	-2.0 V
g_m	1.25	1.6 mA/V
μ	100	100
r_p	80	62.5 k Ω



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TORRINGTON PLACE, LONDON, ENGLAND

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NEW PRODUCTS

RF Coils

378

Q is 100 to 300



These pot-core coils and transformers have a range of 50 kc to 1 mc. For use in hermetically sealed units, they are available variable or fixed. The Q range is 100 to 300. The coils comply with MIL-C-15305A, and operate to 125 C. Stability is 150 ppm per deg C; shock and vibration limits exceed 30 g at 50 to 2,000 cps. Size is 25/32 in. square by 15/16 in. high. Weight is 0.7 oz.

Bulova Watch Co., Inc., Electronics Div., 40-01 61st St., Woodside 77, N.Y.

Price: \$2.50 to \$4 ea, 25 or more.

Availability: 3 weeks.

Temperature Meter

380

With thermistor probe



A glass-tipped probe containing a stabilized thermistor is used to read temperatures within 0.2 F. Rapid response is provided by a sensing element 0.012 in. in diameter. Readings can be obtained between -154 and 554 F; instruments are available with 0.1 to 1.0 C subdivisions, or F equivalents.

Atkins Technical Inc., Dept. ED, 1276 W. 3rd St., Cleveland 13, Ohio.

Insulation Sleeving

405

This insulation sleeving, known as Shur-codes, is available in a complete range of standard and special materials and sizes. They are pre-printed to specifications on one, two or more places around the tubing.

Western Lithograph Co., Westline Products Div., Dept. ED, 600 E. 2nd St., Los Angeles, Calif.

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ELECTRONIC DESIGN • March 15, 1961

M I C R O W A V E S



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RELAY SERVICE:

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TUBES
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OF 23!**

Varian Associates' VA-244 series of reflex klystrons is designed for versatility in microwave relay applications. Three high-performance tubes can do jobs which formerly required 23 different types. They're engineered for flexibility, ideal for equipment in the common carrier bands. Series covers the microwave spectrum from 5.8 to 7.9 kMc. Use VA-244 series klystrons as transmitter tubes with average power output of 1 watt. As local oscillators, they operate at reduced voltages, with average power output of 60 milliwatts. Reliable, exceptionally stable, fully conduction-cooled. Low FM distortion, improved single-screw tuning.



SHOWN ACTUAL SIZE

FREQUENCY RANGE

TUBE #1: VA-244A 5.8-6.6 kMc

TUBE #2: VA-244B 6.5-7.3 kMc

TUBE #3: VA-244C 7.1-7.9 kMc

The versatility of the VA-244 series minimizes manufacturers' and customers' stocking problems. Order in quantity to take advantage of price reductions. For technical data, write Tube Division.



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MICROWAVES

Section on Microwaves

Research advances in submillimeter, IR and optical maser generation are closing the gaps in the upper frequency spectrum. Applied quantum-electronic techniques give us a continuum of devices operating at every frequency. As the report on the opposite page shows, these upper frequencies may be the major communications carriers of tomorrow. The Graham Bells of today (see photo) eschew wire for infrared maser beams.

Microwave developments are burgeoning at all levels: Lenkurt, Waveguide Systems (Div. of Microwaves Associates, Inc.) and Applied Microwave Electronics, Inc. are among the companies who have recently announced the formation of new microwaves groups. Significant contract announcements are made every day.

This issue focuses attention on research—quantum electronics and antiferromagnetics—and on applied technology—design of waveguides, and use of parametric amplifiers.

Quantum electronics in general, and antiferromagnetics in particular, promise submillimeter devices. New tubes for microwave ovens come with a two-year warranty

Microwave Trends 159

Lightweight waveguides capable of handling high amounts of power through pressurization can be designed if ribs are used properly

Design of Pressurized Waveguides With Ribs 164

A simplified method of estimating the surface of a paraboloid antenna

Nomograph for Determining Surface Areas of Paraboloid Devices 168

Parametric amplifiers are classified so that their salient features and disadvantages are apparent. Better understanding could lead to wider applications in the communications field

A Survey of Parametric Amplifiers 170

Microwave products on display at the IRE Show are featured in the section devoted to

Microwave Products 174

CIRCLE 181 ON READER-SERVICE CARD

Quantum-Electronic Devices Extending Microwave Spectrum

DEVELOPMENT of a continuously operating infrared maser, announced last month by the Bell Telephone Laboratories, heralds the rapidly growing significance of quantum electronics to the microwave engineer. Amplifiers and oscillators operating in the IR and optical regions are not mere conjecture; they are a vital necessity—and they are on the way.

With overcrowding of the frequency spectrum reaching critical proportions, the only way out is up. Submillimeter, IR and optical waves could well be major communications carriers by the end of this decade.

Quantum electronics is today the only known possibility for design of communications equipment at submillimeter wavelengths and beyond. All radiation is ultimately a resonance phenomenon. At low frequencies, the designer chooses an LC tank circuit; at microwave frequencies he employs a cavity as the resonant device. For still higher frequencies, however, cavity dimensions become unreasonably small, and the designer must apply resonant mechanisms inherent in the atom itself.

The understanding and application of these mechanisms constitute the science of quantum electronics. Its unusual potential has so far been recognized primarily by physicists, who are responsible for the major part of the pioneering research and device design in this field. In fact, designers have been presented with an extensive body of knowledge and an unusual collection of rudimentary devices to be used as a starting point for development.

The roster of electronic companies now actively developing quantum electronic devices is ample indication of the opportunities in this field. Such companies include: Hughes Aircraft Co., Bell Telephone Laboratories, Raytheon, Westinghouse, Varian, Radio Corp. of America, Martin, International Business Machines, Airborne Instruments Laboratory.

The range of applications envisioned for quantum electronic devices operating in various areas of the spectrum is equally diverse. Typical examples are:

- Point-to-point and relay communication links using visible light.

- Circular waveguides and optical fiber transmission of modulated light.

- Simultaneous transmission of a complete image by spatial modulation of an optical maser beam.

- Interplanetary communication.

- Light radar, both for space and anti-submarine warfare.

- Radio and radar astronomy.

- Ultra-sensitive radar receivers, both for ground and airborne applications.

- Control of chemical processes by visible or infrared radiation.

- Completely noiseless photodetectors.

- High speed computers.

- Ultra-stable time and frequency standards.

- Extremely accurate measurement of distance and other physical quantities.

The most important immediate major application of quantum devices will probably involve high volume data transmission. Optical or IR masers may well be in general use for this purpose by the 70's, predicts Dr. John R. Singer of the University of California.

"It will be a welcome change to find a region which the Federal Communications Commission has not yet assigned. For microwave type of relay stations or by transmitting the waves through fine glass or quartz rods, the IR and optical region may become invaluable. It is not difficult to foresee the time when much of the transcontinental communication in the U.S. may be done along optical channels."

Dr. Singer is Chairman of the Second Quantum Electronics Conference, which will be held March 23-25 at Berkeley, Calif. At the first conference, in Sept. 1959, scientists only ventured to predict the feasibility of optical masers. The forthcoming conference will discuss a number of such devices now operating as well as other exotic applications of quantum electronics that may be realizable in the near future.

For a preview of this important conference, a state-of-the-art report on quantum electronics, and a survey of latest quantum devices and systems, turn to the Staff Report on quantum electronics in the News section of this issue. ■ ■



Phone conversation over continuous infrared maser beam is demonstrated by Ali Javan (left) and William Bennett, who developed this first cw device at Bell Telephone Laboratories. Time-sequential and spatial modulation methods to enable fullest utilization of maser bandwidth are under study at Bell and elsewhere.

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NEWS

Mm-Wave Devices With Researchers Show a 175-Kmc Isolator Using Chromic Oxide

RESONANCE isolators operating in the millimeter wave region and beyond are emerging from research into antiferromagnetic materials at the Lincoln Laboratory of the Massachusetts Institute of Technology.

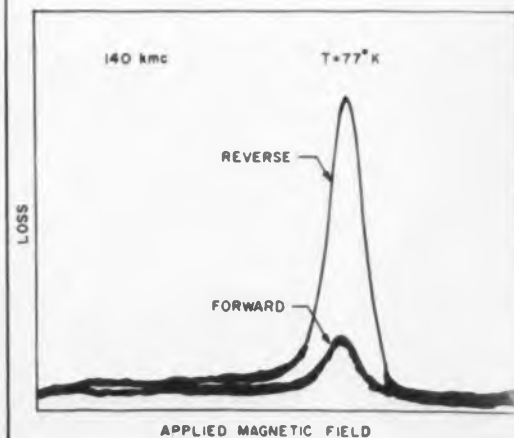
This new class of materials could also make possible development of modulators, phase shifters and circulators for the submillimeter and far infrared portions of the spectrum.

Lincoln physicists have already demonstrated an isolator with a reverse-to-forward loss ratio of 20 to 1 at 175 kmc. This device employs chromic oxide in a straightforward isolator configuration.

Research Is Emphasized Rather Than Devices

No attempt was made to obtain optimum performance from the unit, though later versions will undoubtedly show greater care in crystal shaping, position and dielectric loading. Present emphasis is on materials research rather than device development.

"The figure of merit of this isolator is comparable to that of early, unsophisticated ferrite components," Dr. Gerald Heller of the laboratory's resonance physics group told ELECTRONIC DESIGN. "With proper attention to design, per-



Isolator performance at 140 kmc shows a quality factor of approximately 10. Device employed chromic oxide at 77 K and 10,000-gauss field. The isolator was built to prove feasibility rather than to attain the much higher quality factors theoretically possible. Other devices have been operated at 175 kmc with similar performance.

Antiferromagnetics

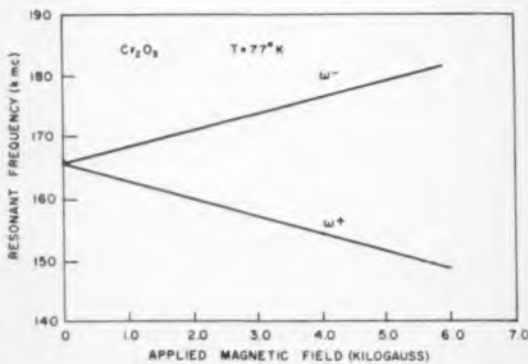
formance of antiferromagnetic devices should be comparable to that of ferrite units, but, of course, at much higher frequencies. The chromic oxide has a theoretical figure of merit of 70."

Low temperatures appear necessary to operate millimeter wave antiferromagnetic devices. At still higher frequencies, however, it may be possible to approach room-temperature operation. Materials studied thus far for millimeter waves are chromic oxide and manganese fluoride. Since operating frequency increases according to the strength of the applied magnetic field, reasonably attainable fields (under 5,000 gauss) limit these materials to the 1-to-2-mm range.

Higher-Frequency Operation Will Require New Materials

Materials suitable for higher frequencies have yet to be found, but Dr. Heller points out that relatively little attention has been given to the study of antiferromagnetism at higher frequencies. This is because of the absence of oscillators operating in the millimeter and submillimeter regions. As such oscillators are developed, study of the materials should uncover a number of suitable antiferromagnetic compounds, Dr. Heller believes.

An antiferromagnetic material exhibits two possible directions of magnetic alignment, with its molecules equally divided between these di-



Antiferromagnetic resonance curves for chromic oxide illustrate high-frequency possibilities of these materials. Note that at zero applied magnetic field, resonant frequency is approximately 165 kmc. By increasing the magnetic field, frequency can be varied considerably in either direction, depending on which of the two curves is selected.



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rections. Ordinary ferrite materials, by contrast, have only one preferred alignment direction.

Because of their high internal fields, antiferromagnetics have natural resonant frequencies in the millimeter and submillimeter range. These frequencies are tunable by moderate, external magnetic fields. Ferrites, with their weaker internal fields, would resonate at high frequencies only in the presence of very strong external fields.

High Resonant Frequencies At Zero External Field

As shown in the accompanying diagram, antiferromagnetics exhibit high resonant frequencies at zero external field strength. Application of an external field then results in two divergent resonant curves. Designers would probably utilize the ascending curve in building high-frequency components.

Line widths of antiferromagnetic materials are said to be on the order of several hundred gauss at the desired frequencies. This suggests their application in high-frequency circulators, thereby avoiding the deterioration of line widths evident in ferrite circulators at low temperatures.

Litton Tube Enters Microwave Oven Field

The Tappan Co., largest producer of domestic electronic ranges, has introduced a new model for 1961, using a microwave cooking unit produced by Electron Tube Div., Litton Industries.

Dubbed the Microtron, the new unit by Litton comes with a 24-month warranty. Costs have been reduced, so that Tappan is selling the new range at \$795. This is \$100 lower than the 1960 unit equipped with Raytheon microwave units.

Although wide sale of domestic microwave ovens could lead to the largest demand for almost any single type of microwave tube—ten to a hundred thousand a year—industry experts do not feel the market will develop overnight. Several thousand are expected to sell this year.

Actually Tappan (and others interested in microwave ovens—Hotpoint sells a unit, Westinghouse and Whirlpool are Raytheon licensees) want to move cautiously. Reliability is a key concern—sales potential would be hurt if \$200 to \$250 electronic replacements were needed

MICROWAVES

As frequency is increased, the effective Curie temperature for these materials is also raised.

Tailor-Made Materials Possible Through Substituted Compounds

New materials being studied at Lincoln Laboratory include substituted compounds. Small quantities of aluminum in chromic oxide, for example, should enable operation of devices near 1.3 mm. It may thus be possible to design materials for given frequency ranges by suitable additions to various antiferromagnetics. The best possibility to date for higher-frequency operation is manganese fluoride, which appears useful in the 1-mm region at liquid helium temperatures.

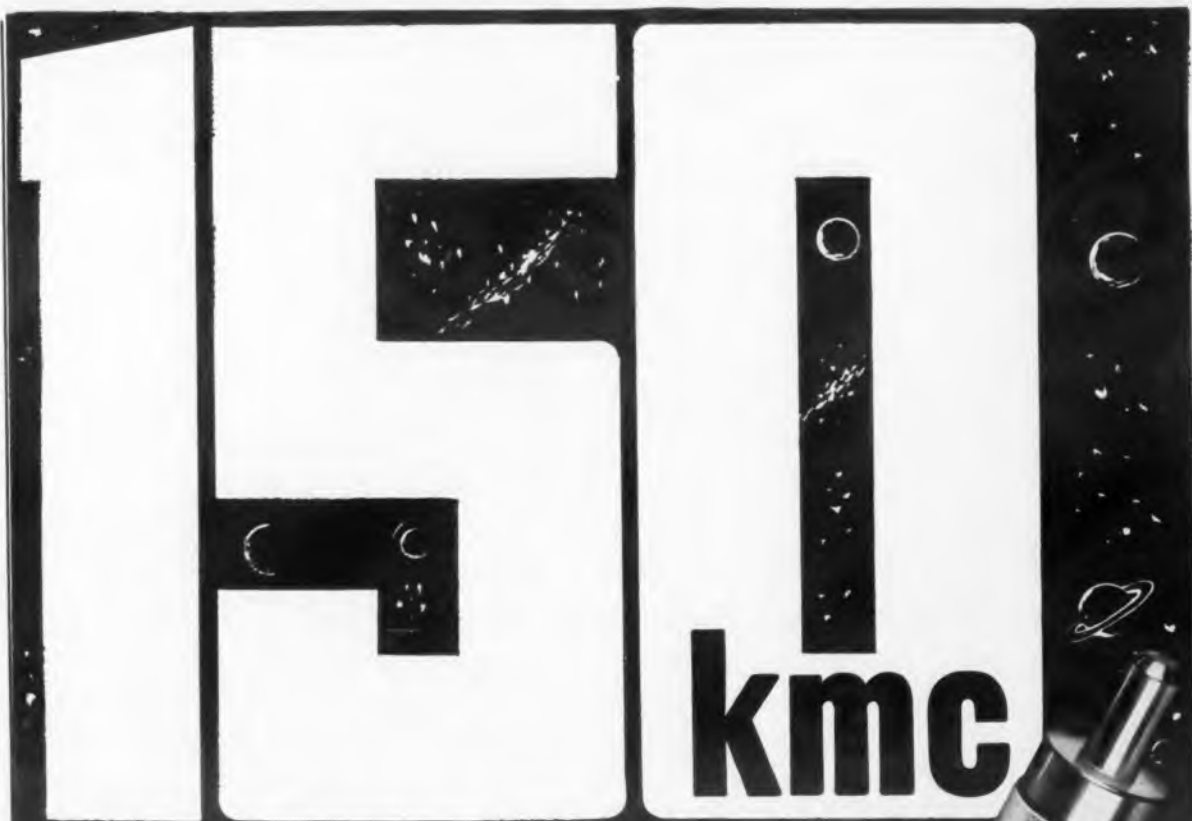
Other organizations reportedly studying antiferromagnetics include Philips Laboratories, Irvington-on-Hudson, N.Y., General Electric Research Laboratories, Syracuse, N.Y., and the Naval Ordnance Laboratory, Silver Spring, Md. The research emphasis at these groups is on study of resonance properties of these materials. Lincoln Laboratory, however, has been the first to report on devices utilizing antiferromagnetic compounds. ■ ■

every few years. It also takes some experience to cook with microwave and range manufacturers do not want to oversell the good features. A full variety of frozen foods is not yet available and this makes a microwave oven not the ideal answer at this time. It is not a substitute for conventional ranges.

Home economists are reluctant to endorse microwave ovens at this time, but neither will they criticize current models. They have adopted a quiet let's-wait-and-see attitude.

Sales will probably show a sharp rise when units can be sold for \$500. The magnetron and accessory equipment will have to be produced for about \$125. This prospect is not in the immediate offing. Since prices will not come down until real mass production can be effected there may come a point when some pump priming will be applied.

The Litton Microtron power pack consists of a magnetron, high-voltage, filament and isolation transformers, and an electromagnet and filter assembly. In addition to the two-year warranty the Litton tube has a fast warm feature. ■ ■



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Sym.	Parameter	Test Conditions	AP-1	AP-2	AP-3	AP-4	AP-5	AP-6	Unit
BV_r	Reverse Breakdown	$I_r = 10 \mu A$	6.0 min for Entire Series						v
C_j^*	Total Capacitance	$V = 0, f = 1mc$	5 to 1.5 for Entire Series						μF
Q^{**}	Figure of Merit	$V_r = 2v, f = 10 kmc$	6 min	7 min	9 min	11 min	13 min	15 min	
f_{co}	Cut-off Frequency	$V_r = 2v$	60 min	70 min	90 min	110 min	130 min	150 min	kmc

*Case Capacitance is 0.4 μF nominal.

** $Q = \frac{f}{f_c} = \frac{1}{2\pi C_j R_s}$ where C_j is the junction capacitance measured at -2.0 volts



MICROWAVES

Design of Pressurized Waveguides With Ribs

Pressurization of a waveguide increases its power-carrying capacity. We urgently need higher power waveguides, but they must also be lightweight. Mr. Olivieri, a senior engineer at Sperry, shows how to design lightweight cast waveguides with ribs so that high pressure can be introduced without high dimensional distortion.

Daniel Olivieri
Sperry Gyroscope Co.
Great Neck, N.Y.

WAVEGUIDES with ribs can be lightweight, yet able to withstand a high degree of pressurization. Since the potential at which breakdown occurs is a function of the pressure within the guide, ribbed waveguides can handle great amounts of power without breakdown. The analysis and design procedure which follows permits the designer of cast waveguides to deter-

mine the size of the rib, the spacing between ribs, and related wall thickness.

