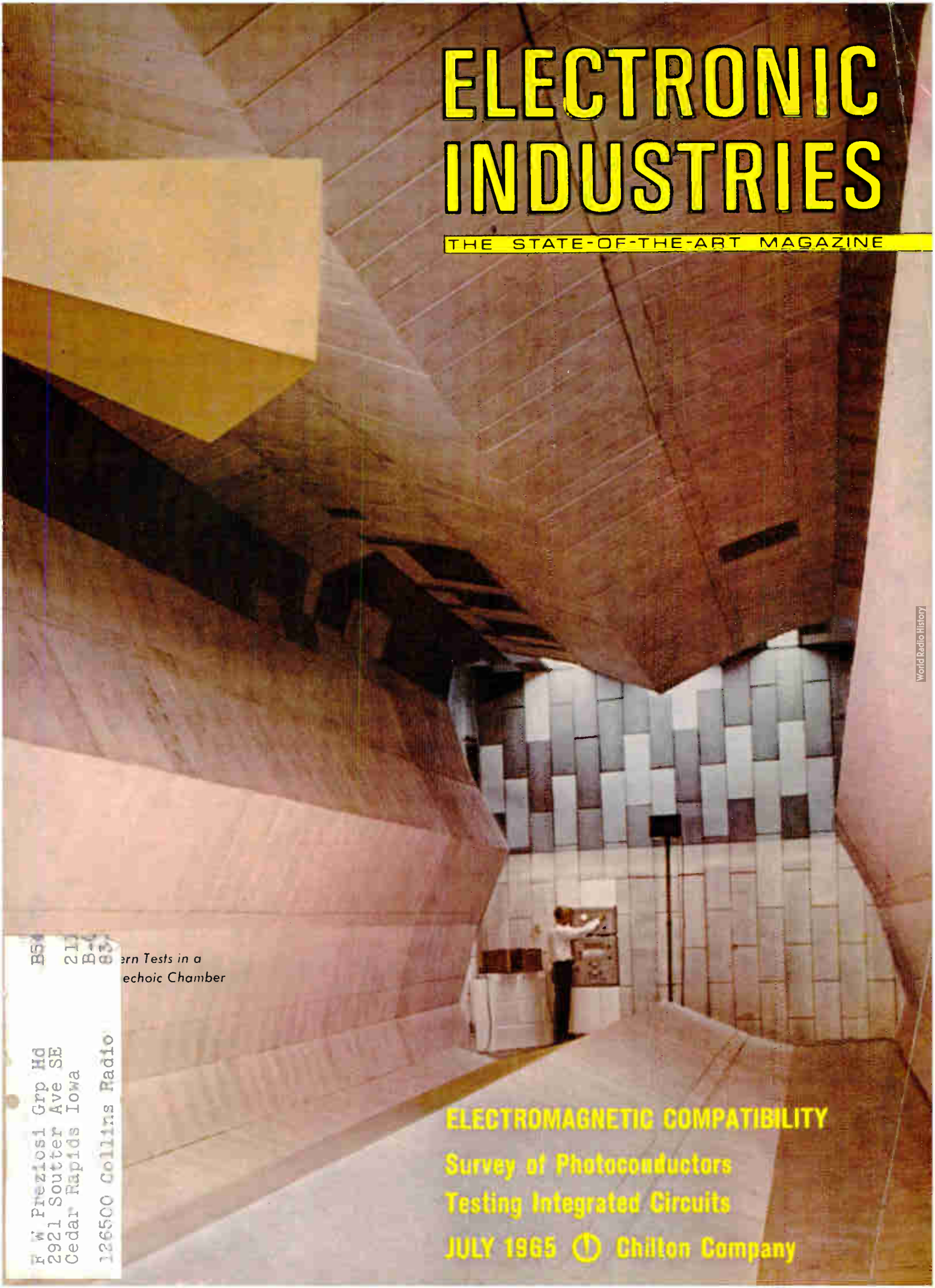
ELECTRONIC INDUSTRIES

THE STATE-OF-THE-ART MAGAZINE



...ern Tests in a
...echoic Chamber

ELECTROMAGNETIC COMPATIBILITY

Survey of Photoconductors

Testing Integrated Circuits

JULY 1965 ① Chilton Company

UTC

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NEW!-VERNIER

HVV VARIDUCTOR™

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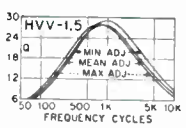
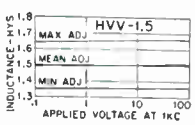




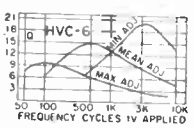
The HVV Variductors have been designed to emphasize extremely high stability with temperature, level, shock and vibration commensurate with the highest obtainable Q. They are ideal for precise matching to other components such as capacitors with standard 10% tolerance. Units are provided with a vernier adjustment variation of ±10% through 900° rotation of adjustment screw on top of case. Setting is positive. There are 12 units in the stock line with mean inductances ranging from .006 Hy to 150 Hys. Specific mean inductances other than stock items are available on special order. Manufactured and guaranteed to MIL-T-27B, MIL type TF4RX20YY. Drawn metal case: 1⅛" long, 25/32" wide, 1-7/32" high (including adjustment screw); weight: 2 ounces. Effective Q over a wide frequency range and variation of inductance with applied AC voltage are illustrated for a typical unit. Patent pending.

HVC VARIDUCTOR™

HERMETICALLY SEALED

WIDE RANGE

HVC units are usable over a wide frequency range and have high stability with temperature and voltage change. Nominal inductance values of 12 stock units in series range from .006 Hy to 150 Hys. The variable inductance range of each unit is +200%, −70% of nominal value through 900° rotation of adjusting screw on top of case. Setting is positive. Case size and weight is the same as HVV. U.S. Patent No. 2,879,489.



TVC VARIDUCTOR™

TVC Variductors are identical to the HVC units, but provide taps at 30% and 50% of total turns. Different taps are available on special order. U.S. Patent No. 2,879,489.

WIDE RANGE

VIC VARIDUCTOR™

COMMERCIAL GRADE

Nominal inductance values of 22 stock items in this series range from .0085 Hy to 130 Hys. Mean inductance may be varied +85%, −45% through 600° rotation of adjustment screw in side of case. Rugged die cast case: 1-11/13" long, 1¼" wide, 1-7/16" high; weight 5½ ounces.

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ELECTRONIC INDUSTRIES
The State-of-the-Art Magazine

COMPONENT SPECIFICATION SURVEYS

Dear Reader:

In this issue (page 84) we present the concluding installment of our 1965 Connector Specification Survey. This section deals with Plug and Jack Connectors.

Many of you have written telling us how helpful our hardware specifications surveys are. We intend to continue this program. Part I of Potentiometer Specifications, which follows the present connector series, starts in our September issue. On the reverse of this sheet we have listed all of the specification charts planned for the rest of the year.

Because of the long lead times required by this type feature, we are planning the 1966 hardware specification program now. If you, as our reader, have specific thoughts or desires in this area we would appreciate receiving your views.

To give you some idea of what is involved in developing these surveys we thought we might summarize the preparation steps for you. First, of course, we have to select a hardware area that is of greatest interest and use to our readers. Next comes the development of a complete name and address list of the manufacturers making these products. This is followed by a letter or questionnaire mailing to manufacturers requesting up-to-date information on the products they make. The gathering of this information may also involve multiple mailings and additional telegrams or phone calls in order to obtain full participation in the program.

By this time we have now assembled hundreds of pages of specification data. All this must be analyzed, checked, and edited to produce an informative and useful editorial feature.

After the information has been compiled, we again seek manufacturers' cooperation in re-verifying what we plan to publish. It is only when we reach the verification phase that we are able to plan and schedule actual publication.

Plans for our present Connector Specification Survey were originally made in November 1964 and the first section of Printed Circuit Connectors was published in the January 1965 issue. This was followed by Coaxial Cable Connectors in February and Multi-Pin Connectors in April. We worked with 160 manufacturers to develop this material and spent more than 300 man-hours in its compilation.