Electrical requirements dictate design parameters such as the maximum allowable deflection in a waveguide wall, the internal dimensions of the waveguide and the air pressure. Minimum wall thicknesses are generally established by foundry requirements which take into consideration, among other things, size of casting, gating, and flow temperatures.

However, the distance between ribs, l , and the

height of the rib, h , Fig. 1, permit the waveguide to take the required pressurization. Suitable values for l and h depend on other dimensions of the waveguide. Typical values of minimum walls for standard waveguides are included in Table 1.

The variables l , h , and t fully describe the ribbed structure as represented in Fig. 1. The thickness of the rib and the wall are made equal in conformance with good foundry practices.

There are two steps in the design procedure.

1. Determining the deflection of a plate section (dimensions a , l , and t) which is uniformly loaded by a pressure, p .
2. Determining the deflection of a tee section (dimension $l + t$, t , a , and h) uniformly loaded by a pressure, p .

An exaggerated picture of the deflections of a ribbed waveguide subjected to an internal pressure, p , is shown in Fig. 2.

Step 1. Determine the deflection of the plate section. The maximum stress, S_{max} , and maximum deflection, $Y_{p,max}$ of a plate with fixed edges are given respectively by the following relations:^{1,2,3}

$$S_{max} = \frac{\phi p l^2}{t^2} \quad (1)$$

$$Y_{p,max} = \frac{\theta p l^4}{E t^3} \quad (2)$$

Symbols

a = broad wall of rectangular guide — in.	I = moment of inertia — in ⁴ of the tee section
b = narrow wall of rectangular guide — in.	Z = section modulus — in ³
p = internal pressure — psi.	ϕ = constant depending on ratio of a/l
t = waveguide wall and rib thickness — in.	θ = constant depending on ratio of a/l
h = height of the rib — in.	ν = Poisson's ratio
S_{max} = max. allowable stress — psi.	K = load — lb/unit length (in.) = $p(l + t)$ for the tee section
$Y_{p,max}$ = maximum allowable deflection of the plate section — in.	A = area in ² of a section making up the tee section
Y_a = total allowable deflection of wall — in.	A' = area in ² of tee section
y_r = deflection of tee section — in.	y = distance from neutral axis to outer fiber of section making up tee section
M = bending moment — lb.-in.	\bar{y} = distance from neutral axis to outer fiber of tee
E = modulus of elasticity — psi.	d = distance — in from the neutral axis of a section in the tee to the neutral axis of the tee section
I_o = moment of inertia — in ⁴ of areas making up the tee section	

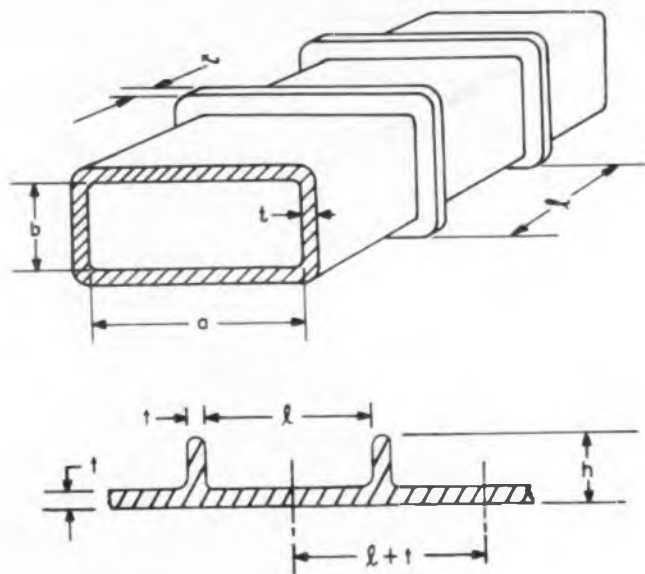


Fig. 1. Ribbed waveguides showing dimensions.

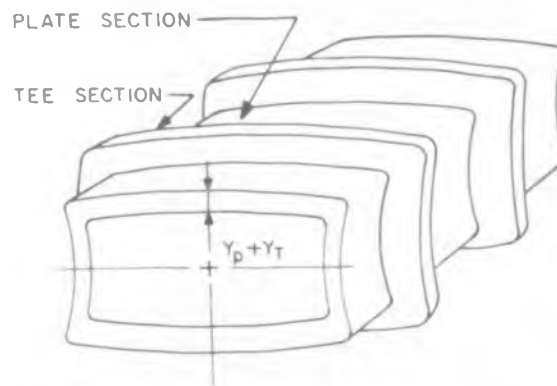


Fig. 2. Exaggerated picture of deflection due to internal pressure.

Table 1 Typical Values of Minimum Walls For Standard Waveguides

Inner Dimensions (in.)		Suggested Min. Wall Thickness (in.)
a	b	t
21.000	11.500	0.250
6.500	3.250	0.156
4.300	2.150	0.156
3.400	1.700	0.125
1.872	0.872	0.093
1.372	0.622	0.093
1.122	0.497	0.093

The parameters, ψ and ϕ , constants depending on the ratio of a/l , are plotted in Fig. 3. Values of ψ and ϕ can be found over the a/l range of 1 to 2. Since curves ϕ and ψ are asymptotic in the region of $a/l = 2$, values of a/l greater than 2 are assumed equal to $a/l = 2$.

It should be pointed out that the graph of Fig. 3 is based on Poisson's ratio of $\nu = 0.3$, which is the value commonly associated with steel. Since microwave components are generally constructed from aluminum or brass, and have a Poisson's ratio of $\nu = 0.33$, a small adjustment may be in order. To make this correction all values of Y_p could be multiplied by 1.021, since the deflection Y_p of the plate is a function of the "flexure rigidity." However, this very small adjustment is justifiable only in cases of large deflections.

The spacing between ribs, dimension l , can now be evaluated from Eq. 1. Variables t and ϕ are selected from the table of minimum wall thickness and the graph Fig. 3, respectively. The

value of l so obtained is obviously a maximum. To make certain that the allowable deflection is not exceeded, Eq. 2 is solved for maximum plate deflection.

Step 2. Determine the deflection of the tee section. This step leads to an unknown h , the height of the rib. In investigating the deflection of the tee section, it is assumed that this cross-section of the waveguide structure can be likened to a continuous beam⁴ uniformly loaded. This results in the bending moment at any corner or point of support to be.

$$M = \frac{(a^2 + b^2) K}{12(a + b)} \quad (3)$$

The deflection at the midpoint due to this moment and the uniform load is

$$y_T = \frac{5Ka^4}{384EI} - \frac{Ma^2}{8EI} \quad (4)$$

Since the plate design is based on all edges being fixed, y_T should approach zero. However, if y_T is made to approach zero h must become infinitely high. The practical approach is to allow the beam to deflect approximately 0.001 in. which is measureable with standard inspection gages. Experience has shown a larger deflection causes the plate theory to break down.

With y_T equal to or less than 0.001 in., this value substituted into Eq. 4 yields the required moment of inertia of the tee section since

$$I = \sum I_a + \sum Ad^2 \quad (5)$$

The last of the unknowns, h , is then found. Where

$$\sum I_a + \sum Ad^2 = \frac{(l+t)t^3}{12} + \frac{t(h-t)^3}{12} \quad (6)$$

$$+ (l+t)t \left(\bar{y} - \frac{t}{2} \right)^2 + t(h-t) \left(\frac{h+t}{2} - \bar{y} \right)^2$$

$$\text{and } \bar{y} = \frac{\sum Ay}{A'} \quad (7)$$

$$\bar{y} = \frac{1}{2} \frac{h^2 - t^2 + t(l+t)}{h+t} \quad (8)$$

Eq. 6 entails the handling of a fifth order polynomial which could prove cumbersome if a computer is not used. In lieu of the computer, a graphical approach proves satisfactory as shown in the illustrative problem given later.

When h is found, a check (using the flexure equation) should be made to make certain the allowable stress is not exceeded. Namely

$$y_T = \frac{S}{Z} \quad (9)$$

In the event the allowable stress is exceeded, the preferable parameter to increase is h .

It is possible, due to high pressure requirements, that the calculated value of h may project beyond the flange boundary. In general this could prove to be undesirable and in order to restrict h to a value equal to or less than the flange height it may be necessary to increase the rib thickness. However, in order to conform to the foundry requirement that all wall thicknesses be the same it would be preferable to reduce l so that the unit load in the tee section is reduced

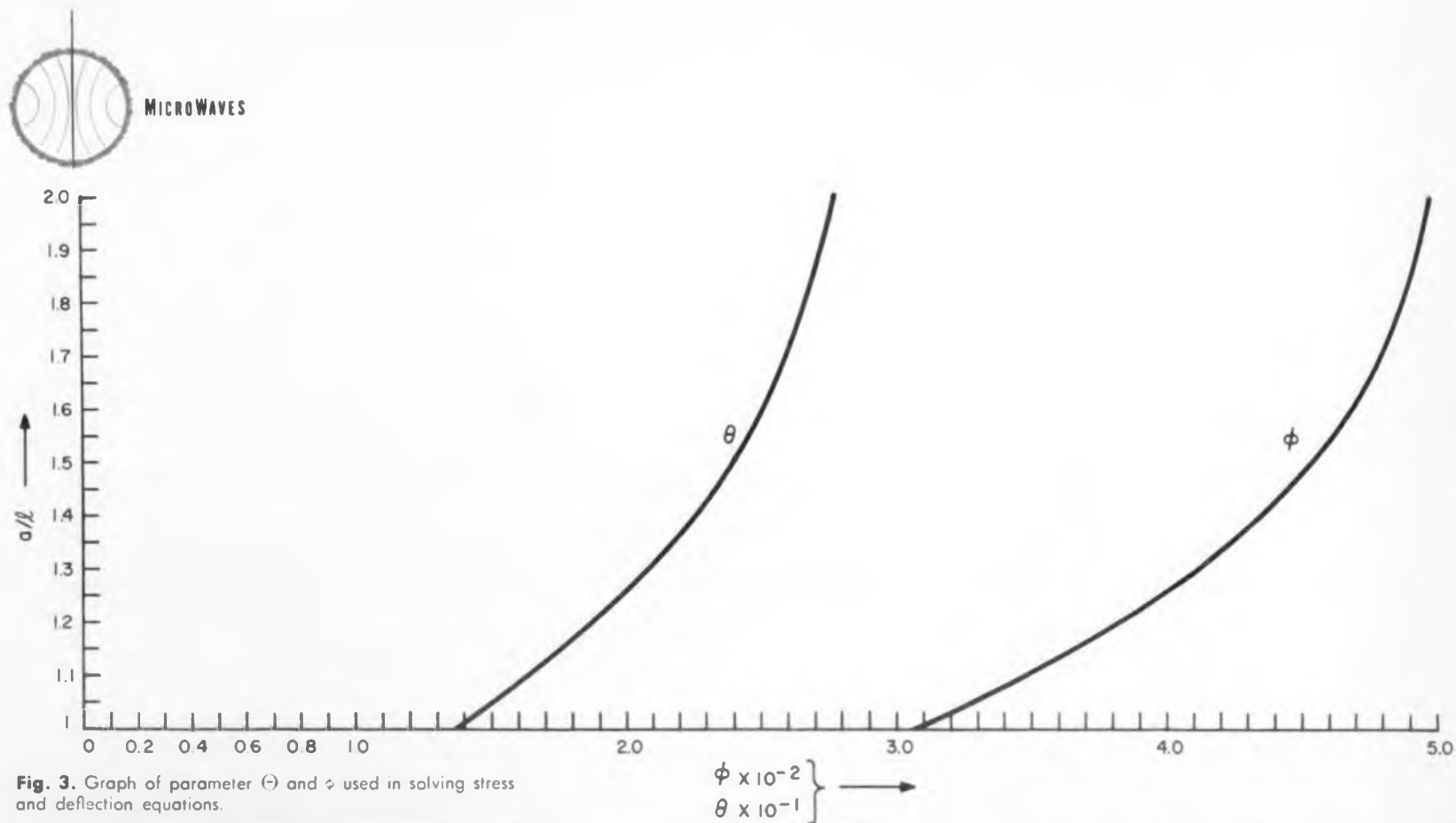


Fig. 3. Graph of parameter θ and ϕ used in solving stress and deflection equations.

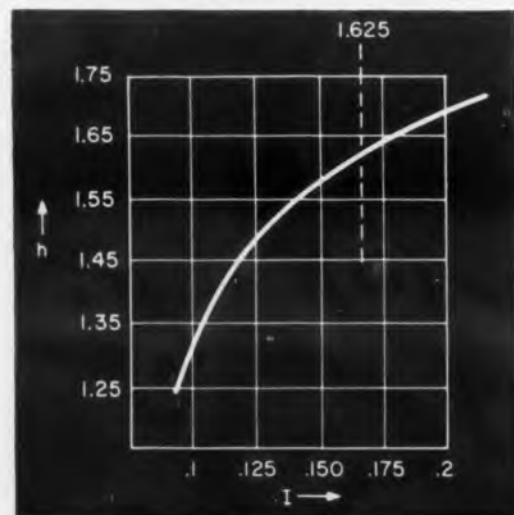


Fig. 4. Solution of h , height of rib, in terms of moment of inertia.

and, in turn, lowering the value of h . Obviously, good judgment must be used with this design procedure.

All equations used above are valid if: 1. The deflections of the plate are small and the maximum is not more than one-half the wall thickness,¹ 2. The plate or tee section is nowhere stressed beyond the elastic limit, and 3. The deflection of the tee section is restricted to a value of not more than 0.001 in.

Some possible values for maximum allowable stresses for both aluminum and brass castings

Table II Maximum Allowable Stresses For Aluminum and Brass

Material	Max. Allowable Stress (S)		Modules of Elasticity (E)
	Tension psi	Compression psi	
Alumu. 7% Si, Stabilized	15,000	16,000	10^7
Silicon Brass	30,000	35,000 psi	1.6×10^7
Leaded Brass	14,000	18,000	1.2×10^7

with their moduli of elasticity are given in Table II.

Throughout this analysis, reference is made to the broad wall of the waveguide only. The narrow wall can be ignored since it obviously is stronger than the broad wall and in any case, the rib will go completely around the waveguide.

This analysis may also apply to the problem of keeping the walls of extruded rectangular waveguides from deflecting beyond the allowable value. In this application bands are welded or brazed around the guide with appropriate spacing between the bands. ■ ■

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3. Tables of Moments and Deflections for a Rectangular Plate Fixed at All Edges and Carrying a Uniformly Distributed Load, Am. Soc. Mech. Eng. Jour. Appl. Mech., Vol. 6 No. 1, March, 1939.
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Sample Problem

Required: An aluminum waveguide casting (7% si.) with internal dimensions of $a = 6.5$ in. and $b = 3.25$ in. capable of withstanding internal pressurization of $p = 30$ psi. The suggested wall thickness $t = 0.156$ in. and the maximum allowable deflection of the waveguide wall is $Y_c = 0.016$ in.

Solve, first, Eq. 1. Determine ϕ from the ratio of a/l . Assume various ratios by trial and error until the maximum stress for the material in either tension or compression, whichever is lower, approximates the allowable stress. This approach will obviously make l a maximum.

Assuming $a/l = 1.1$ (since $a = 6.5$ in., $l = 5.9$ in.) find $\phi = 0.348$ from the graph Fig. 3. Substituting these values in Eq. 1.

$$S_{max} = \frac{(0.348)(30)(5.9)^2}{0.156^2} = 14,933 \approx 15,000 \text{ psi}$$

From Eq. 2 and from Fig. 3, for a ratio of $a/l = 1.1$, $\phi = 0.0164$

$$Y_{p,max} = \frac{0.0164(30)(5.9)^4}{10^7(0.156)^3} = 0.015 \text{ in.}$$

which is less than the allowable 0.016 in. and permits the 0.001 in. allowable deflection for the tee section. Substituting $y_r = 0.001$ in Eq. 4 yields the required l .

$$l = \frac{5(30 \times 6.056)(6.5)}{384 \cdot 10^7(0.001)} = \frac{480(6.5)^2}{8(10^7)(0.001)} = 0.170 \text{ in}^4$$

$$\text{where } M = \frac{(30 \times 6.056)(6.5^2 + 3.25^2)}{12(6.5 + 3.25)} = 480 \text{ in lb}$$

In order to avoid solving the fifth order polynomial $h = 1.25$ is assumed and substituted in Eq. 5 where

$$\bar{y} = 1/2 \left[\frac{1.25^2 - 0.156^2 + 0.156(5.9 + 0.56)}{1.25 + 6.056} \right] = 0.104$$

and

$$I = \frac{6.056(0.156)^3}{12} + \frac{0.156(0.125 - 0.156)^3}{12} + 6.056(0.156) \left(0.014 - \frac{0.156}{2} \right)^2 + 0.156(1.25 - 0.156) \left(\frac{1.25 + 0.156}{2} - 0.104 \right)^2 = 0.0811 \text{ in}^4 \text{ which is less than } 0.170 \text{ in}^4$$

Therefore try $h = 1.5$ and in the same manner as above substitute in Eq. 5 which yielded $I = 0.124 \text{ in}^4$ which is still too small. A third try is made with h assumed to be 1.75 which yield $I = 0.206 \text{ in}^4$ which proves greater than 0.170 in⁴.

A graph is plotted in Fig. 4 of the values obtained with h as the ordinate and I the abscissa which indicate that at $I = 0.170 \text{ in}^4$, h must be approx. 1.625 in, substituting in Eq. 5 for a check yields:

$$I = 0.177 \approx 0.170 \text{ which is close enough.}$$

It is interesting to note that if a thick wall casting was made in lieu of the rib section designed above, the required wall thickness would be 0.276 in. minimum. This indicates a saving of 30 per cent in weight.

Actual test on a waveguide with inner dimensions of $a = 6.5$ in., $b = 3.25$ in. wall thickness $t = 0.156$ in., $h = 1.093$ in. length $l = 5.900$ in. and rib thickness of 0.25 in. showed that for a pressure of 11.6 lb the actual deflection (Y_c) was 0.007 in., as compared to the calculated value of 0.007 in.

Obviously this data comparison cannot be construed to mean that the design procedure is 100 per cent accurate, since the accuracy of the measuring instrument and the uniformity of the cast thickness of the waveguide have not been incorporated in this observed data. It is felt that accuracies of 10 to 20 per cent can be expected.

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TYPICAL SOLID-STATE SOURCE CHARACTERISTICS

frequency accuracy	Crystal, Standard models 0.005%
frequency stability	0.005%
band pass	1% to 5% up to 3 kmc Less than 1% above 3 kmc
spurious frequencies	Down 30-40 db
output impedance	50 ohms
primary power requirements	28 v dc positive; power requirements, 1-20 watts depending on frequency and power output; 28 v regulated power supply operating from 115 v 60 cps or 400 cps can be provided.