Sincerely,
The Editors

1965-1966 EDITORIAL FEATURES

AUGUST	• WESCON Show • Power Relays Specification Chart • Characteristics of Photovoltaic Diodes
SEPTEMBER	• State-of-the-Art in Solid State Devices • Potentiometers, part 1, Specification Chart • Phototransistors & Silicon PNPN Light-Activated Devices
OCTOBER	• Special Purpose Relays
NOVEMBER	• Microwave, 13th Annual Issue • Potentiometers, part 2, Specification Chart
DECEMBER	• Switches, part 1, Specification Chart • Computers, State-of-the-Art
JANUARY	• 1966 Review & Forecast for the Electronic Industries
MARCH	• 1966 IEEE Show Coverage

ELECTRONIC INDUSTRIES
The STATE-OF-THE-ART Magazine

EMC Today

In 1960 Electronic Industries was first to call attention to the growing problems in RFI (Radio Frequency Interference). The ten feature articles we published on RFI in that year formed the basis for a special military training course at the Armour Research Foundation. Since then the scope of this subject has broadened considerably. RFI has grown to EMC (Electromagnetic Compatibility). It has become a topic for special courses at the University of Pennsylvania as well as Massachusetts Institute of Technology. The National Symposium on Electromagnetic Compatibility, held in New York City last month, attests to the growing interest and concern in this area.

We believe that you will find "New Developments in EMC," and "The Broad Aspects of EMC" both interesting and informative state-of-the-art reports. James Senn, James Hill and Rexford Daniels are recognized industry spokesmen. In addition, we should like to make the following constructive suggestions:

1. EMC technology has advanced sufficiently to warrant training engineers in the field of RFI/EMC. They should receive information about how to detect, measure, and design devices and equipment to suppress unwanted radiations. It would be a good subject to include in all college engineering courses.

2. Suppression devices and connections should be clearly marked as EMC devices and made in such a manner that they cannot be left out when equipment is repaired. We suggest that all devices and grounds be tagged with a phrase such as *"Do Not Remove Without Prior Approval of . . . . . ."*

3. There is a definite need for minimum specifications that would be applicable to all services—military, government, and civilian. Critical problems could be covered by more stringent specifications.

4. New EMC test equipment is coming on the market that has the desirable features of portability, automatic operation, and accuracy. This instrumentation is useful in the hands of trained specialists. However, there is still a need for equipment that can be used by technicians who do not have full knowledge of the field. This equipment should be rugged, portable, easy to operate, and less costly.

5. Engineers need comprehensive EMC design handbooks. Such texts would also help them solve existing problems.

6. Designers should more fully consider the electromagnetic environment in which equipment will operate. Some steps have been taken in this direction through ECAC (Electromagnetic Compatibility Analysis Center) for military equipment designers and users. A similar service, embracing the same methods, should be developed for civilian applications. Civilian and military equipment should be capable of living together.

7. Electrical/electronic devices such as heating pads, motors, razors, radios, tape recorders, and SCRs for control devices, etc., are creating unwanted radiation. Steps have been taken with some TV receivers under the "Good Neighbor" policy to reduce spurious radiation. All devices should be under some effective control. The purchaser of electrical devices knows that he should look for the Underwriters Laboratories approval label. Perhaps the engineering department of EIA and NEMA could develop radiation reduction standards. Then it would become possible to tag or label equipment that has met these specifications.

Let's look at electromagnetic radiation as a natural resource that should be nurtured and conserved in every possible way. Senate Bill S. 1015 now before Congress would grant broad power to the FCC to regulate unwanted radiation. We believe this is a constructive step in the right direction.

Bernard F. Osbahr

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For application engineering assistance without obligation, write to Mica Capacitor Section, Field Engineering Dept. For complete technical data write for Engineering Bulletins 1230 and 1240 to Technical Literature Service, Sprague Electric Company, 233 Marshall Street, North Adams, Massachusetts 01248.

SOMETHING NEW and important has happened to transmitter-type mica capacitors! In place of the old-fashioned, bulky assemblies you've had to use in the past, Sprague now offers modern, miniaturized Cast Mica Capacitors—30% smaller in size, 30 to 40% lighter in weight, available in new shapes and mountings for liberal new design possibilities.

Encapsulated in high-temperature epoxy resin by a patented process, Sprague Cast Mica Capacitors will operate at temperatures to 125 C *without derating*—greatly in excess of the 70 C or 85 C limits of conventional capacitors. This exclusive construction also provides superior thermal conductivity—far better than with porcelain—enabling these capacitors to carry higher r-f currents.

Unlike older units with fragile insulating housings, Sprague Cast Mica Capacitors are rugged. Their tough epoxy resin encapsulation, with improved hermetic seals, eliminates use of potting waxes which tend to melt and cause damage to electron tubes and other components.

Sprague Cast Mica Capacitors, designed not only to meet but *exceed* MIL Specifications, are made in both the familiar cylindrical as well as a new rectangular shape, with female threaded terminals on opposite ends. Although smaller in size than conventional capacitors, Cast Micas can be procured—for interchangeability—with one or two aluminum plates having the same center-to-center mounting holes as standard types. Where space is critical, they may also be mounted or stacked without plates by means of dual-ended headless screws.

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CAPACITORS	PULSE TRANSFORMERS	CERAMIC-BASE PRINTED NETWORKS
TRANSISTORS	INTERFERENCE FILTERS	PACKAGED COMPONENT ASSEMBLIES
RESISTORS	PULSE-FORMING NETWORKS	BOBBIN and TAPE WOUND MAGNETIC CORES
INTEGRATED CIRCUITS	TOROIDAL INDUCTORS	SILICON RECTIFIER GATE CONTROLS
THIN-FILM MICROCIRCUITS	ELECTRIC WAVE FILTERS	FUNCTIONAL DIGITAL CIRCUITS

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JULY 1965, Vol. 24, No. 7

ELECTRONIC INDUSTRIES

The STATE-OF-THE-ART* Magazine

COVER: One of a battery of longitudinal-baffle microwave anechoic chambers at the Canton, Mass. facilities of Emerson & Cuming, Inc. It was designed as an experimental chamber to provide solid —40db reflectivity using only —20db absorbing material in the L-band and higher frequency range.

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

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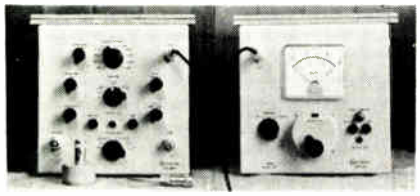
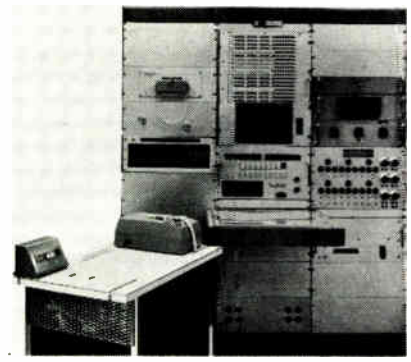
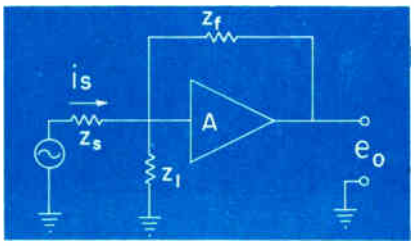
HIGHLIGHTS



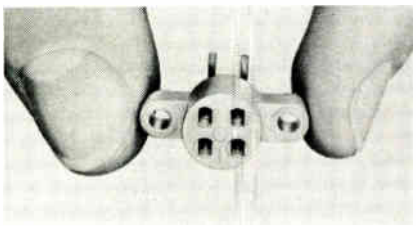
New Development in EMC



DC Testers for I.C.'s

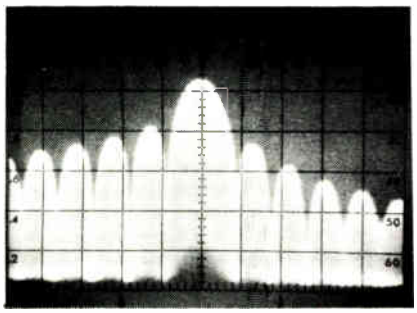


Operational Amplifier Design



Plugs and Jacks

EMC Measurements



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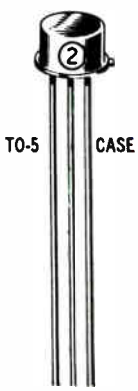

TYPE NO.		APPLICATION	BV_{CBO}	BV_{CEO}	h_{FE}	f_T
TO-5 CASE	TO-18 CASE					
TN53	TN54	High Voltage Switch, Amplifier, Gen. Purpose	75V	45V	50 min.	100 Mc
TN55	TN56	Low-level, Low-noise	40V	30V	60 min.	30 Mc
TN59	TN60	High Speed Switch High Speed Amplifier	40V	30V	100 min.	100 Mc
TN61	TN62		40V	30V	50 min.	100 Mc
TN63	TN64		20V	20V	25 min.	20 Mc

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ELECTRONIC INDUSTRIES, July, 1965. Vol. 24, No. 7. A monthly publication of Chilton Company. Executive, Editorial & Advertising offices at Chestnut & 56th Sts., Phila., Pa. 19139. (Area Code 215) Sherwood 8-2000. Controlled circulation postage paid at Philadelphia, Pa. $1 a copy; Reference issue (June), $5.00 a copy. Subscription rates U. S. and U. S. Possessions: 1 yr. $10.00; 2 yrs. $18.00. Canada 1 year, $12.00; 2 yrs. $20.00. All other countries 1 yr. $18.00; 2 yrs. $30.00.