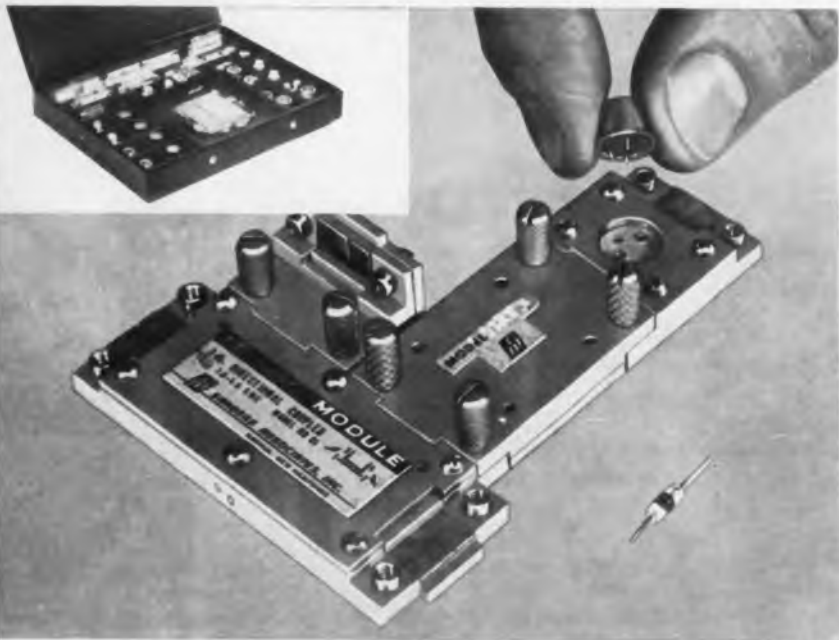
Harmonic generators — to frequency multiply existing power outputs to frequencies as high as 20 kmc — are also available. For details on TI's Solid-state microwave sources and harmonic generators, write for Bulletin No. DLA-1218. For information on other microwave devices contact MARKETING DEPARTMENT.

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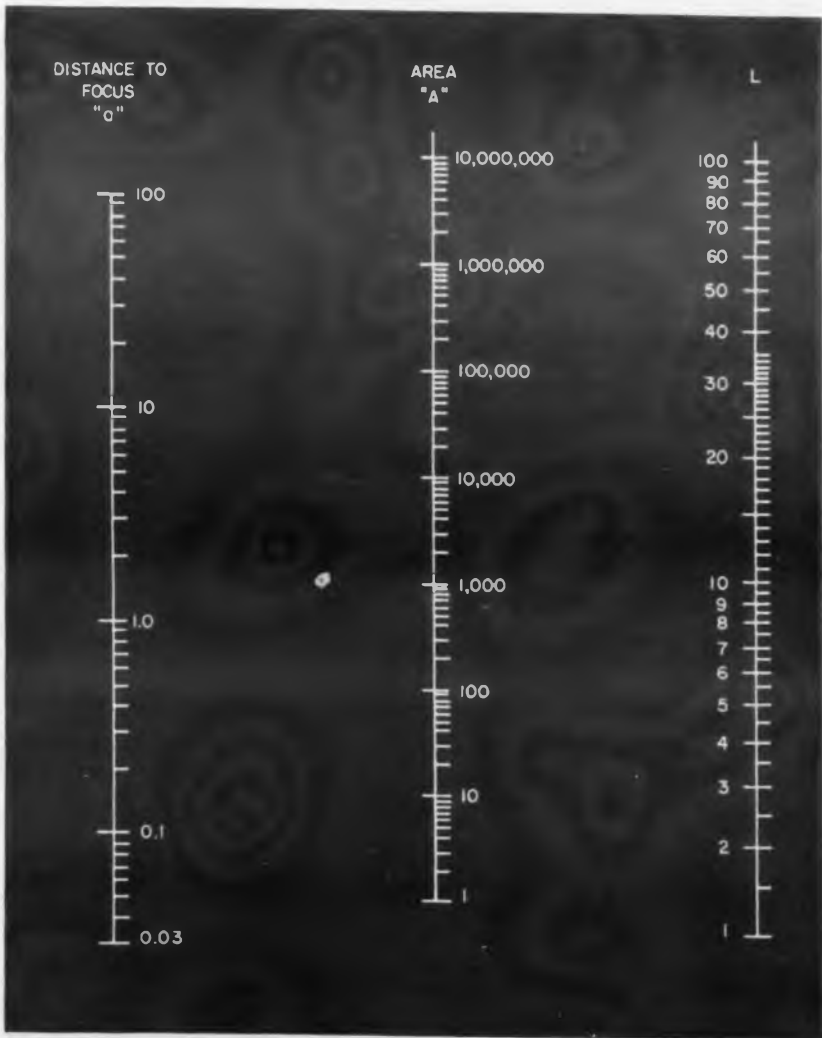
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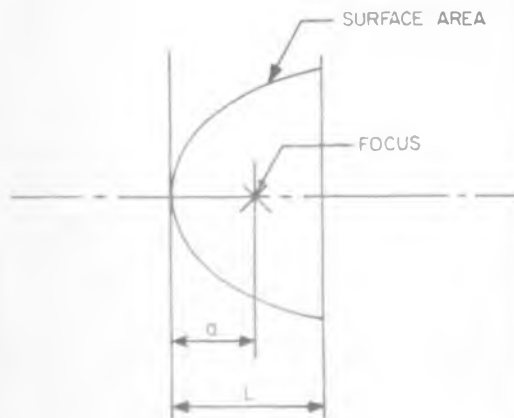
Product Manager, Microwave Products Dept., NASHUA, NEW HAMPSHIRE
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MICROWAVES

Nomograph for Determining Surface Areas of Paraboloid Devices





Robert L. Peters
Consultant
San Francisco, Calif.

THE NOMOGRAPH presents a simplified method of estimating the surface of a paraboloid such as those used in many antenna and optical devices. Often, determination of such a surface requires numerous calculations. By use of a ruler or other straight edge the area may be estimated by this chart without excessive computations. While this chart is intended for initial design calculations, it will be found to be very helpful in optimization in conjunction with other calculations.

To Use The Chart

1 Select the correct distance to focus "a" (as shown on the diagram) on the left line.

2 Select the correct length "L" on the right line.

3 Connect these values with a ruler indexing the centerline at the answer.

Small scale devices may be measured in inches while large scale units may be measured in feet thus allowing greater input-output variation. The metric scale may also be used. However, the selected unit of measure must be standardized throughout each calculation.

Input in inches for "a" and "L" will result in square inches output for "A." Input in feet will result in output of square feet.

This chart allows rapid design changes and numerous calculations simply by pivoting the ruler over desired range of variations. Many otherwise tedious computations are reduced to straight-edging selected values on the related lines. ■ ■

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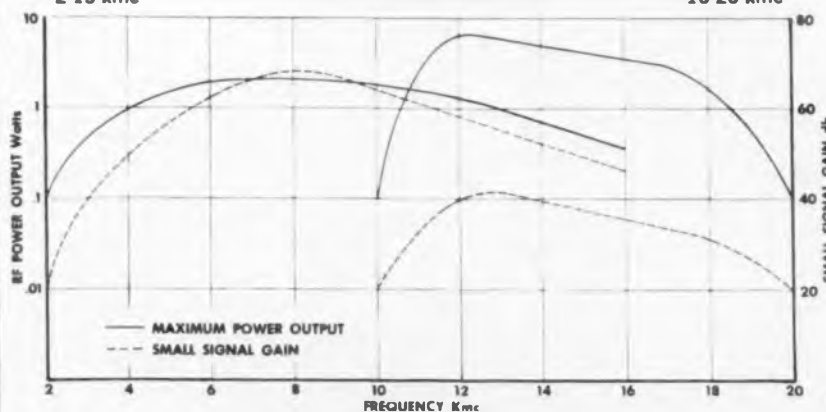
TWT AMPLIFIERS



Model T601
2-15 kmc

TYPICAL CHARACTERISTICS

Model T602
10-20 kmc



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A Survey of Parametric Amplifiers

Parametric amplifiers, because of their low noise, have been a boon to radar and satellite engineers. On the other hand, communications engineers have found their limitations a drawback. To put both advantages and limitations in perspective, Mr. Szirlip has compiled this survey.

A. Szirlip

Packard-Bell Electronics
Los Angeles, Calif.

LOW-NOISE rf amplifiers using varactor diodes have been used extensively in radar and satellite operations in the past few years; but due to practical limitations and engineering compromises, there has been less application in the communication field. Lack of acceptance in the communication field is a result of tuning complexity, instability, poor intermodulation (im) distortion rejection of the uhf amplifiers and the tendency of these amplifiers to saturate at low power levels.

In this article an attempt is made to classify these amplifiers, indicate their salient features, and examine some of the problem areas.

The amplifiers can be divided into two main groups: those having the same input and output (untranslated) frequency and those with a change (translated) in the frequency from the input to the output. (Although these configurations have been referred to as "one-port" and "two-port" amplifiers respectively, this terminology has sometimes proven misleading.) Each of the two groups can be further divided into amplifier types representing other prominent amplifier characteristics as shown in Table 1, Figs. 1, 2, 3, 4, 5, 6, and 7.

Before discussing the individual types, it may

help some readers to indicate why they were grouped into one family. There are two principle features that exist in all of these amplifiers; one is the mechanics of operation and the other is the resulting four-frequency spectrum. The mechanics of operation is indicated by the coined name, MAVACR, meaning a Mixer Amplifier using Variable Capacitor Reactance as its active element. The four-frequency spectrum is the result of mixing products and is seen in the amplifier across the varactor diode. This spectrum shows the typical mixing products (see Fig. 8) that consist of the pump minus the signal (difference idler) and the pump plus the signal (sum idler) together with the signal and pump frequencies. The basic circuit using the four frequencies of this spectrum is shown in Fig. 9. These circuit parameters can be modified. For instance, either the sum or difference idler elements can be removed, or, as found in the single-resonance parametric amplifier, the difference idler circuit is made to use the same element as the signal, or, as in the dual-resonance parametric amplifier, the pump signal appears on the signal cavity circuit.

Single-Resonance Parametric Amplifier

The single-resonance parametric amplifier, Fig. 1, was one of the first amplifier types made commercially available. In this amplifier the differ-

ence idler has the same circuit elements as the signal, and the sum idler is suppressed. The pump generator usually is connected directly to the varactor diode without the use of a pump-tuned circuit. Since the difference idler is at the same frequency as the signal, and this difference idler is the product of the pump frequency minus the signal frequency, the pump frequency must be two times the signal frequency ($2f_0$). The pump frequency is deliberately set slightly off the $2f_0$. This is necessary because with a pump frequency of exactly $2f_0$, the resulting idler phase

may cause de-amplification by being 180 deg out-of-phase with the signal. Experiments with this characteristic of amplification to de-amplification through phase relation of the signal and pump frequencies have been performed in the design of some high-speed computers.

A change in the amplifier operating frequency requires pump tracking and readjustment of the signal circuit elements. Upon loss of pump power, the amplifier displays fail-safe characteristics. When this occurs, the input signal can continue through the amplifier, although at some

power loss. The noise figure for this type of amplifier must be greater than 3 db. This approximate noise figure has been developed in past theory and is shown mathematically as:

$$NF \approx 10 \log \left[1 + \frac{f_p}{f_s} \right] \quad (1)$$

Since the idler and signal are at the same frequency, Eq. 1 shows 3 db. Noise figures of less

TABLE I MAVACR CLASSIFICATION AND CHARACTERISTICS

FREQUENCY INPUT TO OUTPUT	TYPE	IDLER MODE	IDLER FREQUENCY	PUMP FREQUENCY	PUMP POWER MW	BANDWIDTH	NOISE FIGURE	GAIN	CIRCUIT BLOCK DIAGRAM	
									FIGURE	
									C - CIRCULATOR Iso - ISOLATOR PA - PARAMETRIC AMPLIFIER ID - IDLER	
NONTRANSLATED	SINGLE RESONANCE	DIFFERENCE	f_0	$2f_0$	10 TO 500	1-10%	>3	0.10-20		1
	DUAL RESONANCE	DIFFERENCE	$f_p - f_0$	$n f_0$	10 TO 500	1-10%	≥ 0.5 2.5	0.10-20		2
	NONDEGENERATIVE	DIFFERENCE	$f_p - f_0$	$f_0 \ll f_p$	10 TO 500	1-10%	>0.5	0.10-20		3
	TRAVELING WAVE	DIFFERENCE	f_0	$2f_0$	60-3000	10-100%	>3	0.5-10		4
TRANSLATED	DIFFERENCE MODE	DIFFERENCE	$f_p - f_0$	$f_0 \ll f_p$	10 TO 500	1-10%	>0.5	0.10-20		5
	SUM MODE	SUM	$f_p + f_0$	$f_0 \ll f_p$	10 TO 500	1-10%	>0.5	$10 \log \frac{f_1}{f_0}$		6
	SUM AND DIFFERENCE MODE	SUM AND DIFFERENCE	$f_p \pm f_0$	$f_0 \ll f_p$	100 TO 3000	1-10%	0.5	0.10-20		7



than 3 db for the single-resonance amplifier are sometimes listed in various documents, but these figures are always noted as "Double Sideband". The double sideband noise figure is the result of two frequency bands entering the amplifier and is similar to that obtained when measuring the noise of a microwave mixer. In most systems, however, application requires operation in only one of the frequency bands. The other band is rejected and referred to as the image frequency. In these, the noise figure will always be greater than 3 db for the single-resonance amplifier.

Instability is one of the greatest problems encountered with a parametric amplifier operating in the difference idler mode. The instability in this type of amplifier is the effect of a negative resistance appearing at the input terminals. This negative resistance is a characteristic of all difference parametric amplifiers. The amplifier will oscillate when the pump power is increased above the operating level or when small changes in the input vswr occur. This amplifier usually is used in conjunction with a circulator that reduces the sensitivity of the amplifier to vswr input changes. The use of the circulator at its present state of development, limits the lower operating frequency to about 200 mc, restricts the tuning bandwidth to about 5 per cent, and increases the noise figure because of its insertion loss.

Dual-Resonance Parametric Amplifier

The dual-resonance parametric amplifier, Fig. 2, also uses the elements of the signal circuit for a second purpose exemplified in the single-resonance amplifier, but in this latter amplifier instead of the idler, the signal circuit elements are also used for the pump. The pump frequency, unlike the single-resonance amplifier, is set several times greater than the signal. The advantage of this type amplifier is its lower noise figure that results from the greater idler to signal frequency ratio (Eq. 1). A separate idler circuit is set to the difference idler mode and the sum idler is not used. Since this is a difference amplifier, it has the usual instability problems.

A change in the operating frequency of this amplifier requires pump tracking, signal circuit readjustment and tuning of the difference circuit. This amplifier has similar fail-safe operation as found in the single-resonance amplifier. The dual-resonance parametric amplifier has had its greatest acceptance in operation below the frequen-

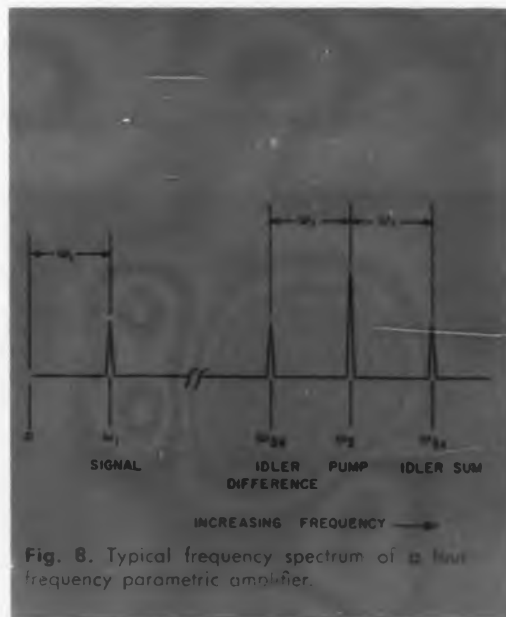


Fig. 8. Typical frequency spectrum of a four-frequency parametric amplifier.

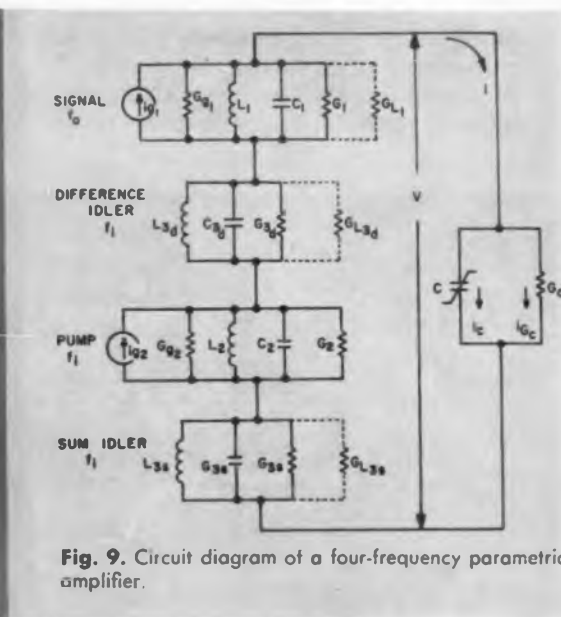


Fig. 9. Circuit diagram of a four-frequency parametric amplifier.

cies at which circulators are available, although a circulator reduces sensitivity to vswr changes.

Nondegenerative Parametric Amplifier

The nondegenerative parametric amplifier, Fig. 3, does not normally double its use of the signal circuit elements and the pump does not have to track for changes in operating frequency. It is necessary to track the signal and idler circuit when changes are made in the operating frequency. The pump frequency is usually many times the signal frequency thus giving very low noise operation with high gain (see Eq. 1). A separate idler circuit is set to the difference idler mode and the sum idler is not used. As in all difference idler mode operations, this amplifier has the problem of instability as described for the single-resonance amplifier. This parametric amplifier is almost exclusively operated in conjunction with a circulator.

The nondegenerative and the single-resonance amplifiers are probably the most widely used parametric amplifier types.

Traveling-Wave Parametric Amplifier

The traveling-wave parametric amplifier, see Fig. 4, input frequencies are made to move along an artificial transmission line that has varactor

diodes distributed throughout its length. The pump-phase relation to each of the varactor diodes is controlled in the amplifier. This signal-to-pump phase control is usually accomplished with a second artificial transmission line for the pump. The advantage of this parametric amplifier is its extremely large bandwidth together with its low noise figure. The main disadvantage is the amplifier low gain. A second problem of the traveling-wave design lies in making the structure a unidirectional amplifier. The gain of this amplifier is dependent on the quantity of varactor diodes, but in most present-day circuits there is a practical limit to the number used. At the present time, the traveling-wave parametric amplifier operation is similar to that of the single-resonance parametric amplifier and the same signal cancellation problem exists when the pump to signal relation is exactly $2f_0$.

The idler signal, at certain signal frequencies, is within the bandwidth of the amplifier and will appear at the output as a second signal. A traveling-wave parametric amplifier, with a pump frequency many times that of the signal, is within the realm of possibility. This amplifier would have an idler signal that is outside the amplifier bandwidth. Unfortunately, at this time no outstanding development in traveling-wave parametric amplifiers has been made public.

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Up-Converter Difference Parametric Amplifier

The up-converter difference parametric amplifier, Fig. 5, is similar in its operation to that of the nondegenerative parametric amplifier with the exception that the signal output is obtained at the difference idler tank circuit. This amplifier has the same instability problems as found in all difference amplifiers and should be used with a circulator or an isolator for stability.

Up-Converter Sum Parametric Amplifier

The up-converter sum parametric amplifier design, Fig. 6, is similar to the up-converter difference amplifier except that the idler is adjusted to the sum of the pump and signal, and the difference idler mode is not used. Since there is no negative resistance at the input, this type of parametric amplifier is unconditionally stable. Unlike the difference amplifiers, the gain of the up-converter sum parametric amplifier is effected by the signal-to-idler ratio. When the signal-to-idler ratio is large, the gain is large. This type of amplifier is normally used for signal frequencies below 1,000 mc so that with the available pump power sources adequate gains can be obtained. An added advantage is that no circulators or isolators are required in this design.