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AlSiBase substrates now are produced in volume at two American Lava plants. They are finding ever widening applications. Our first technical bulletin on this subject is now available. If you'd like a copy, please request Bulletin No. 652.

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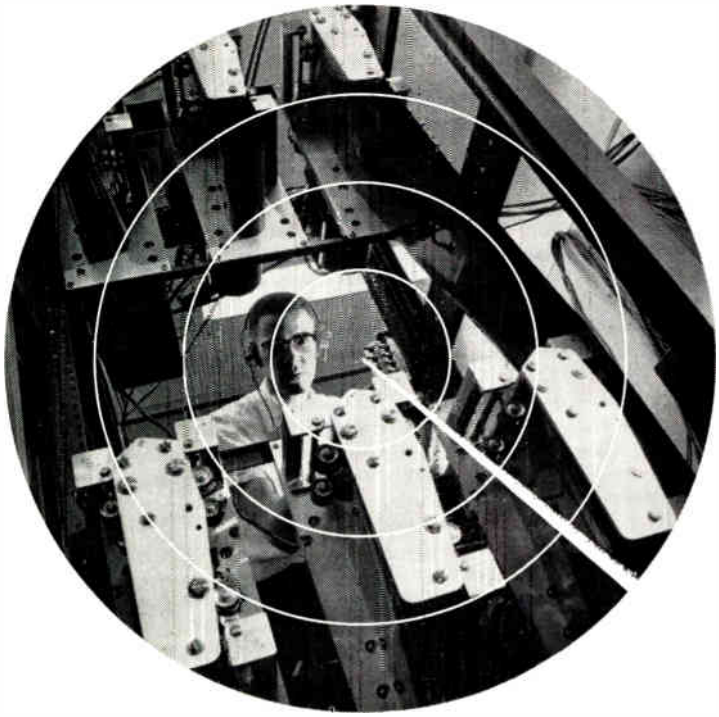
ELECTRONIC INDUSTRIES RADARSCOPE

Developments and trends affecting the State-of-the-Art of technologies throughout the electronic industries



TALKING COMPUTER

J. R. Ball of Westinghouse checks out one of the elements of a computerized teaching system developed by the company for Stanford University. Six of 12 audio units which will enable the computer to talk to students are shown. A Prodac 50 computer system is used to control the battery of random-access audio units.

SOLAR ENERGY COLLECTOR that will be 52 feet in diameter, and petal-shaped for space applications, is to be designed by Goodyear Aerospace Corp. In operation, the collector would be placed in orbit and then unfold like an umbrella. Its surface will reflect and concentrate energy from the sun. The resulting energy then would be converted to electrical power. The contract was awarded by Sundstrand Aviation-Denver.

NEW HIGH-SPEED MEMORY unit recently made available by RCA has a full-cycle time as low as 200 nsec. The monolithic ferrite device is now in pilot production for tests and evaluation. Production economies are realized in this unit as "batch processing" eliminates the tedious task of core-stringing and hand-wiring. The production process uses thin layers of normal ferrite material fired into a solid monolithic ferrite wafer one-inch square and five one-thousandths of an inch thick. Each wafer contains 4,096 theoretical cores, with each core having an effective diameter of 5 mils.

LASER NAVIGATION SYSTEM that could be used on vehicles in exploring and mapping the moon's surface has been successfully tested. The test was described by R. A. Flower, Program Manager at GPL Div., General Precision, Inc., at recent National Aerospace Electronics Conference. The laser is an integral part of a velocity sensor that has been incorporated into an experimental navigation system along with a computer, a map plotter and other electronic equipment.

COMMUNICATION EQUIPMENT that can handle messages at the rate of 2500 words/min. will be used by Standard Oil Co. (N. J.) for company messages between New York and London. The equipment, which can send and receive printed messages over 30 times faster than normal teletype was conceived by Jersey Standard Engineers and designed and developed by Data Communications, Inc. It can also sort, according to destination by actual office, messages fed into it at random.

PROTECTING GERMANIUM from environmental conditions is in the early stages of development by scientists at General Motors Research Labs. A new method converts the common oxide film of germanium to a rare, extremely stable tetragonal form of germanium dioxide. This hard film is about 50 μin. thick. It will protect devices from environmental conditions such as water vapor. The film also improves the semiconductor's electrical properties.

PORTABLE COLOR TV RECEIVER has been introduced by General Electric Co. The 24 pound set will be available late this fall. The new portable—called "Porta-Color" by GE—will use an 11-in. rectangular tube made by the company. The receiver measures 16½ in. deep full front to back, 11¾ in. high, and 17 in. wide.

SUPERCONDUCTIVITY has been established at 5°K in lead telluride, normally a semiconductor, in a research program of the Franklin Institute Research Laboratories. Previously, superconductivity in semiconductors had been achieved only at temperatures around 0.3°K. And, the methods involved were much more difficult and costly than those used at 5°K.

NEW X-RAY SENSITIVE TV tube has the ability to "build up" the contrast and detail of the image during exposure according to Picker X-ray Corp. The tube resembles conventional x-ray sensitive TV units in that it converts the rays directly into shadow images for TV viewing, but with the build up. The new tube is ideal for inspecting microcircuits and other tiny electronic components.

A MALFUNCTION DETECTION SYSTEM developed by the Lockheed-Georgia Co. will constantly check the condition of an aircraft in flight. Readings from over 1,000 test points throughout the aircraft can be relayed to the flight engineer's station through an automatic printer and oscilloscope to provide an immediate "physical examination." These readings pinpoint, and in some cases anticipate, malfunctions.

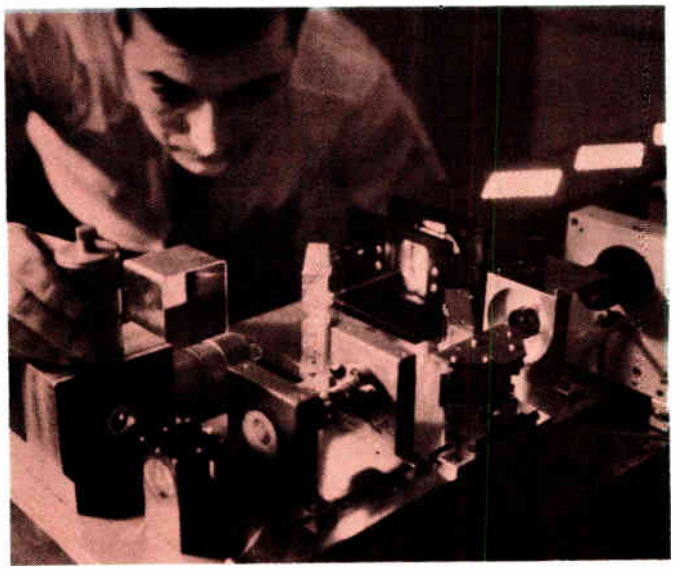
SPECTROSCOPY'S findings about radiation gave birth to the quantum theory in the 1920s. This theory led physicists to a deeper understanding of the natural universe. However, the theory has been inadequate to explain all of the recent findings of spectroscopy. Observations made by Purdue University scientists indicate possible errors in the theory's interpretation.

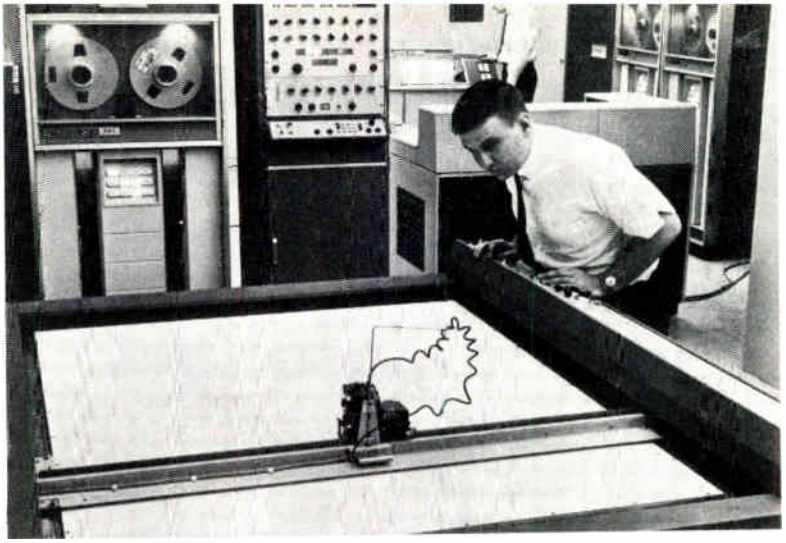
LATEST WELDING PROCESSES such as electron-beam, laser, plasma-arc, friction and electroslag are covered in the new "Welding Handbook" from the American Welding Society. The new handbook reflects the latest information in the processes of metallizing, brazing, soldering, adhesive bonding of metals, ultrasonics and several other methods.

ELECTRONIC MEASURING SYSTEMS that can detect, automatically and continuously, a number of pollutants and indicate the degree of water pollution has been developed by Honeywell. Measurable data on the constituents that define the quality of the water can aid in minimizing pollution.

LASER PHOTOGRAPHY SYSTEM

Optics technician adjusts ruby laser which provides a light source for a hypersonic wind tunnel Schlieren photography system. The 500-kw burst of light, which lasts for 40 nsecs, is used to capture the effect of small, rapid air turbulence on film. The system was developed by Aircraft Armaments, Inc., for the Air Force.





AUTOMATIC DRAWINGS

Structural design and detail drawings are automatically produced by this computer-directed system. Called CONSTRUCTS, the system, recently announced by Meiscon Corp., uses computers in Chicago and Minneapolis communicating via telephone lines. The system (a computer and plotter) allows human intervention.

A SOLID-STATE IMAGING device is used in place of an electronic tube for light sensing and conversion in a camera system developed by the Aerospace Division of Westinghouse for NASA. The imaging device is a mosaic made up of 2500 phototransistors. The mosaic is square with 50 light sensitive elements on a side. It produces an image that has a resolution of 100 lines/in. Associated circuitry is all molecular electronic.

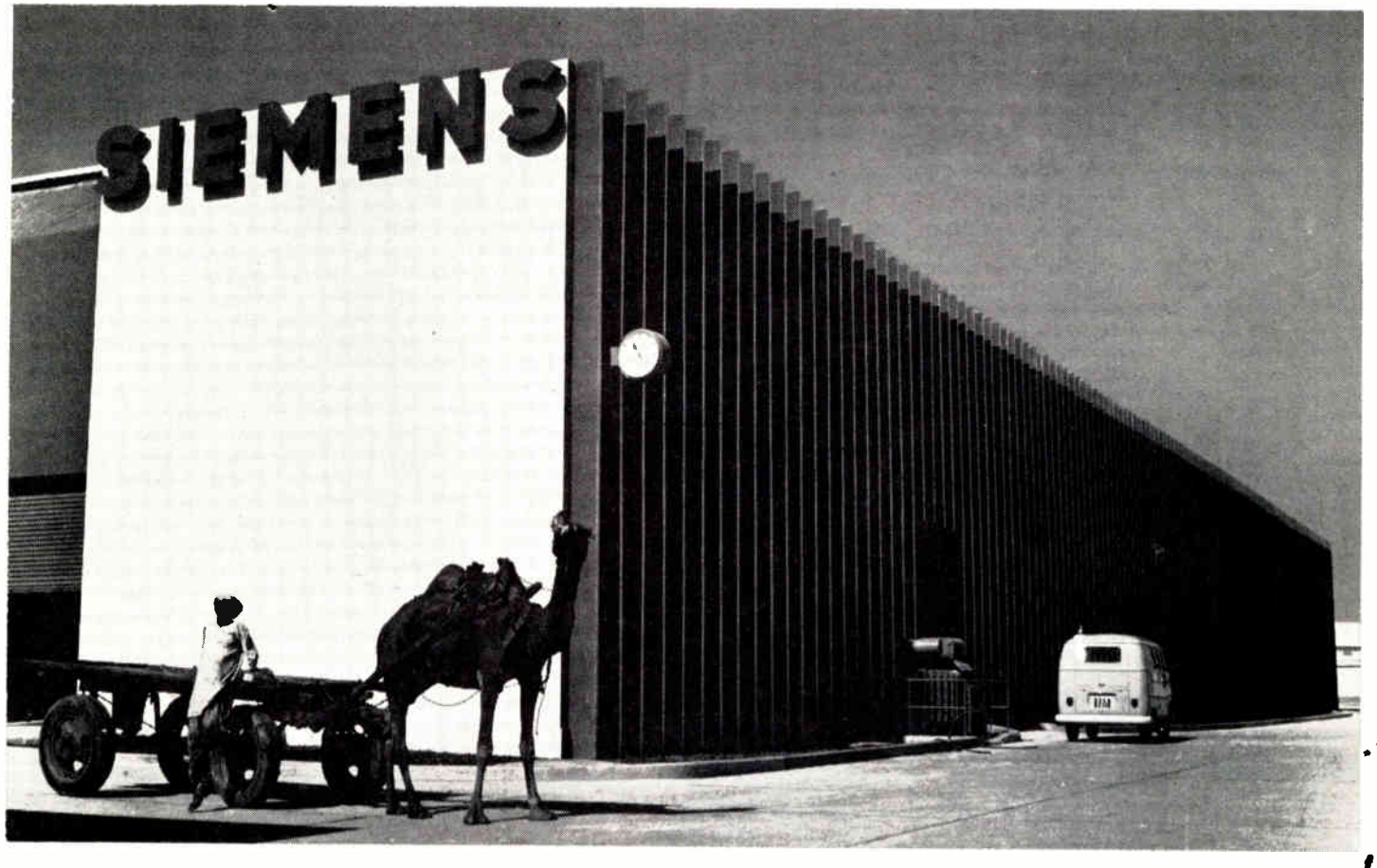
AIRBORNE ELECTRONIC PHOTOGRAPHY system that integrates aerial surveying and photomapping techniques with computer control has been developed by Kollsman Instrument Corp. for the Air Force. The system can map up to 30 to 40 thousand square miles per day. It collects data about where photos were taken, and from what altitude and angle.

CATHODE EMISSION DENSITY of power tubes has been increased by an order of magnitude by the General Electric Co. Readily available cathodes with an emission density of 10 a/cm^2 at 1000°C have been produced. And, emission densities exceeding 10 a/cm^2 at 1000°C have been achieved under laboratory conditions.

FIRE-RETARDANT POLYPROPYLENE which is non-burning, non-dripping and which retains its non-burning classification for 5000 hrs. at 130°C in an air circulating oven, has been announced by Avisun Corp. The new material (Avisun's Grade 2356A) has received a "yellow card" rating from Underwriters' Laboratories. This rating signifies recognition of the material for continuous use in electrical equipment up to 85°C. The thermoplastic material can be used in radio and TV components, communications equipment, electrical parts such as terminal blocks, wiring devices, tube sockets and other applications needing fire-retardant properties.

This is Siemens

...making motors and transformers in Pakistan, in the modern factory shown below. We also make cables in India, generators in Spain, telephones in Argentina. We manufacture in 28 countries and erect, service and repair our installations in almost every country in the world. Of the 240,000 in the Siemens family, 40,000 are employed abroad. Everywhere, they provide imaginative planning, high-quality equipment, skilled and rapid construction and reliable service.



SIEMENS

Siemens MKH

metallized film capacitors

Small size and high reliability are new standards set by Siemens capacitors. Twenty years' experience in making metallized capacitors has resulted in advanced precision techniques which closely control every capacitor property, making them 100% "foolproof" in service. "Self-healing" is an automatic reaction, eliminating the possibility of any voltage breakdown.

Two-way self-healing gives double protection. Internal voltage breakdown very rarely occurs. If it does, the thin metal coatings at the breakthrough point, act as a fuse and immediately vaporize, eliminating the breakthrough point within microseconds.

Electrochemical self-healing is the second protective process. It starts whenever and wherever insulation resistance decreases in the dielectric material. This process operates at any voltage, even as low as 10 mV, changing the metal coating at the point of lowest insulation resistance to a non-conductive oxide—thus eliminating the point electrically.

Less than one breakdown (self-healing) per year and per mF—that is the consistent average shown by tests at nominal voltage. This value, which is for the first year, is even less for succeeding years.