Up-Converter Sum and Difference Parametric Amplifier

The design of the up-converter sum and difference parametric amplifier, Fig. 7, is an approach for arriving at high gain and stability. These objectives are reached by combining the high gain of the difference idler mode with the stability of the sum parametric amplifier. Output from this amplifier can be obtained from either or both the sum and difference idler circuits. The amplifier does not have the unconditional stability found in the sum parametric amplifier. An increase of pump power or changes greater than 4 to 1 in vswr can cause instability. This sensitivity to vswr changes can be reduced in the amplifier by decreasing the over-all gain of the system. Tuning from one signal frequency to another, is more complex with the sum and difference parametric amplifier because the sum and difference idler circuits must track with the signal circuit. Since no isolation is required at the input, this amplifier has an advantage at lower frequencies where isolators are not available and also some advantage at higher frequencies, where the operating tuning ranges are larger than those available in isolators. ■ ■

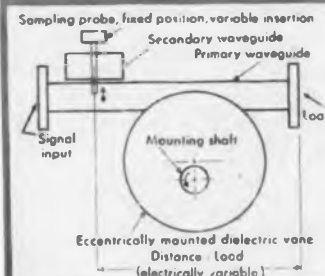
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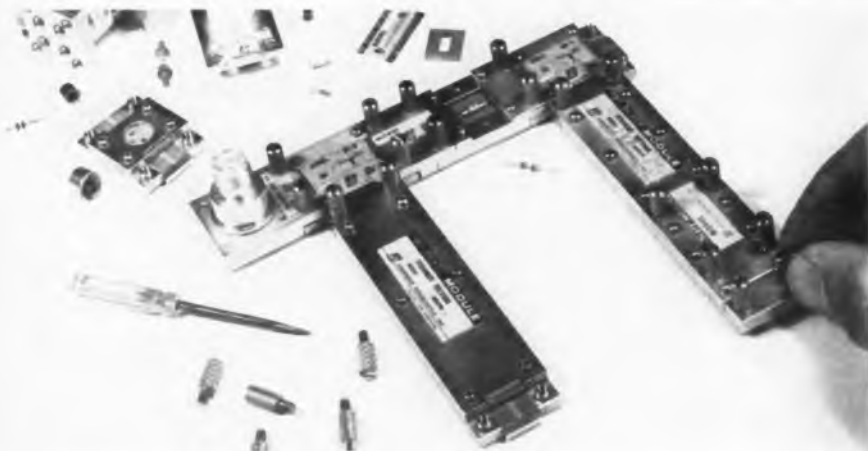
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See at Show Booth 2322-32, 2415-25.

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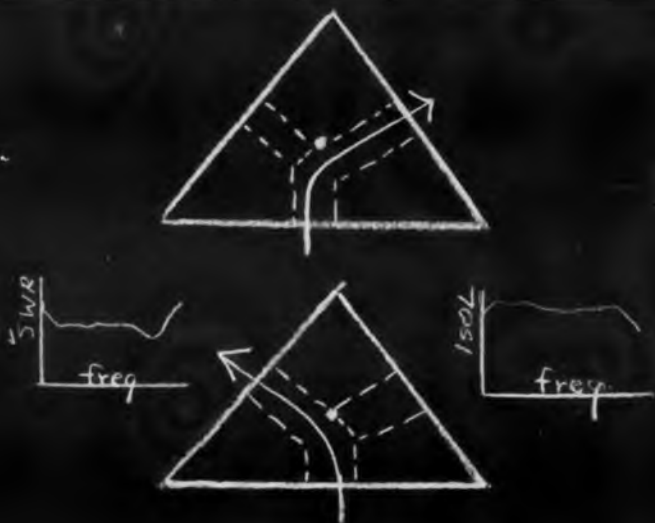
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a subsidiary of
Quantatron, Inc.
1131 Olympic Blvd.
Santa Monica, California
EX 3-0758

Applied Research inc.

WIDEBAND RF AMPLIFIERS

40 to 1500 mcps

Low noise figure • Low power drain
Minimum size and weight • High gain



TYPE HFW AMPLIFIERS are now available for operation in the 600-1500 mcps range, with bandwidths of 100 to more than 400 mcps in the upper ranges. These augment the extant Applied Research amplifiers, which provide for operation in the 40-600 mcps region.

ARI Amplifiers are used as part of receiving systems in antenna preamplifiers, multicouplers, and high frequency IF amplifiers, where faithful reproduction of signals and amplification over a wide band of frequencies are required. The low noise characteristics of these equipments result in a dynamic range of greater than 60 db.

TYPICAL PERFORMANCE CHARACTERISTICS

Model	HFW-5070-3	HFW-77100-3
Frequency range	500-775 mcps	775-1000 mcps
Gain	Greater than 30 db	Greater than 30 db
Noise figure	6 to 8.5 db	8.0 to 9.5 db
Peak to valley ratio	Less than 1 db	Less than 1 db
Zin - Zout	50 ohms	50 ohms
VSWR Input	Less than 1.5	Less than 1.5
VSWR Output	Less than 1.75	Less than 1.75
Anode drain	200V at 60 ma	200V at 60 ma
Filament drain	6.3V at 2.1 amps.	6.3V at 2.1 amps.

Write for further information

Applied Research inc.

76 South Bayles Avenue, Port Washington, N. Y.

CIRCLE 192 ON READER-SERVICE CARD



MICROWAVES PRODUCTS AT IRE

Microwave Device

For low-frequency isolation

437



The SB-100 coaxial component acts as a band-pass from 2.5 to 11,000 mc while isolating frequencies from dc to 2.5 mc. At frequencies of 2.5 to 11,000 mc, insertion loss is 0.2 db or less. Coaxial connectors are N, BNC or TNC. It is available in three configurations: providing dc blocking on both inner and outer conductors; with blocking on inner conductor only; with blocking on outer conductor only.

Sylvania Electric Products Inc., Dept. ED, 500 Evelyn Ave., Mountain View, Calif.

P&A: \$50 and \$55 ea; in sample quantities.

See at Show Booth 2322-32 and 2415-25.

Coaxial Cable

Has air dielectric

433

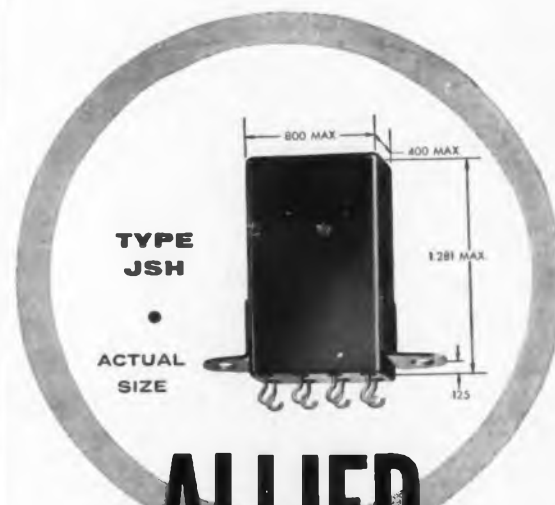


A flexible, air dielectric coaxial cable, Heliac can be manufactured in continuous lengths. With low loss and low vswr, it is suitable for applications from low frequency to microwave. All conducting surfaces are copper, supported by polyethylene. Size ranges from 3/8 to 3-1/2 in., impedances are 50, 75, and 100 ohms.

Andrew Corp., Dept. ED, P. O. Box 807, Chicago 42, Ill.

P&A: \$0.75 to \$10 per ft; 1 week delivery.

See it at Booth 1502-04.



ALLIED CONTROL'S NEW

SENSITIVE 2 AMP RELAY

for

***15 g to 2000 cps vibration**

OPERATING CONDITIONS:

AVERAGE PULL-IN POWER:

SPDT 25 milliwatts at 25°C

DPDT 40 milliwatts at 25°C

CONTACT RATINGS:

Non-inductive — 2 amperes at 29 volts d-c

or 1 ampere at 115 volts a-c

Low level contacts are available on request

VIBRATION:

5-55 cps at 0.12 inch double amplitude

55-2000 cps at a constant 15 g

*20 g available on request

SHOCK:

50 g operational

TERMINALS:

0.2 inch grid spaced

WEIGHT:

1.1 ounce maximum

Write for Bulletin JSH #62

ALLIED CONTROL

ALLIED CONTROL COMPANY, INC.

2 EAST END AVENUE, NEW YORK 21, N. Y.

CIRCLE 193 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

AL 206

MICROWAVES

Spectrum Analyzer 429

Is fully transistorized



Combining all-transistor circuits with microwave plumbing, the model SA-84T spectrum analyzer covers a frequency range of 10 mc to 40,880 mc in eight bands. Resolution bandwidth is 20 kc, all frequencies; frequency dispersion is 500 kc to 25 mc in two bands. Sweep repetition rate is 1 to 30 cps. Frequency dial accuracy from 10 to 13,500 mc is $\pm 1\%$ of fundamental local oscillator frequency, and $\pm 1\%$ of dial reading from 13,500 mc up. Sensitivity is from -50 to -105 dbm. The set provides rf attenuation up to 100 db; if attenuation is calibrated to 41 db in one-db steps. The 70-lb unit can be rack-mounted.

Polarad Electronics Corp., Dept. ED, 43-20 34th St., Long Island City 1, N.Y.

See at Show Booth 3301-07.

High-Gain Tube 452

Is grid-pulsed

A grid-pulsed, high-gain tube, the VA-134 is designed for use as a final amplifier in multi-output-tube radars; or as a driver for megawatt amplifiers of frequency-agile coherent radar systems. It is liquid-cooled and has a periodic permanent magnet for focusing. Characteristics are: bandwidth, 120 mc; frequency coverage, 0.490 to 0.610 Gc; power output, peak, 5 kc; gain 45 db.

Varian Associates, Dept. ED, 611 Hansen Way, Palo Alto, Calif.
P&A: \$4,475; on request.

See at Show Booth 2708-18.

CIRCLE 194 ON READER-SERVICE CARD ▶



MOPA
DRIVER

QKW 750A

One of a series of advertisements featuring tubes for MOPA chains



MOPA chain at S-band.

New Raytheon broadband TWT drives Amplitron* in high-duty-cycle frequency-diversity applications

QKW 750A has 60 kw minimum peak power, 18 db minimum gain, and more than sufficient bandwidth to drive the QKS 622 Amplitron in S-band MOPA chain.

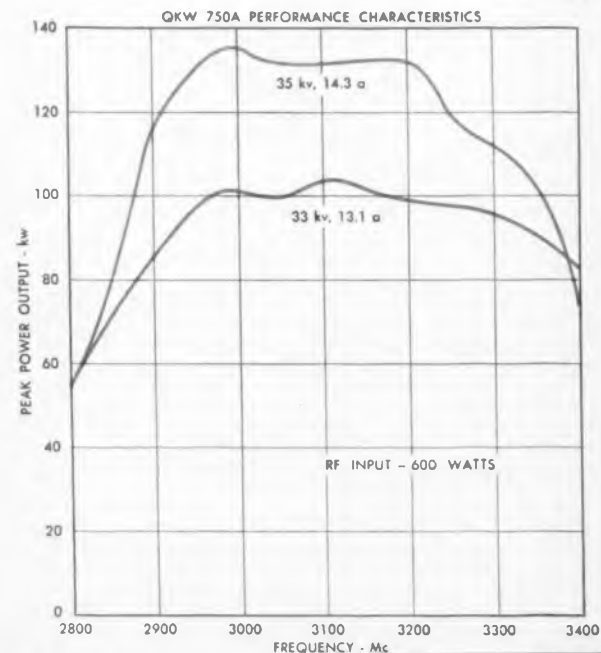
A new traveling wave tube—Raytheon's QKW 750A—now makes possible a complete broadband, high-power MOPA chain at S-band.

The tube has a duty cycle of .015 and is designed for pulsed operation over the full 2,900 to 3,100 Mc range. It provides a minimum of 18 db gain and 60 kw peak power to drive a Raytheon QKS 622 Amplitron. Output of the amplifier chain is in the megawatt range. A companion tube—the QKW 782—covers the 2,700 to 2,900 Mc range.

Microwave systems designers should note that the bandwidth, peak and average power capability, and gain characteristics of the new TWT are well above the specified values as shown in the accompanying curve. This fact lends a high degree of conservatism and reliability to system design.

Write for detailed information and application service to Microwave and Power Tube Division, Raytheon Company, Waltham 54, Massachusetts. In Canada: Waterloo, Ontario.

*Raytheon Trademark



RAYTHEON COMPANY
MICROWAVE AND POWER TUBE DIVISION

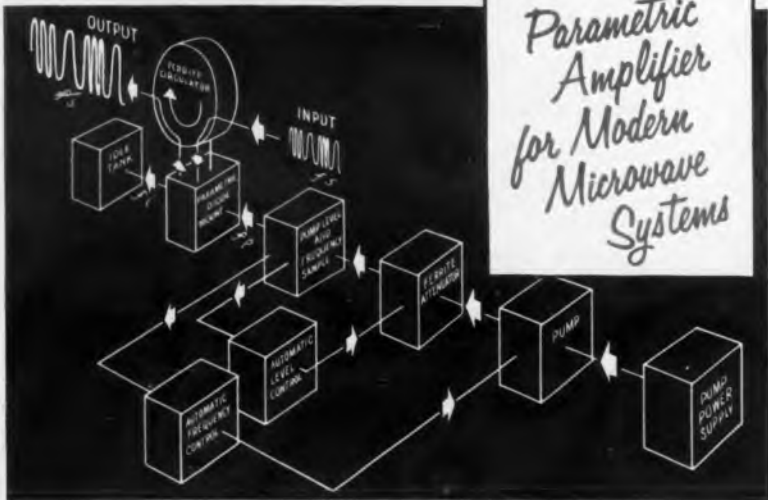
RAYTHEON

BOSTON, MASS., Browning 2-9600 • ENGLEWOOD CLIFFS, N. J., Lowe 1-7-4911 • BALTIMORE, MD., Southfield 1-0450 • CHICAGO, ILL., National 5-4000
DAYTON, OHIO, Baldwin 3-8128 • LOS ANGELES, CALIF., Plymouth 7-3151 • CANADA: Waterloo, Ont., Sherwood 5-6831

FUNDAMENTALLY SPEAKING

NO. 3 IN A SERIES
SUBJECT:

*Parametric
Amplifier
for Modern
Microwave
Systems*



The low-noise parametric amplifier has emerged as a practical and important building block of modern microwave systems. It allows, for the first time, low-noise, wide-band preamplification of all microwave frequencies with a vast improvement in noise figure over conventional microwave receivers. It provides system performance that otherwise can be achieved only by increasing the transmitter power by a factor of 2 or 3. Such system parameters as range, fade margin, reliability, etc. are greatly improved. Reliable low-noise parametric amplifiers are now available for application in Tropospheric Scatter, Microwave Radio Relay, Radar, and Telemetry Systems.

Systems designers should be aware, however, that a parametric amplifier does not consist merely of a parametric diode mount, but includes various other components such as a pump, pump power supply, and possibly automatic frequency and level control circuitry. These auxiliary devices need not be excessively complex or expensive if care is taken in their design. Complete parametric amplifier systems can, with care, be completely packaged in a minimum volume.

The Pump: Parametric amplifiers require an A.C. power supply rather than a D.C. power supply as in conventional amplifiers. This power supply has been called the "Pump" since this term is descriptive of its function. In a sense, it is pumping energy into the parametric amplifier system. The pump frequently is a reflex klystron or crystal multiplier chain, but may be any form of microwave oscillator, including some of the newer solid state oscillators.

Automatic Frequency Control: Different system types have different A.F.C. requirements. In radar systems, it is necessary for the pump to follow frequency drifts of the magnetron so as to maintain a constant idle frequency. In communication systems, the signal is usually crystal controlled so that it is important to maintain the pump at a constant frequency. Here the goal is primarily to prevent instability of the center frequency of the parametric amplifier since this will give rise to spurious phase and amplitude modulations of the signal. This A.F.C. problem may be reduced in large measure by the selection of pump sources with inherent frequency stability and by the design of broadband idle tank circuits for the amplifier.

Automatic Level Control: Additional spurious amplitude modulation may arise due to gain instabilities of the parametric amplifier. These gain instabilities arise due to the dependence of gain upon pump power. In those systems where this spurious A.M. is of importance, it is desirable to provide some sort of pump automatic level control. This may be provided in the form of voltage variable ferrite attenuators.

C.E.C. offers a line of Broadband Parametric Amplifiers complete with pump A.F.C. and A.L.C. for application to your system at frequencies from U.H.F. to Ku Band.

Your particular requirements can be satisfied merely by minor modifications of our existing designs. A representative of our Microwave Division, will be glad to talk to you on your specific requirements.



See us at Booth 1911 at the IRE Show.



CONTROL Electronics CO., INC.
Ten Stepar Place, Huntington Station, N. Y.

CIRCLE 195 ON READER-SERVICE CARD



MICROWAVES PRODUCTS AT IRE

Transmission Line Hybrids

486

Are compact



Compact coaxial transmission line hybrids type 2210 covers 2 to 1 frequency ranges. The 120 to 240 model measures 4-1 16 x 3-15/16 x 1-1/8 in. exclusive of external matching cables. The residual unbalance is greater than 40 db over the entire frequency range; the parallel input vswr is 1.35 or less and the series input vswr is 1.4 or less over the band. Design impedance is 50 ohms. Available with N, BNC or TNC connectors.

Alford Manufacturing Co., Dept. ED, 299 Atlantic Ave., Boston 10, Mass.

P&A: Under \$300; 45 days.

See at Show Booth 1718-20.

Klystron Power Supply

438

Is portable



The 809-A klystron power supply is a compact, portable instrument designed to operate low-power klystrons. It has a reflector voltage resolution and ripple of 1 mv rms. The unit contains a regulated 250 to 600 v beam voltage, a regulated 0 to 900 v reflector voltage and a 6.3 v ac filament supply. The reflector voltage is available either unmodulated or internally modulated by square wave or sawtooth. An internal blower is provided.

P R D Electronics, Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N.Y.

P&A: \$350; from stock by April 1961.

See at Show Booth 3602-06.

New
ULTRagraph
440



Direct Writing

Light Beam

Oscillograph

Up to 56 Channels



A MAJOR ADVANCEMENT IN THE STATE-OF-THE-ART

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Booths 3612-14 at IRE

CIRCLE 196 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

MICROWAVES

Microwave Receiver 430

Fully transistorized



A general-purpose microwave receiver, the fully transistorized model RT has a frequency range of 950 to 11,260 mc. The set can receive am, fm, cw, modulated cw, and pulse signals. Impulse bandwidths are 1, 5, and 8 mc. Sensitivity is -85 db to 7,740 mc, and -80 db to 11,260 mc. Peak, quasi-peak, and average power indications are provided. The receiver will operate on 12 v dc or 115 v ac.

Polarad Electronics Corp., Dept. ED, 43-20 34th St., Long Island City 1, N.Y.

See at Show Booth 3301-07.

Backward Wave Oscillator 441

Electrostatically focused



Backward wave oscillator VA-181 is an electrostatically focused unit for local oscillator, signal generator or missile applications. Balanced dual output is provided by means of two coaxial connectors. Electrical characteristics are: frequency, 2 to 4 Gc; power output, min. 10 mw; tuning voltage, 200 to 2,000 v dc.