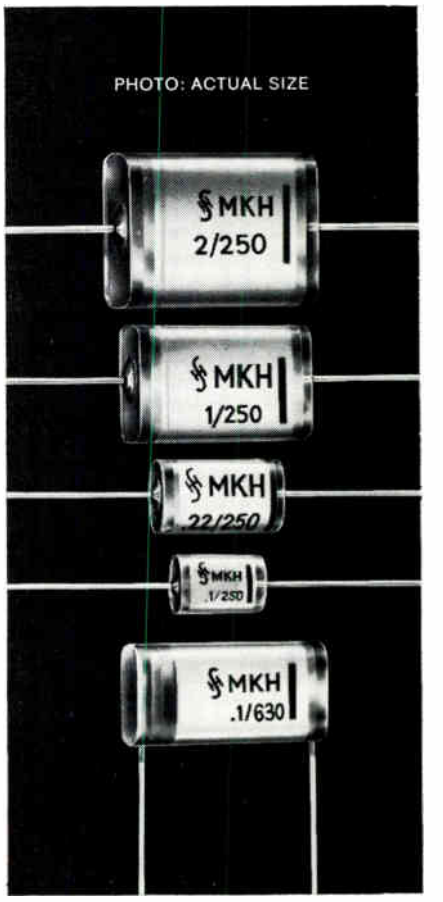
Highly stable capacitance. Overload tests (at 2.2 nominal voltage and at 85°C) show that decrease in capacitance as a result of self-healing is negligible, even after several years.

Small size—low cost. Intricate manufacturing techniques enable MKH (metallized polyester) capacitors to be produced to unvarying standards. They are available with axial or radial leads, in flat compact form. Leads soldered to metallized ends ensure reliable contact. The dielectric is polyester film, widely used for capacitors.

MKH properties. Operating temperatures: −40° to +125°C. Insulation resistance: minimum 20,000 megohms for normal capacitance up to .022mF at +20°C. For higher capacitance values: 10,000 megohms X mF (typical values). Temperature coefficient: approx. .04%/C° between 0° and 70°C. Dissipation factors: 0.5% at 1 kc; 1.5% at 10 kc (typical values).

Immediate shipment. Substantial stocks are held in White Plains, N. Y.

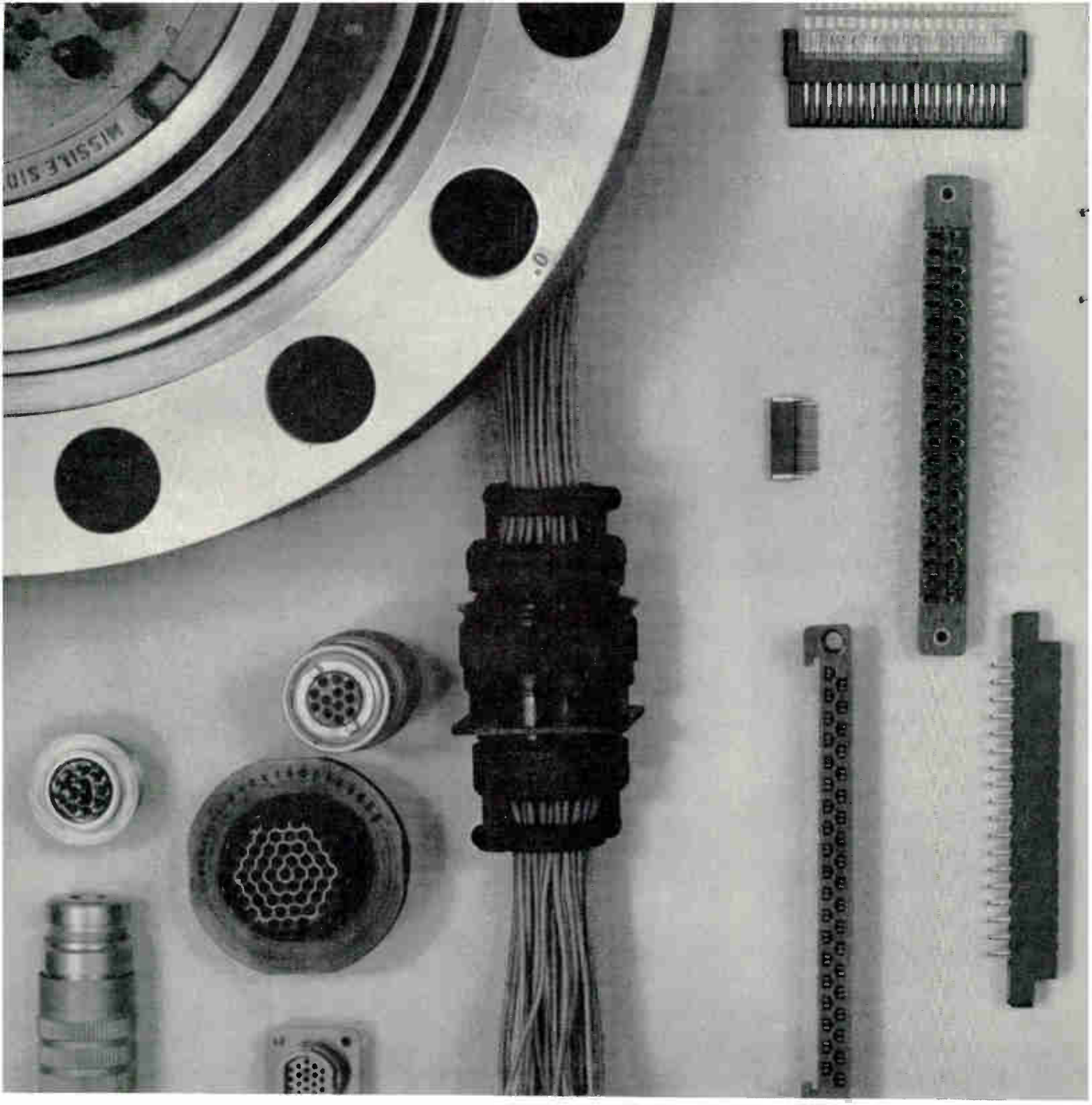
Write now for full information on Metallized Film Capacitors.



SIEMENS AMERICA INCORPORATED
Components Division
230 Ferris Avenue, White Plains, N. Y.

In Canada:
SIEMENS HALSKE SIEMENS SCHUCKERT (CANADA) LTD.
407 McGill Street, Montreal 1, P.Q.