Varian Associates, Dept. ED, 611 Hansen Way, Palo Alto, Calif.

P&A: \$1,075; on request.

See at Show Booth 2708-18.

CIRCLE 197 ON READER-SERVICE CARD

General Electric Offers . . .

2 New Compact, Lightweight VTM's



**NEW HIGH-POWER (50 W MIN.)
VOLTAGE-TUNABLE MAGNETRON**
Type Z-5424

2900 to 3200 mc. Specially designed for airborne ECM, remote telemetry, data link systems and rapidly tuned radar. Compact and lightweight . . . a 42.5 cu. inch package, weighing only 4.5 lbs. Gives approximately 60 percent conversion efficiency.



NEW COMPACT VOLTAGE-TUNABLE MAGNETRON—ONLY 24 oz.
Type Z-5337

2900 to 3100 mc. 4 watts (min.) output. Bowl-magnet design reduces size (only 15 cu. inches) as well as weight. Also offers increased reliability. One of several similar designs ranging from 1625 to 4400 mc., with outputs in the order of 2 watts. Now available for applications in missiles and aircraft.

General Electric VTM line offers you these outstanding features...

LINEAR TUNING permits design of simpler circuits. **HIGH EFFICIENCY** eliminates need for forced air-cooling. Reduced battery load increases battery life. **UNIFORM POWER SPECTRUM** assures driving traveling-wave tubes at optimum conditions. **SMALL SIZE** aids in design of compact, lightweight equipments.

SELECT, THEN SPECIFY General Electric VTM's. For application engineering assistance in simplifying new or retrofit circuits . . . for sample price and availability, contact nearest G-E Power Tube Sales Office. Bulletins PT-1 and PT-39 available. *Power Tube Department, Section 8481-30, General Electric Company, Schenectady 5, New York.*

265-02

POWER TUBE DEPARTMENT

GENERAL ELECTRIC

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with the finest in:**

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- Thyratrons
- Magnetrons
- Metal-ceramic tetrodes
- Camera pick-up tubes
- Traveling-wave tubes
- Parallel-plane microwave tubes
- High-power duplexers
- High-power waveguide filters
- Klystrons



7-C-12 Evaporator system, 360 liter/sec. capacity; available with glass or metal chamber

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clean vacuum—no fluids, no contaminants

high vacuum— 10^{-5} through 10^{-9} mm Hg and below, chamber volumes from 0.001 to 100 cubic feet

low-cost operation—UlteVac ionic pumps need minimum maintenance, operate unattended for months. System completely self-contained and movable. No water lines or plumbing connections. Requires only an AC outlet.

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Ultek vacuum station designed for experimental tube processing



MICROWAVES PRODUCTS AT IRE

Traveling Wave Tube

For S-band

436



Traveling wave tube QKW750A is a 60-kw unit designed for pulsed operation in S-band frequencies from 2,900 to 3,100 mc. It may also be used as a driver for the firm's QKS622 Amplitron. Average power output is 720 w. Pulse width is 30 usec and load vswr is 1.5 max.

Raytheon Co., Microwave and Power Tube Div., Dept. ED, Foundry Ave., Waltham 54, Mass.

P&A: \$8,750; 90 days.

See at Show Booth 2604-14.

Microwave Absorber

Is completely flexible

492



A thin and completely flexible microwave absorbing material, metal-film Mylar has a resistance material film of pure metals approximately 50 millionths of 1 in. thick. Values are between 25 and 400 ohms per square; tolerance is $\pm 10\%$. Silver contact areas can be provided for dc contact. Uses include application as cavity linings and, bonded to antennas, as spurious energy absorbers.

Filmohm Corp., Dept. ED, 48 W. 25th St., New York 10, N.Y.

See at Show Booth 1806.

Band-Pass Filter

Peak power is 3 to 5 megawatts

493

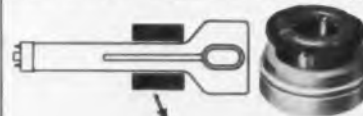
Designed for long-range radar and space communications transmission, this high-power band-



a **spot** is a **spot**
is a high
resolution **spot**
with

CELCO YOKES

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keep spots **smallest**
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CIRCLE 199 ON READER-SERVICE CARD



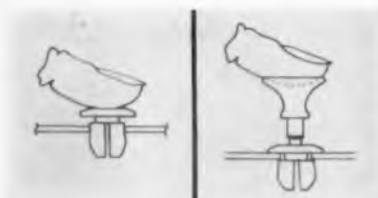
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Nylatch, a new push-pull fastener, is now offered off the shelf to industry needing the ultimate in dependable low cost fastening.

Nylatch will replace most existing fasteners for metal, wood and synthetics yet gives these outstanding features —

- Less than 10 seconds installation — merely insert grommet into material to be fastened and insert plunger in grommet.
- Standard punched or drilled holes accommodate Nylatch.
- Nylatch allows up to .040 misalignment tolerance.
- Rugged two-piece construction gives 30,000 complete cycles of operation. Thoroughly tested for temperature, creep characteristics, fatigue and load.
- Versatility of design allows you a selection of plunger head designs. Available in wide range of decorator colors.



Press grommet into removable sheet

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CIRCLE 200 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

MICROWAVES

pass filter permits a peak power of 3 to 5 megawatts with 15 kw avg. No external cooling is required. Bandwidth is 8% to the 3-db points with rejection 50 db or greater at $1.15 f_0$ and $0.85 f_0$. Insertion loss is 0.15 db max.

Frequency Standards, Dept. ED, P.O. Box 504, Asbury Park, N.J.

See at Show Booth 3844.

TWT Amplifiers

484

Are self-contained



Model T601 traveling-wave tube amplifier covers a range of 2 to 15 Gc while model T602 has a range of 10 to 20 Gc. Both models utilize permanent magnets and the amplifiers are completely self-contained. They include fully metered internal power supplies with meters for measuring beam current, beam voltage and grid voltage. The units have broadband characteristics without tuning and power outputs as high as 3 w may be obtained.

A E L Inc., Dept. ED, 121 N. 7th St., Philadelphia 6, Pa.

P&A: T601, \$6,670; T602, \$7,400; 90 days.

See at Show Booth 3503.

Y-Circulators

495

Isolation is 20 db



Waveguide Y-circulator, model 20-20, has 20% bandwidth and more than 20 db isolation. Frequency band range is 2.6 to 12.4 Gc. Specifications for any frequency band within the range are: vswr, less than 1.2; insertion loss, less than 0.5 db; bandwidth, 20% of f_0 ; isolation, 20 db min. Hughes Aircraft Co., Dept. ED, Culver City, Calif.

P&A: \$375; 30 to 60 days.

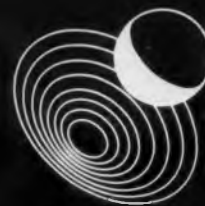
See at Show Booth 1811-17.

5 MEGAWATT HIGH POWER MICROWAVE BAND PASS FILTER!



First from America's foremost creator of microwave products — a high power microwave band pass filter to handle 5 megawatts! Here is the ideal filter for lunar probe radar equipment, other high power radar equipment and cyclotrons. Insertion loss is less than 5 db. VSWR is 1.3. And the band pass is approximately 6% to 10% at 380 MC to 420 MC.

SEE IT AT BOOTH 3844 IRE SHOW!



FREQUENCY STANDARDS

A Division of Harvard Industries, Inc.

THE FAST-MOVING, FORWARD-THINKING CENTER FOR MICROWAVE IDEAS
P. O. Box 504, Asbury Park, N. J.

CIRCLE 201 ON READER-SERVICE CARD

DIRECT READING
Calorimetric Power Meter



ACCURACY: 3% (less load error)

These power meters are greatly simplified Calorimeters, which use an accurate metering pump of the gear type driven by an over-powered synchronous motor to keep the fluid flow constant. The instrument is fully self-contained, portable, self-cooled and requires only connection to the power line. It does not use any flow meters, thermometers or any other controls. There is only the "ON" & "OFF" switch for the operator to use on the front panel, when a measurement is to be made. A sensitive thermopile and microammeter measures the power dissipated in the R.F. load. The microammeter is calibrated in watts and is direct reading. These Calorimeters are available with either a coaxial or a waveguide load.

COAXIAL CALORIMETERS

Type	Full Scale Power	Freq. Range KMC	Price
CPM-10	10	DC-10	\$950.00
CPM-50	50	DC-10	950.00
CPM-100	100	DC-10	950.00
CPM-500	500	DC-10	950.00
CPM-5000	5000	DC-1	1400.00
CPM-10000	10000	DC-1	2000.00
CPM-20000	20000	DC-1	3250.00

WAVEGUIDE CALORIMETERS

Type	Full Scale Power	Price
CPW-10	10	\$850.00
CPW-50	50	800.00
CPW-100	100	800.00
CPW-500	500	800.00
CPW-5000	5000	1200.00
CPW-10000	10000	1750.00
CPW-20000	20000	2850.00

DIRECT READING
Calorimeter Bridge



ACCURACY: 2% (less load error) with Self-Contained Calorimeter Loads, Cooling System & Circulating System.

This Calorimeter is completely self-contained with its own circulating system, cooling system and the radio frequency dummy load and requires only connection to the regular power line. The R.F. power is read directly on a 4 1/2" meter in watts. A single coaxial dummy load is available to cover the frequency range from DC to 10,000 Mc and for the power range from 1 to 1000 watts. The overall accuracy of this Calorimeter is 3%. However, this accuracy can be improved greatly by calibrating the Calorimeter by means of an external laboratory-type wattmeter.

Model	Range	Frequency	Price
CB-11	1 watt	DC-4 KMC	\$900.00
CB-12	5 watts	"	900.00
CB-13	25 watts	"	1250.00
CB-14	150 watts	"	1250.00
CB-15	500 watts	"	1450.00
CB-16	1000 watts	"	1650.00
CBW-1	1 watt	7-12 KMC	1450.00
CBW-2	5 watts	"	1450.00
CBW-3	25 watts	"	1250.00
CBW-4	150 watts	2.4-12 KMC	1100.00
CBW-5	750 watts	1-12 KMC	1500.00
CBW-6	3000 watts	"	2400.00
CBW-7	8000 watts	"	3000.00

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Phone: SHadyside 1-0404

CIRCLE 202 ON READER-SERVICE CARD



MICROWAVES PRODUCTS AT IRE

Reflex Klystrons

Are conduction cooled



Reflex klystrons, VA-244, are conduction-cooled, long-life, stable, low-distortion tubes for microwave relay applications. Electrical characteristics for the VA-244B are: power output, 1,000 mw avg at 6.5 Gc; frequency, 6.5 to 7.3 Gc; beam current, 78 ma dc; beam voltage, 750 v dc.

Varian Associates, Dept. ED, 611 Hansen Way, Palo Alto, Calif.

Price & Availability: \$175; 120 days.

See at Show Booth 2708-18.

Microwave Antennas

For 806 mc to 12.7 Gc



Microwave antenna line includes frequency ranges from 806 mc to 12.7 Gc. Reflector sizes range from 2 to 12 ft. A 12-ft mesh reflector is available in 900 and 2,000 mc frequency bands. In the 2-Gc band dual polarized feeds are available. In the 5,925- to 8,500-mc band, button-hook feeds for plane polarization and dual polarization feeds are offered.

Technical Appliance Corp., Dept. ED, Sherburne, N.Y.

Availability: 10 days.

See at Show Booth 1207.

Microwave Amplifier

463

Microwave power amplifier model 526 operates in the frequency range of 12.4 to 18 Gc. It will provide a 1-w power output over the entire

350 MODELS available!



MERCURY "10" SERIES
of standard cavities triode

IMMEDIATE DELIVERY!

Low cost standard cavities produced to military specifications. Ranges from 220 to 6,000 MC. J-V-M quality cavities are designed for use as oscillators, amplifiers, doublers and triplers. CW or pulse using following tube types:

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GL-6442	2C39A
GL-6771	7554
GL-6299	7552

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CIRCLE 203 ON READER-SERVICE CARD



"because every assembly job is different, only **CUSTOMED** preforms perform correctly."

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New customed preforms consist of an accurately predetermined amount of a specific alloy. The proper melting temperature and correct volume of solder are assured. Labor costs are lowered. Production increases. Scrap is eliminated. Get the facts today! Write for 8 page Guide to Preform Soldering.

21-01 43rd Ave., Long Island City 1, N. Y.

CIRCLE 204 ON READER-SERVICE CARD

ELECTRONIC DESIGN • March 15, 1961

MICROWAVES

octave for a signal of 30 db.

Alfred Electronics, Dept. ED, 897 Commercial St., Palo Alto, Calif.

P&A: \$4,950; from stock.

See at Show Booth 3934.

Spectrum Analyzer

Display is up to 4 Gc

434



Model WSA spectrum analyzer covers the frequency range from 10 mc to 40 Gc in 20 bands. Band selection is by push-button switches. The unit has a frequency marker up to 4 Gc; synchronization is internal, line frequency or external; resolution is 20 kc in narrow band and 1.5 mc in wide band.

Polarad Electronics Corp., Dept. ED, 43-20 34th St., Long Island City 1, N.Y.

P&A: \$50,000, on order only.

See at Show Booth 3301-07.

Backward Wave Oscillator

Is voltage tunable

435



Backward wave oscillator QKB924 is voltage tunable and designed for applications where frequency stability is essential. It may also be used as a driver tube with amplifier chains. A permanent magnet is used for beam focusing and a control electrode for low-voltage pulsed or amplitude modulation. Frequency range is from 2.7 to 3.2 Gc. Power output is 100 mw with delay line tuning voltage of 350 to 700 v.

Raytheon Co., Microwave and Power Tube Div., Dept. ED, Foundry Ave., Waltham 54, Mass.

P&A: \$1,650; 90 days

See at Show Booth 2604-14.

HIGH POWER FERRITE DUPLEXERS with WATER LOAD TERMINATIONS

● High power ferrite duplexers are now available with the new Sperry water loads to meet the most exacting high power system requirements and military specifications.

Sperry duplexers, available for operation in C, S, and L bands, reflect the Company's leadership in the manufacture of high-power solid state devices using Sperry-developed solid state materials. These duplexers readily meet every requirement consistent with their specifications.

The water load termination is one integral unit with a standard connecting flange and input and output ports having standard pipe fittings. It is small, compact and extremely rugged. Model E42C1 water load (shown here attached to duplexer D51C1) is only 6³/₄" long, weighs 3 lbs. These water loads will also be available in the L and S Radar bands.

Write for complete information.



**TYPICAL SPECIFICATIONS:
FOR THE C, S, AND L RADAR BANDS**

MODEL	PEAK POWER	AVERAGE POWER	APPROXIMATE DIMENSIONS	APPROXIMATE WEIGHT
DUPLEXER				
D51C1*	5.0 Mw	5.0 kw	24" x 8" x 6"	25 lbs.
D51S1	5.0 Mw	10.0 kw	32" x 13" x 7"	75 lbs.
D51L1	10.0 Mw	15.0 kw	96" x 20" x 16"	470 lbs.
WATER LOAD				
E42C1*	3.0 Mw	4.5 kw	3 ³ / ₄ " Dia. x 6 ³ / ₄ "	3 lbs.
E42S1	2.0 Mw	10.0 kw	4 ³ / ₄ " Dia. x 11 ¹ / ₂ "	11 lbs.
E42L1	10.0 Mw	18.0 kw	9" Dia. x 21"	25 lbs.

*Illustrated C Band ferrite duplexer and water load available as standard items.

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Scheduled for early operational service with USAF, this Avien-Bogner acquisition and tracking array will cover the new 1430 to 2400 mc telemetry bands — provide significantly expanded capability for gathering data from far-reaching and high-speed space vehicles. ■ Utilizing the patented Bogner end-fire element modules which allow highly efficient array design, it achieves high gain, low side lobes, unambiguous acquisition, bi-linear or bi-circular polarization. Fully automatic, its beamwidth can be instantly varied between 2° and 50° for acquisition, tracking during acquisition, self-tracking and uninterrupted reception of data through zenith. ■ Relatively small and light — and quickly produceable to user specifications for gain, frequency and other characteristics — it's one more example of Avien's Quick Response Capability for meeting advanced or complex antenna system requirements. To learn how this capability can serve you, call or write today. Avien, Inc., 58-15 Northern Boulevard, Woodside 77, N.Y.

CIRCLE 206 ON READER-SERVICE CARD



MICROWAVES PRODUCTS AT IRE

Impedance Plotter

485

For continuous information



Entirely self-contained except for the use of an external oscillator, type 14 automatic impedance plotter presents continuous impedance information on an internal crt or an external X-Y recorder. The following ranges are covered: 0.1 to 2.5 mc; 2.5 to 250 mc; 150 to 1,100 mc; 1,100 to 1,700 mc.

Alford Manufacturing Co., Dept. ED, 299 Atlantic Ave., Boston 10, Mass.

P&A: From \$7,000, 60 days

See at Show Booth 1718-20.

Field Intensity Meter

423

Range is 1 to 10 Gc



A calibrated field intensity meter and receiver, the model CFI also functions as a calibrated impulse signal generator. Range is 1 to 10 Gc; accuracy is $\pm 1\%$ of frequency dial reading. The set can receive am, fm, cw, modulated cw, and pulse signals. Impulse bandwidths are 1, 5, and 8 mc. It is supplied with four plug-in rf tuning heads and five antennas. The fully transistorized unit has a built-in inverter for 12-v dc field operation. Sensitivity is -85 db to 7,740 mc, and -80 db from 7,740 mc to 10 Gc. Audio, video, and recorder outputs are provided.

Polarad Electronics Corp., Dept. ED, 43-20 34th St., Long Island City 1, N.Y.

See at Show Booth 3301-07.

NEW LITERATURE

Transformers

261

Arranged for quick reference, catalog No. 103 lists nearly 300 stock MIL-T-27A transformers, chokes and reactors. Detailed photographs, diagrams, dimensions, performance information, and engineering data are provided. The detailed index contains unit net price data. 26 pages. Dresser Electronics, HST Div., 555 N. Fifth St., Garland, Tex.

Instrumentation Equipment

262

A wide inventory of instrumentation and other electro-mechanical components made by leading companies is listed in this catalog. Among the 855 items are recording devices, telemetering equipment, and instrumentation equipment for measuring force, temperature, acceleration, and rotary-linear displacement, along with synchros, motors, inverters, amplidyne, pneumatic and hydraulic controls. 71 pages. AST Co., Inc., Astrex, Inc., 150 Fifth Ave., New York 11, N. Y.

Digital Modules

263

An integrated line of digital modules, operating from dc to 1 mc, is described in catalog S. Called the S-Pac series, the card-mounted devices used NOR-AND logic. Circuit descriptions, specifications, block diagrams, and schematics are included. Prices are given. 12 pages. Computer Control Co., Inc., 983 Concord St., Framingham, Mass.