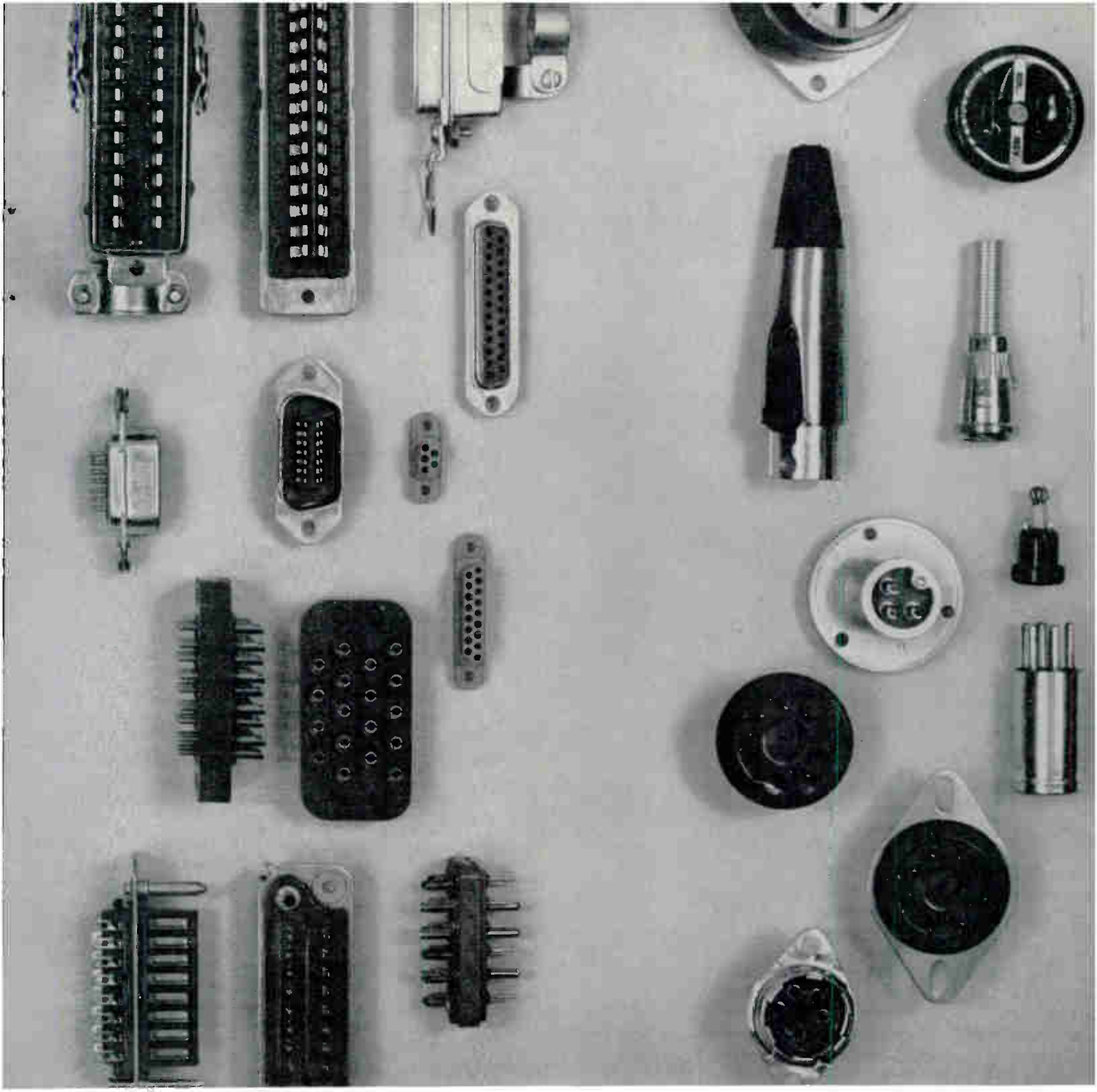
Circle 5 on Inquiry Card



Here are just 36 of the 36,000 Amphenol connectors

Why so many? Because interconnection jobs have become so diverse and complex. On a Polaris, you may need a big aft umbilical connector that withstands 5000°F for 2½ minutes. But if you're miniaturizing a strip chart recorder, you can pack 50 contacts into a 1" connector. What else?

MILITARY CONNECTORS. (Far left) We make all the standard AN/MS and other Mil-spec types, including



MIL-C-26500 and MIL-C-38300 circular environmental connectors. (Incidentally, we have a Space and Missile Systems facility just for specials.)

PRINTED CIRCUIT CONNECTORS. (Middle left) There are actually thousands. Everything from the microminiature 64 Series to the bellows-contact type 225 Series to the new Amphenol Flex-1 connector that welds directly to unstripped flat cable.

RACK AND PANEL CONNECTORS. (Middle right) There's the Min-Rac 17, with its extremely uniform body contacts. For the ultimate in mating reliability, consider our new Series 217. It is 99.99% reliable with three positive seals: around the contacts, at the rim, and at the lip. Or for easy blind mating, choose the Amphenol Blue Ribbon connector with sturdy, wedgelike contacts.

COMMERCIAL PLUGS AND SOCKETS. (Far right) Pick from a long list of tube sockets, microphone plugs, cable jacks, tip jacks, heavy duty industrial sockets—all you'll ever need.

Delivery? The fastest in the business. Ask your nearest distributor or Amphenol Sales Engineer. (Or write to us.) *Amphenol Connector Division, 1830 South 54th Avenue, Chicago 50, Illinois.*

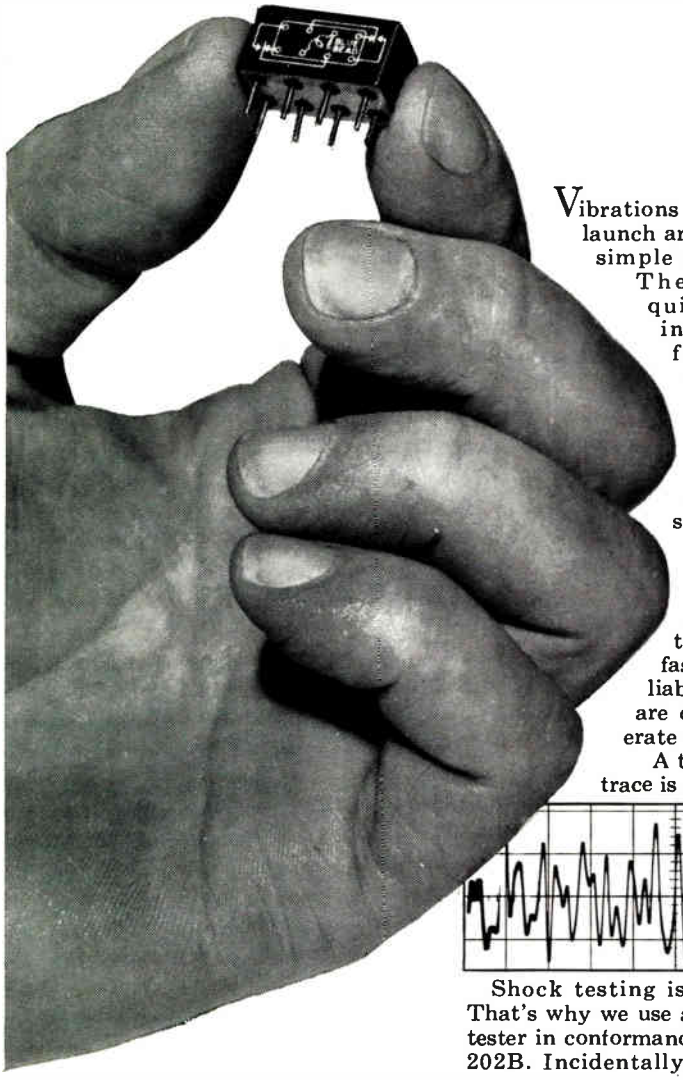
Amphenol® CONNECTOR DIVISION

amphenol corporation

Specify Amphenol . . . the leading name in cable, connectors, assemblies, RF switches, potentiometers, microelectronics

Circle 6 on Inquiry Card

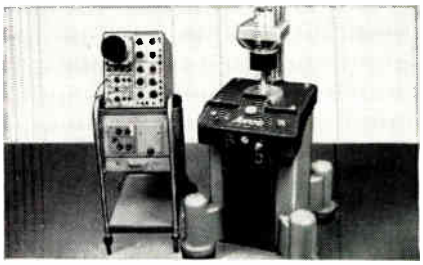
Is random vibration testing necessary for half-size crystal case relays?



Vibrations of a missile upon launch are far from being a simple sinusoidal affair. They are, indeed, quite random both in amplitude and frequency. It makes only good sense, then, to test our aerospace/military relays for their ability to withstand random vibrations.

This we do. Few if any other relay manufacturers test in this fashion. *All* high reliability P&B relays are constructed to tolerate random vibration. A typical oscilloscope trace is shown below.

Shock testing is important, too. That's why we use a pneumatic shock tester in conformance with MIL-STD 202B. Incidentally, our HC relay is



conservatively rated to withstand 150g shock for 11 milliseconds with no contact opening.

HC Series half-size crystal case relays are built with loving care and precisely controlled processes. Assembly is done at Whitfield-type laminar flow workbenches. They employ absolute filters which are capable of stopping cigarette smoke (or particles as small as .0000118") and provide what many experts consider to be the cleanest environment available.

Over and above all this, our HC relays are designed to be reliable. They have bifurcated contacts, and make use of some superior materials not found in similar relays. All-welded enclosures are available. Our Quality Assurance program keeps production within the scope of MIL-Q-9858A.

Remember . . . you can buy cheaper relays but you cannot buy P&B quality for less. For more information, call your P&B representative or write us direct.

HC ENGINEERING DATA

GENERAL: Non-polarized half crystal case size.

Shock: 150_g for 11 ms.
Vibration: 20_g to 3000 cps. } No contact opening in either armature position.
Random vibration testing to customer specifications is available.

Operate Time: 3 milliseconds max. at nominal voltage @ +25°C coil temperature.

Life: 100,000 operations at maximum rated load.
Temperature Range: −65°C to +125°C.
Size: .810" long, .410" wide, .410" high (max.).
Weight: Approx. ¼ oz.

CONTACTS
Arrangement: DPDT (bifurcated, gold-plated silver-alloy).
Rated: Dry circuit to 2 amps at 28.0 VDC res.