Shaft Encoders

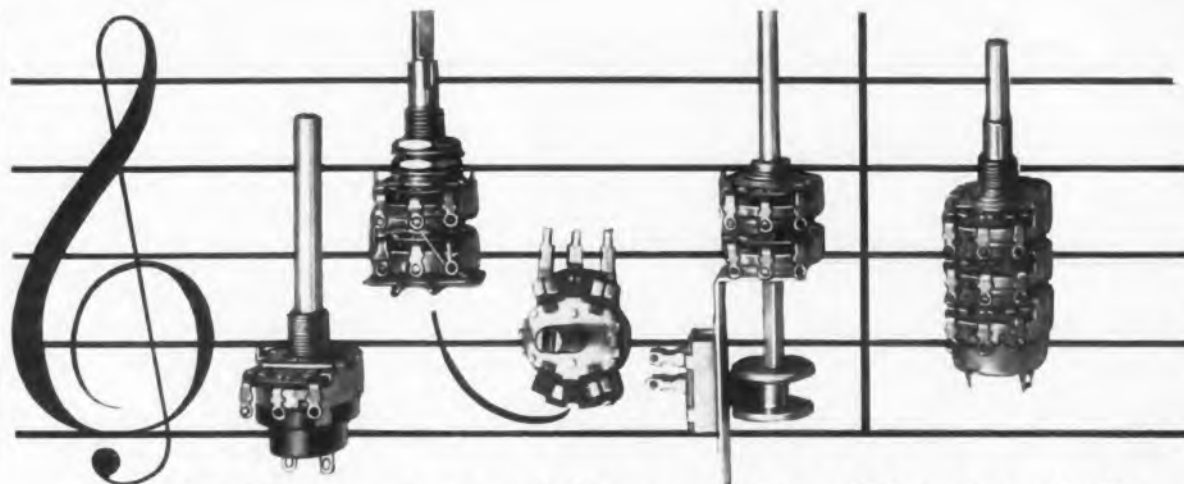
264

The AD 11-13 line of miniature V-scan shaft-angle encoders and their systems application are described in an illustrated brochure. Photos, specifications, application information, and V-scan circuitry, both parallel and serial readout, are included. 14 pages. Shaft Encoder Sales, Litton Systems, Inc., 5500 Canoga Ave., Woodland Hills, Calif.

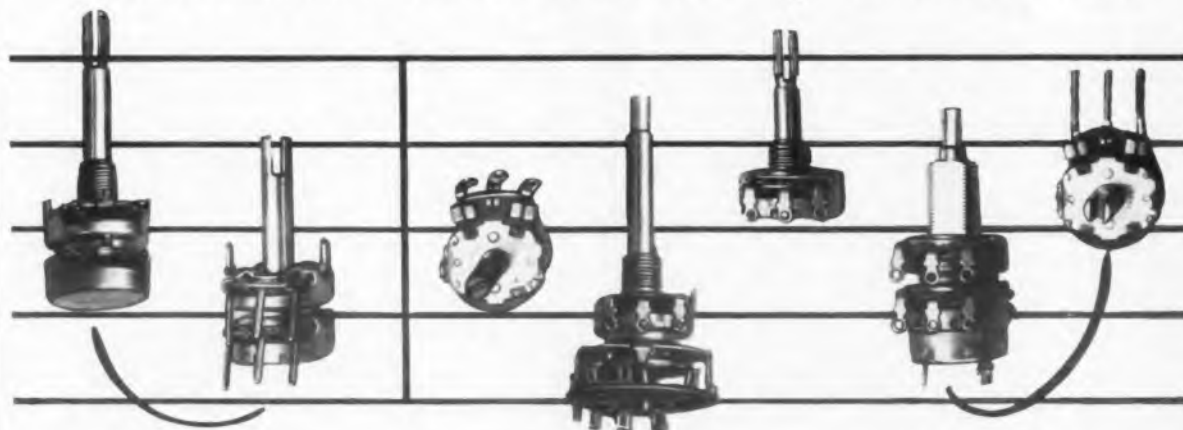
Power Supplies

265

Engineering details of nine wide-range, transistorized power supplies and five transient-suppressed, high-current, magnetically regulated dc power supplies are contained in this catalog. Applications, electrical, mechanical and environmental specifications, outline drawings, impedance curves, plus operational and special features are provided. 12 pages. Armour Stabvolt Div., Magnetic Research Corp., 3160 W. El Segundo Blvd., Hawthorne, Calif.



Variations on a Theme by Centralab



The Conventional Model 2 Composition Variable Resistor has 15 separate identities*...and potentially more!

Versatility is music to the ears of CENTRALAB engineering and production people—which is one of the reasons that our 15/16" composition variable resistor (known as the Model 2) is such a favorite. The basic unit, rated at $\frac{1}{2}$ watt, with resistances from 200 ohms to 10 megohms, in various tapers, is highly adaptable.

It is available as a single, dual or twin control, metal or plastic shaft, with a choice of 5 types of switches

(snap action, push-push, push-pull, slide, or rotary), 5 types of mountings (bushing, twist-tab, snap-tite*, "doghouse" bracket or "grasshopper"), 3 types of terminals (solder lug, wire wrap, or printed circuit), with unlimited variations and combinations.

Harmonizing with your requirements is our business. We probably make the type of Model 2 you need—if not, we can develop it for you. We're always interested in an additional variation on our favorite theme.

* Described in our brand-new Model 2 Brochure, available free by requesting Bulletin #42-1081.

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NEW LITERATURE

Static Transducers 278

Manual T-11 describes in detail the characteristics and functions of static transducers, and outlines typical applications. It is illustrated with chart, diagrams, curves, cutaway drawings and photographs. The devices, used for measuring large quantities of electrical power, are made in form for measuring dc voltage, and in compensated and noncompensated types for direct current. 38 pages. Control Div., Magnetics Inc., Butler, Pa.

Precision Switches 279

An expanded line of snap-acting precision switches is described in catalog No. 10-1. Data on a hp-rated series, a low-cost dpdt series, and three sealed series are given. A pictorial index shows location of dimension drawings, descriptions, force and movement specifications, electrical ratings, and photographs of each switch. Data on bases, terminals, circuit arrangements, and standard definitions of terms are included. 32 pages. Unimax Switch Div., The W. L. Maxson Corp., Ives Road, Wallingford, Conn.

Laboratory Oscilloscopes 280

Eight general-purpose laboratory oscilloscopes are detailed in this booklet. There are four complete-unit models in the range from dc to 450 kc, 1 from dc to 1 mc and 3 from dc to 15 mc. Specifications, performance characteristics, and pertinent illustrations for single-beam, dual-beam, dual-trace, and rack-mount models are provided. 20 pages. Advertising Dept., Tektronix, Inc., P. O. Box 500, Beaverton, Ore.

RF Connectors 281

A catalog of ConheX subminiature rf connectors for RG and other coaxial cables, along with a list of distributors, is available. Jacks, bulkhead receptacles, feed-throughs, right-angle units, cable terminations, tee adaptors, printed wiring board units, BNC and TNC plugs are described. Detailed assembly and outline drawings are given. 12 pages. Sealectro Corp., 610 Fayette Ave., Mamaroneck, N.Y.

Terminals and Components 282

An extensive line of solder terminals, terminal boards, hardware, capacitors, coil forms and coils is listed in catalog S600. Detailed drawings, specifications, and mounting information are given; electrical characteristics are provided

HOW TO RECORD RADAR ON MAGNETIC TAPE

For needed frequency response, use Ampex's new 4-megacycle tape recorders. Magnetic tape arrests radar giving you a second look or second try in reconnaissance, tracking, simulation, evaluation or training.

Want to know more? See our full page in the September 9th issue of Electronics. Or write us and we will send both the ad and descriptive literature.



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where applicable. 120 pages. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass.

Process Controls

283

A brochure describing closed-loop, all-electronic process-control systems, capacitance-actuated level-detection and control instruments, and malfunction detectors, is available. Bulletin No. 10 describes functions and the manner in which both individual instruments and groups of instruments are used. Technical bulletin references are also cited for additional information. 8 pages. Aeronautical and Instrument Div., Robertshaw-Fulton Controls Co., Santa Ana Freeway at Euclid Ave., Anaheim, Calif.

Wirewound Potentiometers

284

This six-page data sheet describes the firm's line of single-turn, wirewound potentiometers. The units are for missile and space applications, computer assemblies, calibration controls, servo-mechanisms and precision industrial control systems. Electrical and mechanical specifications for 28 standard models of linear, nonlinear and sine-cosine units are given in a selector table. Outline drawings are included. Fairchild Controls Corp., Components Div., 225 Park Ave., Hicksville, N.Y.

Low-Level Pulse Transformers

285

The design, operation, and application of low-level pulse transformers are covered in this 20-page catalog. Data on equivalent circuits, transformation polarization, and core degaussing are included. Manufacturing methods and specifications, including circuit diagrams and pulse width charts, of a line of miniature pulse transformers are given. PCA Electronics, Inc., 16799 Schoenborn St., Sepulveda, Calif.

Stock Relays

286

Illustrated brochure No. 60-8, eight pages, gives diagrams, prices and electrical operating characteristics of stock relays. Relays shown include sensitive, power, antenna, microminiature, hermetically sealed, telephone and multipole sensitive types. Kurman Electric Co., 191 Newel St., Brooklyn 22, N.Y.

Interchangeability Chart

287

This four-page interchangeability chart, No. AO-2, lists the firm's series J800 replacement numbers for Japanese radio transistors. Electronic Transistors Corp., 9226 Hudson Blvd., North Bergen, N.J.

DRAFTING TRENDS



This is a size comparison between the 10" POST Versalog and its 5" replica, the POST Pocket Versalog.

The trend to "COMPACT" slide rules

Why a small slide rule?

Users of America's best-selling POST Versalog, in the regulation 10" desk size, have been known to covet a 5" POST Pocket Versalog, and even buy one . . . as a more easily carried convenience . . . as a spare . . . or just for the sheer joy of having, like a gun collector, a "matched pair."

It took more than requests from pleased users of the 10" Versalog to convince our marketing people that the need actually existed for a premium-priced 5" pocket rule with 23 scales. Our technical men were even harder to convince that high Versalog standards of accuracy could be maintained in miniature.

Who can use them?

That there is a need has since been proved by the thousands of engineers, architects, scientists, and students who have bought and used a POST Pocket Versalog in preference not only to the larger version, but

after comparing it with other smaller makes.

As to accuracy, we are still amazed at the exquisite job our production team has done in miniaturization—the 5" Pocket Versalog includes every one of the 23 scales found on its much larger counterpart and, in addition, bears engine-divided calibrations of such sharpness and clarity that no magnifier is needed.

Own a Versalog for less

To further popularize this fine instrument, POST dealers are offering it at a special low price for a limited time. All models come with a hand-crafted leather case and spring pocket clip. Also available with hard-bound instruction text.

For further information, ask your POST dealer. Or, for free literature, price data and name of nearest dealer, write to Frederick Post Company, 3644, North Avondale Avenue, Chicago 18, Illinois.



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3352**

Pulse Generator 3352 has fast rise, no overshoot or tilt, unlimited duty cycle, double pulse and high reliability.

With external trigger 3352 exceeds 2Mc. Frequency, width, delay and amplitude are all variable and calibrated, 5%. Marconi is proud to offer this exceptional instrument.

Frequency	1cps to 1.1Mc	Rise time	10 μ sec
Width	90 μ sec to 105m sec	Output	50V 1000 Ω , 5V 75 Ω
Delay	90 μ sec to 105m sec	Also pre-pulse and sawtooth sweep	

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**STABILITY:
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CRYSTAL OSCILLATORS**

Shown: Bliley CCO-7M 1000 kc Packaged Oscillator

FEATURES

- Transistorized circuitry with high precision glass-sealed crystal
- **STABILITY:**
... at room temperature: 1×10^{-4}
... over range 0°C. to +60°C.: 3×10^{-4}
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- **BULLETIN 522 AVAILABLE**



BLILEY ELECTRIC COMPANY
UNION STATION BLDG., ERIE, PENNSYLVANIA

CIRCLE 213 ON READER-SERVICE CARD

NEW LITERATURE

Transistor Digital Circuits

This brochure, entitled "Transistor Digital Circuits," describes the firm's line of advanced solid-state transistor and magnetic components for computer applications. Write on company letterhead to EPSCO, Inc., Components Div., 275 Massachusetts Ave., Cambridge, Mass.

Motor Reliability Brochure 267

This six-page brochure describes the firm's motor reliability program that provides precision miniature electric motors to specified reliability levels for critical applications. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio.

Semiconductor Catalog 268

This 20-page catalog contains specification charts of the division's line of semiconductor products. Electrical and physical parameters of silicon solar devices, silicon transistors, silicon diodes, silicon-controlled rectifiers, Zener regulators and Zener reference devices are given. Listings of sales offices and industrial distributors are included. Hoffman Electronics Corp., Semiconductor Div., 1001 N. Arden Drive, El Monte, Calif.

Ferrite Materials 269

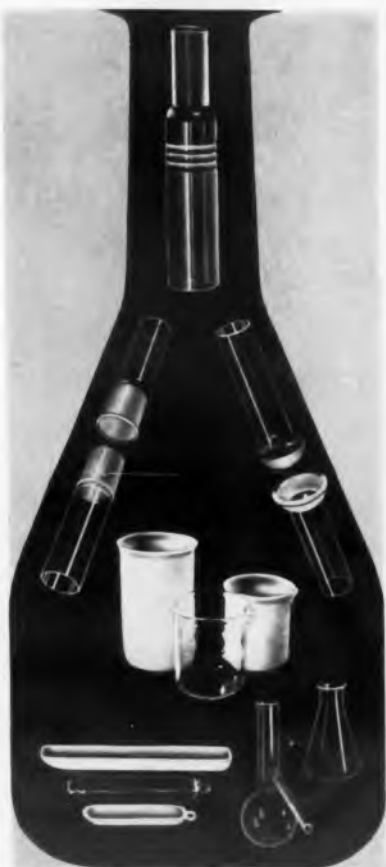
Applied Magnetics, Vol. 8, No. 1, 16 pages, describes and illustrates four main groups of ferrite materials. An application chart gives usage and magnetic characteristics. Problems involving cast and sintered Alnico are discussed and a guide for plating cast Alnico with cadmium is given. Indiana General Corp., Valparaiso, Ind.

Semiconductor Products 270

This 12-page brochure describes the firm's line of industrial and military semiconductor products. Specifications such as breakdown voltage, current capacity, operating temperatures and power dissipation are given for germanium power transistors, audio and switching transistors, silicon and germanium Mesa transistors, silicon rectifiers and silicon Zener diodes. Motorola Semiconductor Products Inc., 5005 E. McDowell Road, Phoenix, Ariz.

Relays 271

This eight-page booklet gives instructions and line drawings for adjustment and maintenance of relays. P.K. Neuses, Inc., 511 N. Dwyer St., Arlington Heights, Ill.



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DC Power Supplies

272

Bulletin GEA-6690A, 12 pages, gives operational and application information on custom-built dc power supplies for computers, aircraft, missiles, military and special applications. Photographs, load-current graphs, and a comparison table of characteristics of supplies and supply systems are included. General Electric Co., Schenectady 5, N.Y.

RF Connectors

273

This six-page, illustrated brochure describes the research, development and quality control in the firm's manufacture of rf connectors. Equipment utilized and procedures of manufacture are given. Descriptions of available rf connector literature are included. Gremar Mfg. Co., Wakefield, Mass.

Spectrum Analyzers

274

This eight-page brochure describes and illustrates the firm's line of spectrum analyzers. It explains the principle of operation and gives specifications, diagrams and applications. Raytheon Co., Commercial Apparatus & Systems Div., 1415 Providence Turnpike, Norwood 67, Mass.

Product Reference Guide

275

This illustrated electronic electrical product reference guide, 10 pages, gives ratings and other technical data on the firm's most frequently ordered products. These products include variable transformers, automatic voltage regulators, electrical connectors, synchronous motors, packaged transformer primaries, decade line correctors, loading reactors, and ac and dc power supplies. The Superior Electric Co., 83 Laurel St., Bristol, Conn.

Microwave Test Equipment

276

This four-page brochure illustrates and describes a line of microwave test equipment in the WR-51 waveguide size. Instruments include attenuators, terminations, frequency meters, crystal mounts, couplers, transitions, tuners, and straight sections, elbows and twists. Waveline, Inc., Caldwell, N.J.

Four PDT Relays

277

Bulletin BR-595, two pages, describes and illustrates series BR-14 4 pdt, hermetically sealed relays. Electrical, mechanical, mounting and operating specifications are given. Dimensional diagrams are included. Babcock Relays, Inc., 1640 Babcock Ave., Costa Mesa, Calif.



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BOOTH 4328

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Roy P. Foerster Wins 1960 "Idea of the Year" Award

FOR THE OUTSTANDING idea published during the sixth anniversary of Ideas for Design, Roy P. Foerster, group engineer at The Martin Co. in Baltimore, will receive a \$500 cash award. Mr. Foerster, a regular contributor of Ideas for Design, will receive the cash and a commemorative plaque at a ceremony to be held at ELECTRONIC DESIGN's booth 4403-05, at the IRE International Convention. The ceremony will take place on March 20, the first day of the convention.

Published in the June 22, 1960 issue of ELECTRONIC DESIGN, Mr. Foerster's Idea shows how an LC ringing circuit can be used in blocking oscillators or multivibrators to stabilize the triggering points and enhance the frequency stability. A breadboard of Mr. Foerster's circuit will be displayed at ELECTRONIC DESIGN's booth along with a photographic enlargement of his published, award-winning Idea for Design.

His Idea will appear in a book containing the 100 most valuable ideas published in Ideas for Design in 1960. The book will be available for inspection and purchase at ELECTRONIC DESIGN's booth 4403-05.

Seventh-Anniversary Cash Awards

Idea of the Year	\$1,000
Most Valuable Idea of Issue	\$50
For each Idea Published	\$20

Mr. Foerster has let it be known that he plans to be in the running for 1961's "Seventh-Anniversary Award." As announced in the March 1 issue of ELECTRONIC DESIGN, p 186, the 1961 award of \$1,000 in cash will be the grand award for the "Idea of the Year" appearing in Ideas for Design in 1961. A \$50 award will be made for the most valuable Idea in each bi-weekly issue of ELECTRONIC DESIGN. The contributor of each published Idea for Design will receive \$20.

The Seventh-Anniversary Awards will be based on the judgment of ELECTRONIC DESIGN's readers. Each Idea for Design published will have a key number that will correspond with a number on ELECTRONIC DESIGN's Reader-Service Card. Readers are invited to circle the numbers on the card corresponding to the Ideas they con-

sider valuable. In each issue, the Idea receiving most readers' votes will be named Most Valuable Idea of Issue. Its contributor will receive \$50.

The Idea of the Year will be selected from among the Most Valuable of Issue Ideas by ELECTRONIC DESIGN's staff of technical editors. The contributor of the Idea of the Year will be awarded \$1,000 at the 1962 IRE Convention.

100 Ideas published in 1961 will be selected by ELECTRONIC DESIGN's editors to appear in a book that will be available at the 1962 IRE Convention. Each Idea will have the author's byline and company affiliation as they originally appeared in ELECTRONIC DESIGN.

Readers can submit ideas for consideration by following the rules shown next to the accompanying Entry Blank.

Each Idea must be accompanied by an Entry Blank or reasonable facsimile thereof. Additional Entry Blank may be obtained by circling 750 on the Reader-Service Card. ■ ■

SEVENTH ANNIVERSARY AWARDS

IDEAS-FOR-DESIGN

Entry Blank

To: Ideas-for-Design Editor
ELECTRONIC DESIGN
830 Third Ave.
New York 22, N. Y.

How You Can Participate

Rules For Awards

Here's how you can participate in Ideas for Design's Seventh Anniversary Awards: All engineer readers of ELECTRONIC DESIGN are eligible.