HC RELAYS ARE AVAILABLE FROM LEADING ELECTRONIC PARTS DISTRIBUTORS

RIDE THE AMF MONORAIL
AT THE NEW YORK WORLD'S FAIR

POTTER & BRUMFIELD
Division of American Machine & Foundry Company, Princeton, Indiana
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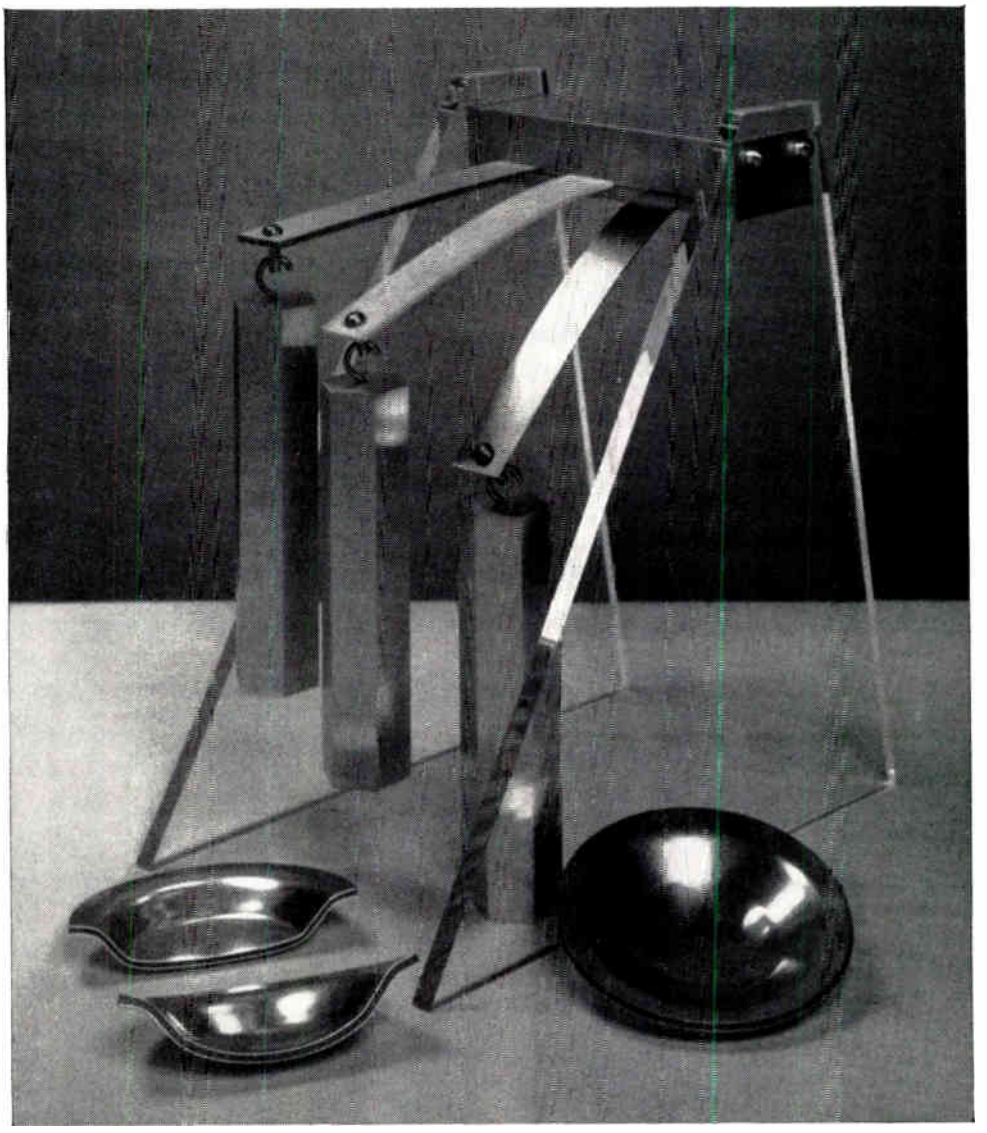
Export: AMF International, 261 Madison Avenue, New York, N. Y.

Report from

BELL LABORATORIES



Strip of postformable aluminum-polyethylene laminate developed by Bell Laboratories (left) shows best stiffness-to-weight ratio compared with equal-weight, -length and -width strips of glass-mat-reinforced polyester (center) and cold-rolled steel. Samples of the laminate after deep-drawing are also shown. Note the uniform thickness possible with this process.

Aluminum-polyethylene structural laminates formed without adhesive

A laminate of polyethylene sandwiched between lightweight metals such as aluminum would have highly desirable strength-to-weight properties. But conventional methods of making such a laminate by using intermediate adhesive agents are incapable of producing a structural bond.

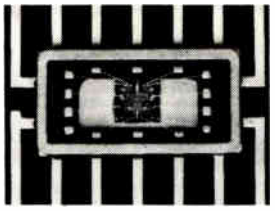
A. T. Spencer (left) and K. H. Pohl, originators of the structural laminate, demonstrate the results of postforming it with a heated die.

Recently, however, K. H. Pohl and A. T. Spencer of Bell Laboratories developed a structural-quality aluminum-polyethylene laminate *without* using adhesives. Such a laminate was concurrently predicted by Bell Laboratories' work on adhesion, which indicated that thermoplastics generally considered "unbondable" without surface modification can form strong joints with materials on which they spread spontaneously.

To produce the aluminum-polyethylene laminate, sheet polyethylene is molded between properly prepared sheets of aluminum. No preparation of the polyethylene is required, other than cleaning. The aluminum, however, is roughened, degreased and etched to produce a suitable surface. In a heated press the polyethylene melts, spreads spontaneously on the aluminum and, on cooling, produces a strong, durable bond.

In addition to its high flexural strength, the laminate has other characteristics which make it desirable for use in electronic equipment and elsewhere. It can be bonded, riveted, bolted, punched and sheared, and unlike reinforced plastics, it can be welded. It can also be bent readily or otherwise postformed at temperatures which soften the polyethylene core and thus allow independent motion of the aluminum skins. A Bell Laboratories-developed process for deep-drawing the laminate, in which the edges remain cool and only the portion to be deformed is heated, produced the samples seen in the illustrations.

Bell Telephone Laboratories
Research and Development Unit of the Bell System



TI Series 54 TTL Sets in Saturated Digital

TYPICAL CHARACTERISTICS Parameter	Basic Gate	Flip-flop
Propagation delay	15 nsec	40 nsec
Power dissipation	10 mw/gate	60 mw
Fan-out	10	10
D-c noise margin	1 v	1 v
Supply voltage	4.5 to 5.5 v	4.5 to 5.5 v
Temperature range	−55 to +125°C	−55 to +125°C

Figure 1. Typical characteristics of Series 54 TTL integrated circuits

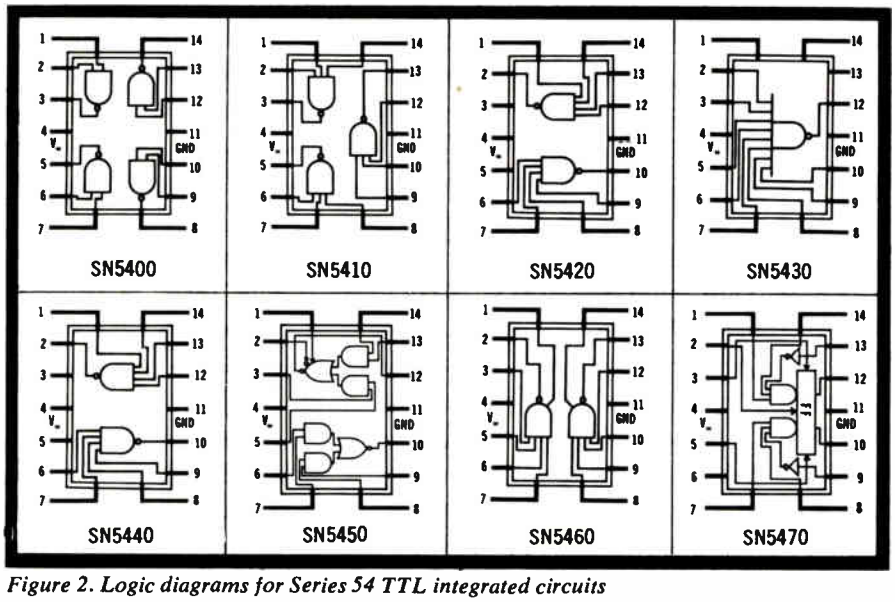


Figure 2. Logic diagrams for Series 54 TTL integrated circuits

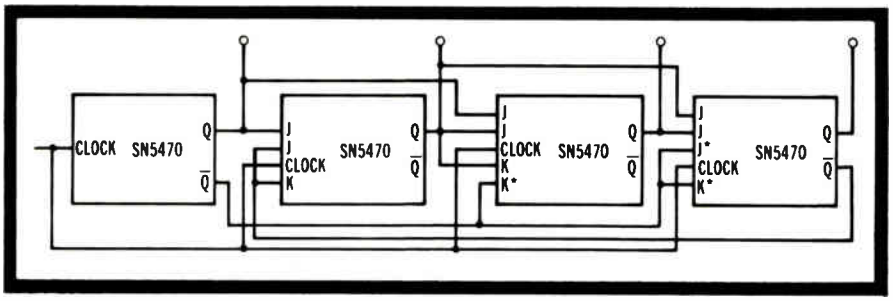


Figure 3. This complete synchronous binary decade counter uses only four SN5470 flip-flops

Industry's major source for integrated circuits*— 97 catalog circuits in ten families — offers you high speed with low power dissipation, high noise margin with high fan-out

Series 54 optimized circuit design gives you an ideal trade-off between speed (15 nsec) and power dissipation (10mw). High noise margin (typically 1 v) is maintained with full fan-out of 10 for each gate. Fan-out of 30 is available from the power gate.