Entries must be accompanied by filled-out Official Entry Blank or facsimile. Ideas submitted must be original with the author, and must not have been previously published (publication in internal company magazines and literature excepted).

Ideas suitable for publication should deal with:

1. new circuits or circuit modifications
2. new design techniques
3. designs for new production methods
4. clever use of new materials or new components in design
5. design or drafting aids
6. new methods of packaging
7. design short cuts
8. cost saving tips

Awards:

1. Each Idea published will receive an honorarium of \$20.
2. Ideas judged Most Valuable of Issue will receive \$50.
3. The Idea judged to be Idea of the Year will receive the Grand Prize of \$1,000 in cash.

The Idea of the Year will be selected from amongst those judged to be Most Valuable of Issue.

Most Valuable of Issue and Idea of the Year will be selected by the readers of ELECTRONIC DESIGN. Votes will be cast by circling keyed numbers on Reader-Service Cards. Payment will be made eight weeks after Ideas are published.

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Idea (State the problem and then give your solution. Include sketches or photos that will help get the idea across.)

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IDEAS FOR DESIGN

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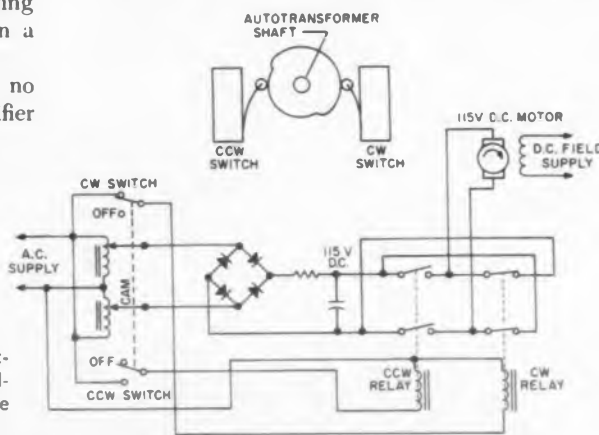
Single-Lever, DC Motor Control 749 Provides Smooth, Reversible Action

The circuit presented here shows a novel means by which the speed and direction of a dc motor can be governed with a single control. A dual auto-transformer and a cam for operating the motor direction switches are mounted on a common shaft as shown in the figure.

In the center position of the control lever, no voltage difference exists across the rectifier

bridge circuit and both control switches are open. When the control lever is rotated in the clockwise direction as indicated in the figure, an ac voltage, proportional to the degree of shaft rotation, appears across the bridge.

The CW control switch closes, simultaneously



Dc motor control provides smooth, reversible action with reversing switches mounted on speed-control shaft. The circuit is shown for clockwise rotation.

actuating the CW relay, and dc voltage appears across the motor armature. The rotational speed of the motor is a function of this dc voltage, and is thus governed by the degree of control-shaft rotation.

When the control lever is rotated counter-clockwise, an ac voltage is again applied across the bridge. However, the CCW control switch actuates the CCW relay, thus causing the dc output of the bridge to be placed across the motor armature in the opposite polarity, reversing its direction of rotation.

Aside from the simplicity of single-lever control, this circuit also has the advantage that there is always zero potential across the control-relay contacts when they are opened or closed. Also, the load driven by the motor is always started and stopped in a finite time interval, thus lessening the danger of gear damage from sudden torque changes.

James Bain, Project Engineer, Rantec Corp., Calabasas, Calif.

Versatile Transistorized Alarm 745 Detects Pulse Dropouts

A simple alarm circuit is often necessary to monitor different types of signal sources and indicate different types of failures. The circuit shown gives an indication whenever a maximum "off" period exceeds a preset time. It was designed to monitor three types of sources:

1. It detects dropouts of one or more consecutive pulses in a repetitive pulse train.
2. It detects "dead" periods exceeding a pre-

set interval in a random pulse pattern or in a pulse train having random pulse widths.

3. It detects a momentary dropout longer than a preset period in monitoring a dc line.

The circuit has provision for manual or automatic reset. In the reset condition it returns to the nonalarm state upon renewal of the source voltage. Using low standby power, it operates from a single power supply with wide limits on voltage variation.

The circuit operates as follows: In the absence of an input voltage, Q1 doesn't conduct and C1

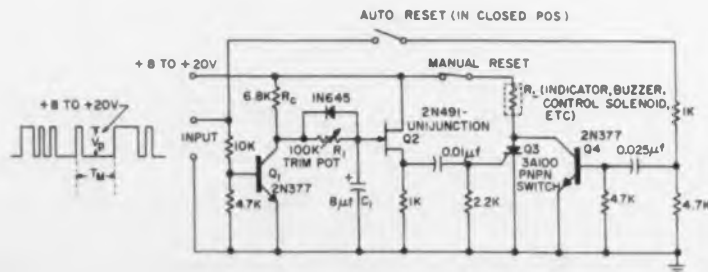
charges towards the critical "fire" voltage of Q2. A pulse at the input momentarily switches Q1 into saturation and causes C1 to discharge to ground through the diode and C1's collector resistor.

If the maximum time between pulses exceeds the firing time constant of the unijunction transistor (as determined by R_c , $R1$ and $C1$), fires and turns on Q3, thereby initiating the alarm signal.

The circuit is manually reset by disconnecting the voltage supplied to the pnpn switch. When the automatic reset switch is closed, return of source voltage at the input capacitively couples a turn-on pulse to Q4 which resets Q3 to the blocking state.

For the values shown, an interval of 100 msec to 1.5 sec can be obtained. The pulse widths required at the source can occupy less than 1 per cent of the time-interval setting so the alarm can be used in low-duty-cycle circuits.

The circuit has been used for a wide variety of industrial-control and alarm-indicating applications. Two widely differing applications in one plant can illustrate the circuit's versatility.



Novel use of diode in unijunction-transistor timing circuit makes for versatile alarm circuit. Most unijunction circuits described in the literature deliver a pulse when a charge cycle on a timing capacitor is completed. In this circuit, this is actually the abnormal condition. The diode provides an alternate discharge path, yet does not interfere with the normal charging cycle.

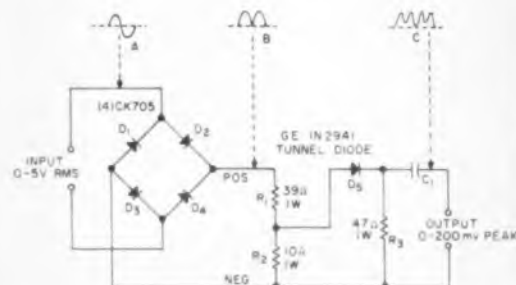
In the first case it was used to monitor answer-sheet feed on a test-scoring machine. Occasional misfeeds cause jams unless they can be detected shortly after the first sheet misfeeds. A micro-switch, driven by a cam, supplies dc to the alarm circuit for a few milliseconds as each sheet passes a certain point. The circuit detects absence of the pulse, indicating a jam, and shuts off the feed by means of a control solenoid.

In another case, the alarm circuit monitors the initial state of a pulse-sequence generator. The circuit fires a visual indicator (an incandescent lamp) which flashes a warning if a given cycle is delayed.

John V. McMillin, Project Engineer, Measurement Research Center, Iowa City, Iowa.

Tunnel Diode Doubles Doubled Frequency

747



Frequency quadrupler uses tunnel diode to double the frequency at the output of a bridge rectifier which doubles the input frequency.

Our need was for a simple untuned circuit which would give a timing wave at four times the frequency of a stable input signal. The tunnel diode circuit shown in the figure satisfied the requirement.

The germanium diode bridge rectifier (D_1 - D_4) gives two positive output pulses (waveform B) for each input-signal cycle (waveform A). This dc output is stepped down and applied to the tunnel diode (D_5) from the low-resistance leg (R_2) of the voltage divider. Each positive pulse swings the tunnel diode through the positive- and negative-resistance portions of its characteristic, giving the output waveform C (four positive pulses).

With the aid of an oscilloscope connected to the circuit output terminals, the input signal voltage is set to the point between zero and 5 v rms (varies with tunnel diodes) which gives the best output-pulse waveform. The circuit operates up to several megacycles.

Rufus P. Turner, Consulting Engineer, Los Angeles, Calif.



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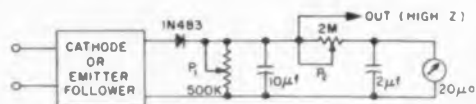
Circuit Calibrates Meter For Sine Waves and Noise

739

White noise and sinusoids of the same effective value read differently on averaging or peak-reading instruments. Some average instruments which are calibrated to read rms values on sine waves, read white noise inaccurately. The circuit of Fig. 1 will read identically for sine waves and noise of the same effective value, and can be calibrated for rms voltages.

The potentiometer P_1 is adjusted until noise and sine waves of the same rms values read the same on the meter. P_2 is then adjusted to give the proper scale value on the meter (1-10 v or 5-50 v). The theory of operation is not given here, but may be had by writing to the author.

Limitations of the method are that it may not read rms of harmonic waves or combinations of a small number of sinusoids. It is also sensitive to the noise bandwidth, when the noise is filtered narrower than, say, 1-kc bandwidth.



Circuit calibrates meter to read identically for sine waves and noise of the same effective value. Author Davis will send, upon written request, a description of the circuit operation.

The application in which this circuit finds its best use is as a cheap "rms" meter on a spectrum analyzer or bandpass filter. The circuit can be adjusted to read the same for a sine wave and filtered noise of any specific bandwidth. Calibration, noise and combinations of a single sinusoid plus noise may then be measured without computations or adjustments.

A. J. Davis, *Research Engineer, Marshall Space Flight Center, Huntsville, Ala.*

Reed Switch Senses Plasma Torch Arc-Over

740

We were using a radio-frequency spark to start a plasma jet torch. We wanted to terminate this spark as soon as the arc struck in the torch.

At first, the voltage drop across a resistor in series with the dc leads was used to operate a control relay. This relay stopped the spark and started programed timers.

However we discovered a simpler way to do this, using a Revere Glaswitch taped to the outside of the core-and-coil-type filter choke in the supply. When the dc arc current flows, there is sufficient leakage flux from the choke to actuate

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HC73	1000	700	
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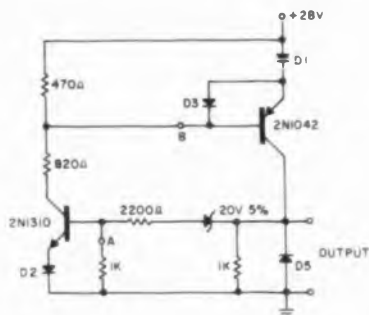
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the Glaswitch. The Glaswitch in turn operates the control relay. It was also found that the Glaswitch would actuate in the magnetic field of the air-wound series rf choke used to keep rf from feeding back to the dc supply.

Louis E. Owen, Laboratory Supervisor, Good-year Atomic Corp., Portsmouth, Ohio.

Transistorized Output Switch 748 Limits Short-Circuit Current

Transistorized switches are useful circuits, but when their loads are subjected to frequent short circuits, the circuits can be troublesome and they require protection. The circuit shown here limits



Half-ampere output switch limits short-circuit to safe, 1-amp value.

the output current in a half-ampere switch to about 1 amp.

The circuit is a modified all-on—all-off flip flop. *D1* and *D2* are silicon diodes which back bias the transistors during their *off* state. They may be eliminated if silicon transistors are used. *D3* is a silicon diode which causes several volts to be dropped across the output transistor when its current exceeds approximately 1 amp. Whenever an excessive load causes the output to approach the voltage of the Zener diode *D4*, the circuit reverts to the *off* state.

A positive trigger at *A* or a negative trigger at *B* will turn the circuit on. A negative trigger at *A* or a positive trigger at *B* will turn the circuit off. If the duration of the *on* trigger pulses is limited to the order of a millisecond and the trigger pulses duty cycle is kept low, no damage will result from triggering even when the output remains shorted.

The device may be turned on and off by a trigger coupled from an isolation transformer, thus making it practical to employ several such devices, each operating from its own power supply, to have isolated grounds.

James G. Barr, Senior Engineer, The Martin Co., Denver, Colo.

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RUSSIAN TRANSLATIONS

J. George Adashko

Transformer Turns-Ratio In Shock-Excited Converter Circuits

IN LOW-POWER, high-voltage converters, where shock-excited autotransformers are used, maximum operating efficiency can be obtained by choosing the optimum transformer turns-ratio. A popular type of converter circuit is shown in Fig. 1. The converter stage can be excited by pulses of various wave forms—rectangular, sawtooth, parabolic, etc. With the autotransformer in the circuit, an amplified, rectified voltage is obtained.

The graphical plot of Fig. 2 shows that the output voltage of the converter varies with the load current. Also, if n , the autotransformer turns-

ratio (L_b/L_a) ranges from 0.5 to 2.5, the maximum output voltage shifts to the right as the load resistance, R_L , is increased.

To design the converter for maximum efficiency, an equivalent circuit, shown in Fig. 3, is used. This circuit is analogous to the equivalent circuit of a pulse-transformer stage.² A theoretical analysis of this equivalent, which contains two resonant circuits, is quite complicated if the capacitance, C_a , is taken into account. However, if C_a is neglected, the error this causes decreases with decreasing C_a .

The amplitude of the first cycle, positive volt-

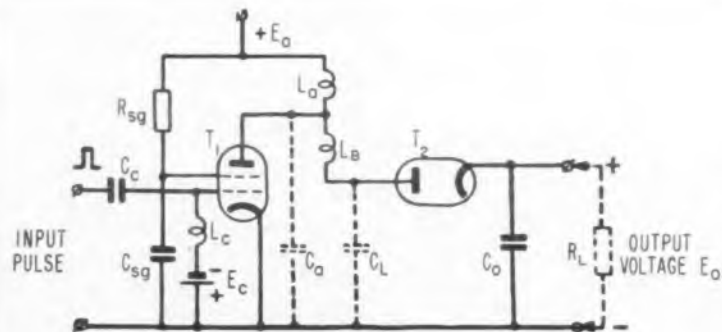


Fig. 1. Shock-excited converter circuit provides rectified, high-voltage output.

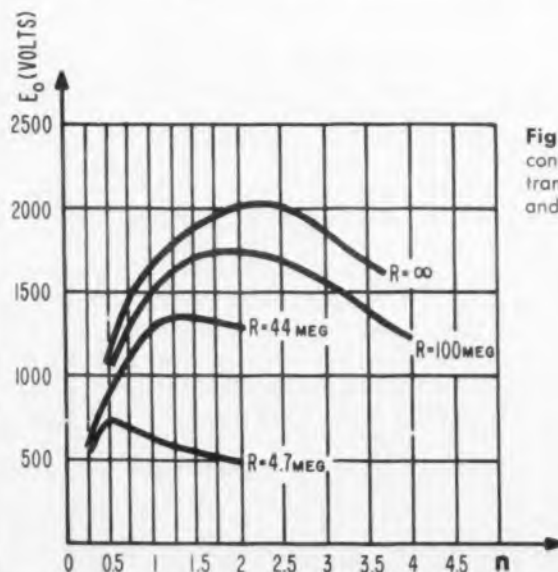


Fig. 2. Output voltage of the converter depends upon the transformer turns-ratio L_b/L_a , and the load.

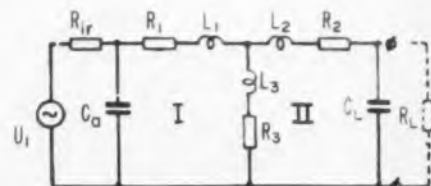


Fig. 3. Equivalent converter circuit for determining optimum transformer turns-ratio for maximum efficiency.

age overshoot in the secondary winding, which is to be rectified, is:

$$U_{2m} = AU_{1m}(1 + \delta)n \quad (1)$$

where A is a constant coefficient

U_{1m} is the input voltage

δ is the relative voltage overshoot.

For this case the relative overshoot is equal to:

$$\delta = e^{-\frac{\pi d}{\sqrt{4-d^2}}} \quad (2)$$

where d is the damping, determined by the network parameters.

For the general case (finite load resistance R_L) we have:

$$d = n \left(R_i \sqrt{\frac{C_L}{L_S}} + \frac{1}{R_L} \sqrt{\frac{L_S}{C_L}} \right) \quad (3)$$

where R_i is the internal resistance of the converter tube.

C_L is the output capacitance of the circuit.

L_S is the leakage inductance of the autotransformer.

We are interested in a maximum first half cycle amplitude of the damped voltage U_{2m} , to be developed across the autotransformer coil. Thus, since:

$$U_{2m} = U_{1m} n \left(1 + e^{-\frac{\pi n \left(R_i \sqrt{\frac{C_L}{L_S}} + \frac{1}{R_L} \sqrt{\frac{L_S}{C_L}} \right)}{\sqrt{4 - n^2 \left(R_i \sqrt{\frac{C_L}{L_S}} + \frac{1}{R_L} \sqrt{\frac{L_S}{C_L}} \right)^2}} \right) \quad (4)$$

the maximum value of n is given by:

$$n = \frac{1.14 \cdot R_L \sqrt{L_S C_L}}{C_L R_i R_L + L_S} \quad (5)$$

For the particular case when the converter operates with no rectifier load ($R_L = \infty$) the expression for the damping is:

$$d = nR_i \sqrt{\frac{C_L}{L_S}} \quad (6)$$

Using transformations and criteria analogous to those made for the general transformer case, we obtain for the optimum transformer ratio:

$$n = \frac{1.14}{R_i} \sqrt{\frac{L_S}{C_L}} \quad (7)$$

Comparing Eq. 7 with the plotted data of Fig. 2, we obtain:

$$nr = \frac{1.14}{R_i} \sqrt{\frac{L_S}{C_L}} = \frac{1.14}{20.5 \cdot 10^3} \sqrt{\frac{0.028}{15 \cdot 10^{-12}}} \\ = 2.4 < 2.5 = n_{exp}$$

Thus the theoretical value obtained for the optimum autotransformer turns-ratio compares favorably with the experimental value.

Translated from "Choice of Optimum Transformation Coefficient in Conversion Circuits With Shock Excitation," M. V. Agapov, *Radio-tehnika*, Vol. 15, No. 11, 1960, pp. 47-49.

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2. S. N. Krize, Low-Frequency Amplifiers, *Gosenergoizdat*, 1953.



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■ *Dr. Robert N. Hall, G.E. research physicist, developed indium-germanium junctions, and the "rate growing" process for making grown junction transistors.*

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YOUR CAREER NEWS AND NOTES

Who needs a degree? Despite the emphasis on engineering degrees, it is still surprising how many engineering jobs are open to a man "with the equivalent." For example in a recent listing of job openings published by a technician-level trade school, eight of the 44 jobs listed were open to either engineers or technicians. True, most were of the "field engineer" variety, but at least two were of full engineering stature. One was for "systems engineers to study and analyze complex weapon-system support requirements."

One can conclude that the distinction between the professional engineer and the trade-school technician is still hazy. Part of the blame may rest with companies that haven't yet learned to utilize engineers as engineers; part with engineering schools that turn out "scientist-engineers," who are not as immediately useful as technicians. However, credit must go to some of the better trade schools for doing a good job.

• • •

General Dynamics has established a graduate fellowship in electrical engineering at Syracuse University and has renewed a similar grant established at Cornell University last year. Each of the fellowships carries a stipend of \$2,400 plus full tuition and all fees. The fellowships will be administered by the dean of graduate studies at each university.

In another phase of General Dynamics support of advanced electronics study, Watson F. Walker, assistant chief engineer, is currently at Syracuse University doing graduate work leading to a doctorate in electrical engineering. The company said it was paying tuition, all fees, and part of Mr. Walker's salary. Other General Dynamics electronic engineers are working for doctoral degrees at the Universities of Kansas and Illinois.

• • •

Hertz Engineering Scholarship Foundation has initiated a free scholarship administration service designed especially for smaller companies. The extent to which the companies will benefit can be judged from the fact that administration costs on smaller scholarship programs often amount to more than the cost of the scholarships themselves, according to a Hertz spokesman. Details of the foundation's program, as well as other programs for engineering students, may be obtained from the Hertz Engineering Scholarship Foundation, 1314 Westwood Blvd., Los Angeles, Calif.

ELECTRONIC DESIGN CAREER INQUIRY SERVICE

USE BEFORE APR. 26, 1961

6

After completing, mail career form to *ELECTRONIC DESIGN*, 830 Third Avenue, New York, N. Y. Our Reader Service Department will forward copies to the companies you select below.

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ELECTRONIC DESIGN's Confidential Career Inquiry Service helps engineers "sell" themselves to employers—as confidentially and discreetly as they would do in person. The service is fast. It is the first of its kind in the electronics field and is receiving high praise from personnel managers.

To present your job qualifications immediately to companies, simply fill in the attached resume.

Study the employment opportunity ads in this section. Then circle the numbers at the bottom of the form that correspond to the numbers of the ads that interest you.

ELECTRONIC DESIGN will act as your secretary, type neat duplicates of your application and send them to all companies you select—the same day the resume is received.

The standardized form permits personnel managers to inspect your qualifications rapidly. If they are interested, they will get in touch with you.

Painstaking procedures have been set up to ensure that your application receives complete, confidential protection. We take the following precautions:

- All forms are delivered unopened to one reliable specialist at *ELECTRONIC DESIGN*.
- Your form is kept confidential and is processed only by this specialist.
- The "circle number" portion of the form is detached before the application is sent to an employer, so that no company will know how many numbers you have circled.
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Position Desired _____

Educational History

College	Dates	Degree	Major	Honors

Recent Special Training _____

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Company	City and State	Dates	Title	Engineering Specialty

Outstanding Engineering and Administrative Experience _____

Professional Societies _____

Published Articles _____

Minimum Salary Requirements (Optional) _____

Use section below instead of Reader Service Card. Do not write personal data below this line. This section will be detached before processing.

Circle Career Inquiry numbers of companies that interest you

900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924
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CIRCLE 902 ON CAREER INQUIRY FORM

ENGINEER-IMPROVEMENT COURSES AND SEMINARS

Below are courses and seminars intended to provide the engineer with a better knowledge of various specialties. Our grouping includes several different types of meetings: National Courses—those held on consecutive days and intended to draw attendees from all geographical areas; One-Day Seminars—one-day intensive seminars which move from city to city; and Regional Lectures—regional symposia or lecture series which generally run one night a week for several weeks.

National Courses

Graduate Program on Solid State At Penn. State

A graduate-level technology course on solid state has been established at Pennsylvania State University. Candidates for M.S. and Ph.D. degrees will be accepted beginning with the 1961-62 school year.

The program will be grouped in four major areas: the structure of solids (crystal chemistry and structure determination); theory related to the solid state (physics, chemistry and mechanics); properties of solids (optical, electrical, magnetic, mechanical, thermal and chemical); and reactions of solids (phase equilibria, reaction mechanisms, reaction kinetics and surface reactions).

Candidates should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, metallurgy or a closely related field. At least one year each of chemistry and physics are required as well as mathematics through integral calculus.

Information may be obtained from Dean, Graduate School, Pennsylvania State University, University Park, Pa.

Nonlinear Systems Analysis at Case, July 10-21, 1961

A two-week summer study course in nonlinear system analysis for engineers and others concerned with feedback control systems and networks will be offered at Case Institute of Technology, Cleveland, July 10-21. The course will present current techniques for describing nonlinear equipment. It will consist of 20 lectures and 20 problem sessions, including techniques for finding a possible exact solution and analytical and topological treatment of forced and free oscillations. Tuition is \$300, and requests for applications should be addressed to Herbert Schultz, manager of special programs, Case Institute, University Circle, Cleveland 6, Ohio.



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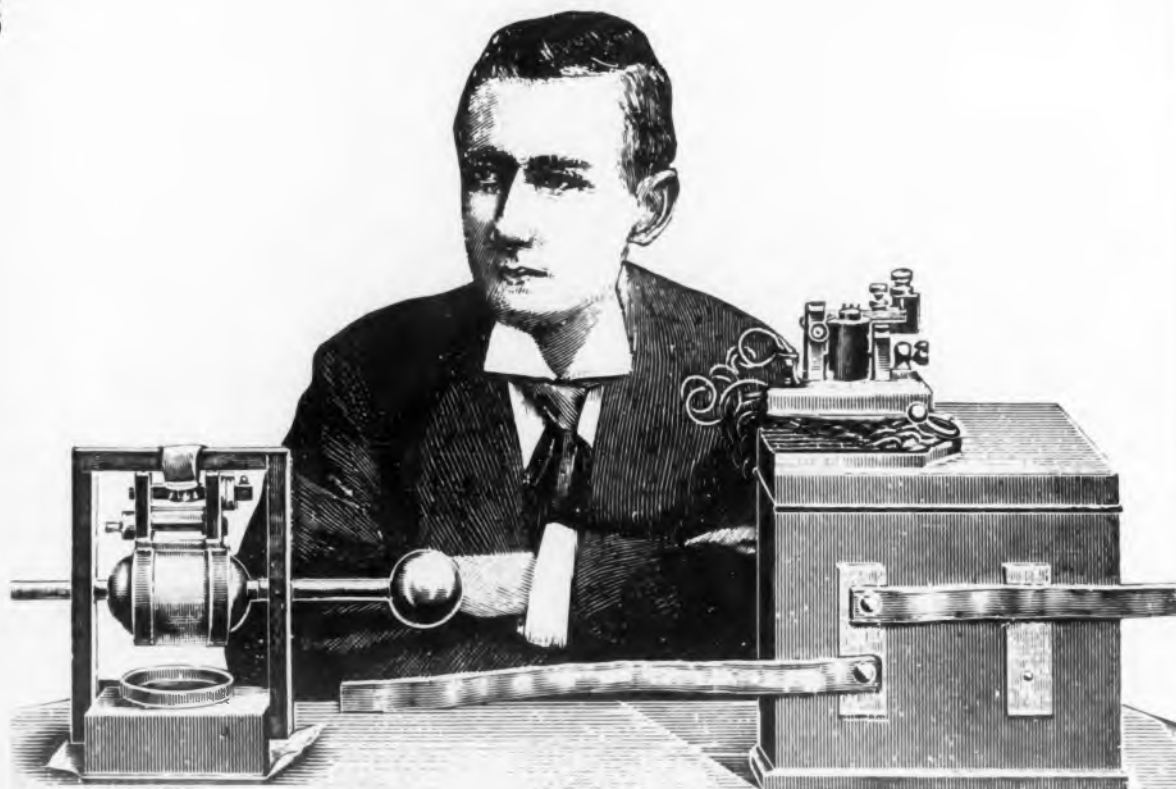
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of enormous strides in the development of the wireless concept.

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DISCUSS YOUR FUTURE WITH COLLINS AT THE IRE SHOW

Mr. L. R. Nuss, Manager, Professional Employment, will be at the New York IRE show in the Career Center. You may telephone him at LT 1-1200 or stop in for a personal interview if you qualify for one of the following immediate openings: Advanced circuit design engineers; Commercial airborne communication and navigation equipment design engineers; Reliability analysis and design engineers; Aircraft system engineers with experience in gyro design, flight

control and/or airborne navigation equipment design; MSME in thermodynamics; Transistorized RF circuit design engineer; BSEE's with experience in transistorized pulse application or automatic fault isolation; MSEE interested in tracking, guidance and telemetry. If you are unable to attend the IRE show, send your resume immediately to Mr. L. R. Nuss, Manager, Professional Employment, Collins Radio Company, Cedar Rapids, Iowa.



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CIRCLE 905 ON CAREER INQUIRY FORM

CAREER COURSES

Math for Operations Research To Be Taught At Purdue in June

A ten-day course on the mathematical techniques of operations research will be offered at Purdue University starting June 5.

Prof. Paul H. Randolph, director of the course, said it was intended for engineers and other technical personnel in industry. Emphasis will be on the mathematical techniques of operations research as applied to current industrial and military problems.

Among the topics to be discussed are inventory control models, waiting line models, linear programming, simplex method, transportation methods, production scheduling models, search theory, cost-effectiveness studies and system analysis.

Dr. Albert Madansky of the University of California and Dr. Bernard Lindgren of the University of Minnesota will conduct the course. Dr. Madansky has done work in stochastic linear programming, and Dr. Lindgren has specialized in probability statistics.

Further information may be obtained from the Div. of Adult Education, Purdue University, Lafayette, Ind.

Computer Symposium Slated At Denver University in June

The University of Denver's Research Institute will hold its Eighth Annual Symposium on Computers and Data Processing June 22-23 at the Elkhorn Lodge, Estes Park, Colo.

The continuing theme of these meetings is the advanced treatment of basic problems in computer technology. Papers will cover components and devices, logic design, philosophy of computer design and computers in education.

For further information, write to W. H. Eichelberger, chairman of arrangements, Denver Research Institute, University of Denver, Colo.

PAPER DEADLINES

Convention Program Chairmen have issued the following deadlines to authors wishing to have their papers considered for presentation.

May 15: Deadline for submitting the titles and abstracts of papers for Eighth National Symposium on Reliability and Quality Control. The symposium will be held Jan. 9-11, 1962, at the Statler Hilton Hotel, Washington, D.C. Letters and spaces in the title for the program must not exceed 50, and abstracts not more than 800 words. Submit brief biographical sketch of authors suitable for publication in the proceedings. Send 10 copies to E. F. Jahr, IBM Corp., Dept. 351, Owego, N.Y.



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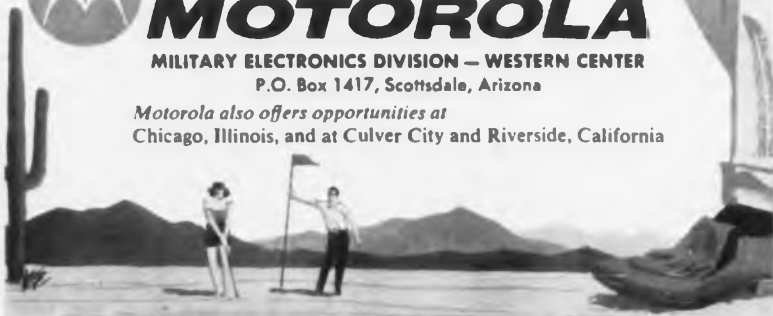
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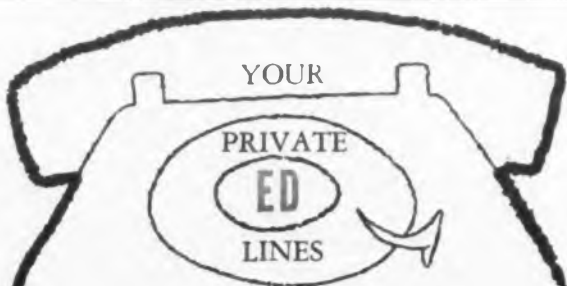


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When employment information is obtained through *ELECTRONIC DESIGN*, it's sent direct to your home, so that only you and one prospective employer at a time know about it. You can conduct your employment campaign privately—as it should be conducted.

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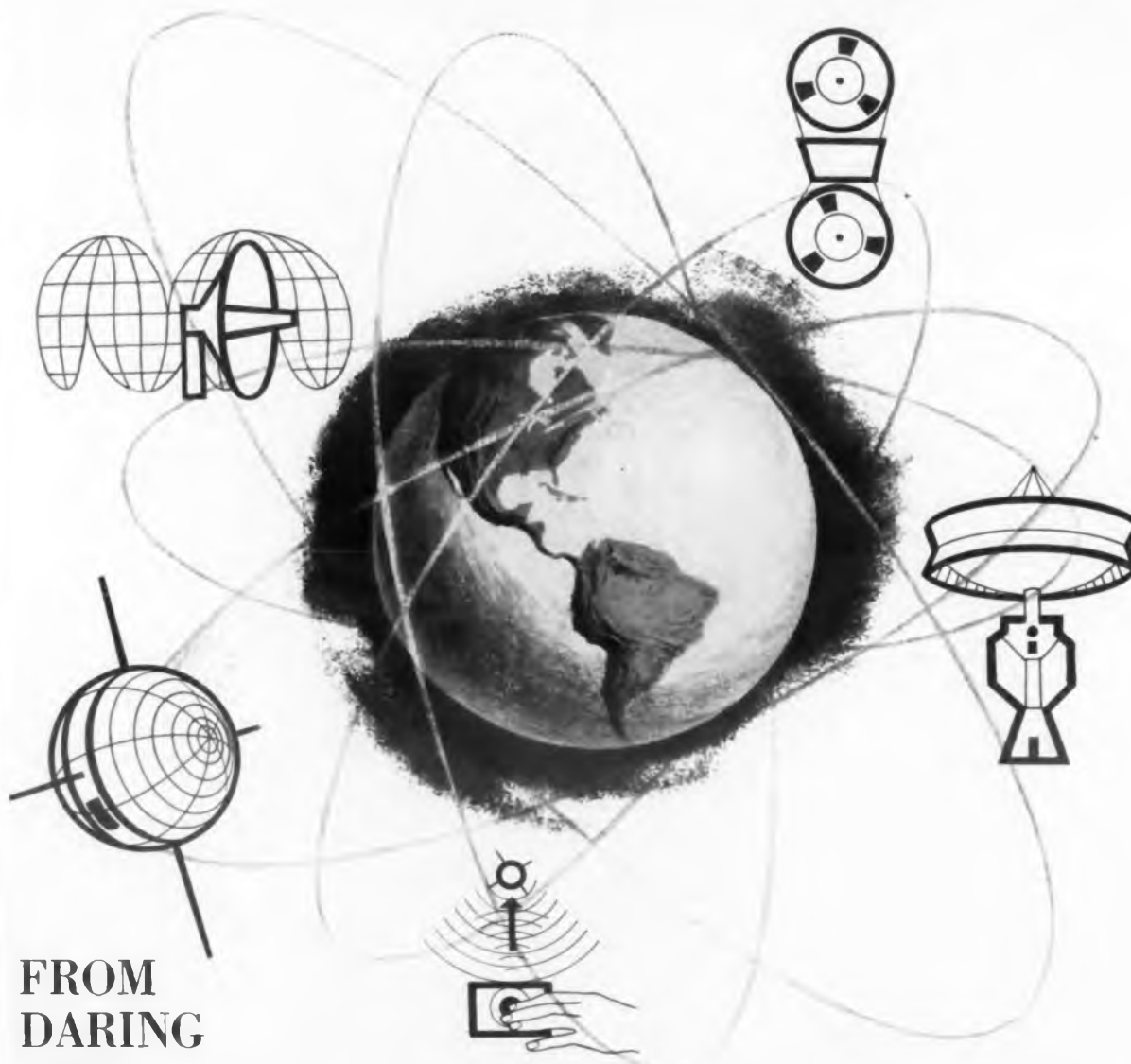
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Contact Rating	Dry circuit or 2 amperes resistive at 28 volts dc *
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hp 420A Coaxial Crystal Detector Mount, 10 MC to 12.5 GC

Detects rf signals over a three decade frequency range from 10 MC to 12.5 GC. Sensitivity is approximately 0.01 v/0.1 mw, and frequency response is ± 3 db over the full range. Maximum SWR is 3:1.

⊕ 420A, \$50.00.



hp 420B Coaxial Reflectometer Mount

Identical to the ⊕ 420A in frequency range, the ⊕ 420B is available in pairs matched to within ± 1 db over the range 1 to 4 GC.

⊕ 420B, \$75.00; \$150.00 per matched pair.

hp 485 Waveguide Barretter Mounts, 2.6 to 12.4 GC

Reflectometer Mounts—characterized by flat frequency response, low SWR, true square-law characteristics and high sensitivity, the broadband 485D Waveguide Barretter Mounts are supplied with factory selected barretters for maximum accuracy in reflectometer applications.

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hp 421A Waveguide Crystal Detector Mounts, 7.05 to 18.0 GC

Silicon diodes are employed in these mounts for better SWR characteristics at higher waveguide frequencies. Frequency response ± 2 db maximum over full range, square-law characteristic ± 1 db. Matched pairs are available for reflectometer applications. ⊕ H421A, 7.05 to 10 GC, \$95.00 each, \$210.00 per matched pair; ⊕ X421A, 8.2 to 12.4 GC, \$75.00 each, \$170.00 per matched pair; ⊕ M421A, 10.0 to 15 GC, \$125.00 each, \$270.00 per matched pair; ⊕ P421A, 12.4 to 18.0 GC, \$130.00 each, \$280.00 per matched pair.



hp 440A Detector Mount

For use in coaxial or waveguide systems, the ⊕ 440A covers 2.4 to 12.4 GC. The mount uses either 1N21 or 1N23 silicon crystal, 1/100 amp instrument fuse or Sperry 821 barretter. (Detector element not furnished as part of instrument.) With the ⊕ 442B Broad Band Probe (not shown), the 440A becomes a sensitive, easily tuned detector for slotted waveguide sections. ⊕ 440A, \$85.00; ⊕ 442B, \$40.00.

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Sales representatives in all principal areas

HEWLETT-PACKARD S. A.

Rue du Vieux Billard No. 1 Geneva, Switzerland
Cable "HEWPACKSA" Tel. No. (022) 26. 43. 36

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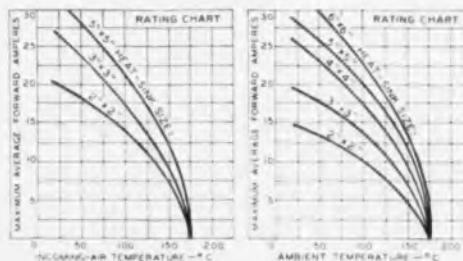
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	PIV	Average Amperes @ 100°C Case Temp	Peak Surge Amperes*	Max. Reverse Voltage (Volts)	Max. Forward Voltage Drop (Volts)†
1N248C	55	20	350	3.8	0.6
1N249C	110	20	350	3.6	0.6
1N250C	220	20	350	3.4	0.6
1N1195A	300	20	350	3.2	0.6
1N1196A	400	20	350	2.5	0.6
1N1197A	500	20	350	2.2	0.6
1N1198A	600	20	350	1.5	0.6

- * For One-Half Cycle
- † For 60 cps, single-phase operation, resistive or inductive load
- ‡ At Maximum Forward Current and Peak Inverse Voltage Ratings, and averaged over one complete cycle

Reverse Polarity Versions: 1N248RC, 2N249RC, 1N250RC, 1N1195RA, 1N1196RA, 1N1197RA, 1N1198RA



Forced-air cooling: Air velocity is 1000 feet per minute parallel to plane of heat sink. Single-phase operation. Rectifier type is stud-mounted directly on heat sink. Heat sink: 1/16"-thick copper with a mat black surface and thermal emissivity of 0.9.

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