This unique combination of parameters promises to standardize integrated-circuit usage in applications calling for high-performance saturated logic.

Multi-function circuits for low system cost and improved reliability

In the eight Series 54 networks shown in Fig. 2, TI's multi-function approach to semiconductor-network design and fabrication is used extensively. Up to four circuit functions are built in a single bar of silicon, making possible savings in system cost, weight, and size, while increasing system reliability.

The SN5400, for example, incorporates four 2-input NAND gates in a single package. The SN5450 includes two EXCLUSIVE-OR gates, the equivalent in complexity of six NAND gates. The SN5470 is a clocked J-K flip-flop with two additional inverters in the same structure available for input gating. The synchronous binary decade counter shown in Fig. 3 requires only four SN5470 flip-flops; no auxiliary gates are required.

TTL at its best

Transistor-Transistor Logic (TTL) fully exploits the inherent capabilities of integrated semiconductor structures, and the TI NAND gate circuit shown in Fig. 4 is TTL at its best.

*Patented by TI

a New Industry Standard Integrated Circuits

The multiple-emitter transistor input provides a faster turn-off time than other logic forms, thereby minimizing propagation delay. Because of unique circuit characteristics and exacting process control, propagation delays are almost independent of temperature and loading (see Fig. 5).

The output stage of the circuit provides low line-termination impedance in both logical "0" (12 ohms) and logical "1" (100 ohms) states. This contributes to low propagation delays and preserves undistorted waveforms even when driving large-capacitance loads. The low line-termination impedance also accounts for low susceptibility to capacitively coupled noise.

Typical noise margin for Series 54 integrated circuits is one volt. Guaranteed worst-case noise margin is 400 millivolts for both logical "1" and logical "0" conditions, as shown in Fig. 6. This wide margin for ground- and signal-line noise is made possible by the strong overdrive to the output transistor and by the large V_{BE} drops inherent in the small transistor geometry.

Series 54 uses reliable "flat-packs"

TI's standard ¼" by ⅛" flat package is used for all Series 54 networks. This package — proved by more than 35,000,000 hours of controlled tests and four years of field use — features all-welded construction with hermetic glass-to-metal seals. The thin, rectangular configuration and 14 lateral leads make this package suitable either for high-density equipment or for mounted circuit-card assemblies.

For your added convenience, all TI integrated circuits — including Series 54—are now shipped at no extra charge in TI's exclusive Mech-Pak carrier. This plastic carrier simplifies handling, and reduces your costs of incoming inspection, testing, breadboarding, storage, and assembly.

Circle 149 on the Reader Service Card for data sheets on Series 54 integrated circuits, or contact your local TI Sales Engineer.

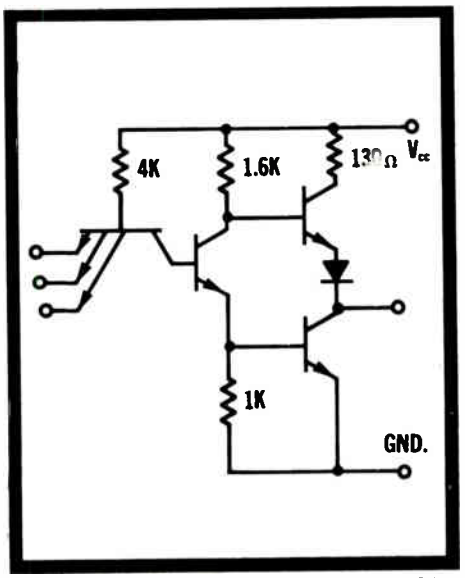


Figure 4. Circuit diagram for basic Series 54 NAND gate

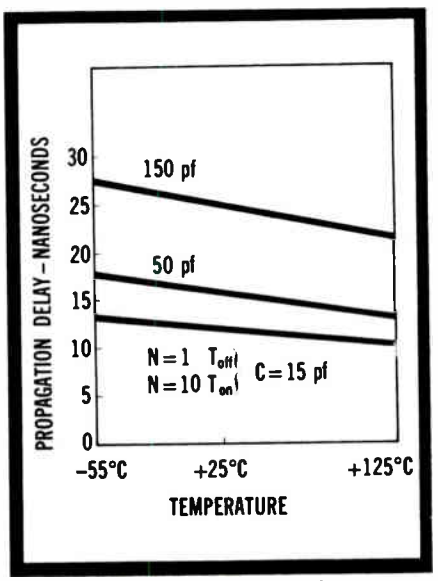


Figure 5. Typical propagation delay vs temperature

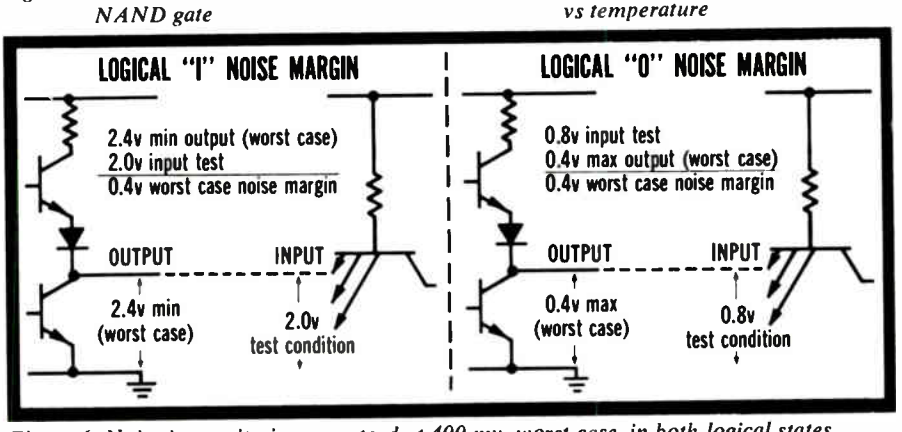


Figure 6. Noise immunity is guaranteed at 400 mv, worst-case, in both logical states

CHANGE IN 'CONFLICT' LAW — FCC wants Congress to change its "conflict of interest" law so it will conform with those governing other agencies. (The FCC law is separate because it is an "independent" agency of Congress, rather than part of the Executive branch.) The proposed change, pushed by Sen. Warren Magnuson (D.-Wash.), Senate Commerce Committee leader, controls stock purchases, gifts from applicants, former employees pleading before the agency, etc. The measure would exempt part-time consultants from law sections that prohibit employees from having financial interests in licenses.

NAB URGES CATV CONTROL—The National Association of Broadcasters feels that "urgent action" is needed to regulate community antenna television systems to "prevent them from disrupting free television service and stifling future local growth." NAB president Vincent T. Wasilewski, told the House Commerce Subcommittee on Communications and Power that the "unrestrained expansion of CATV systems, with their ability to bring in distant broadcast signals, could destroy the locally-oriented system of free television."

FEDERAL EDP PROBED — Buying and using data processing equipment is among federal cost and supply programs being probed by Congress. The EDP probe is a new area for the five-year-old program of the Senate Subcommittee on Federal Procurement and Regulation, headed by Sen. Paul H. Douglas (D.-Ill). New hearings on the "economic impact of federal procurement" also are checking, among other things: DOD cost reduction program; progress in finding a system to avoid duplication between military and civilian agencies; and disposal of billions of dollars in surplus property.

SMALL BUSINESS AWARD

Vice President Hubert H. Humphrey presents Small Business Administration's public service award to William L. Hoffman (right), vice president of Hughes Aircraft Co. for "outstanding leadership in developing programs to increase small business participation in government subcontracting work," as part of recent Small Business Week.

CATV GRAB RAPPED—FCC has been rebuked sharply by congressmen for its attempt to regulate the CATV (community antenna television) industry without specific authority. Oren Harris (D.-Ark.) House Commerce Committee chairman, accuses the agency of failure to forward its recommendations on the CATV issue. Harris does not disagree with FCC on the need for such regulation. He says simply that FCC must not "power grab" and he reminds commissioners that their regulatory powers must be defined by Congress.

NASA BUDGET CUT SLIGHTLY—Congress is handling the Administration's space spending package very gingerly. President Johnson's $3.5 billion space request for next year is expected to be almost untouched by usually zealous budget cutters. House Space Committee approved a cut of only $42 million—less than 2%—in NASA budget. Only $30 million was trimmed from the nearly $3 billion earmarked for the Apollo project, the overall moon shot.

NUMBERS CHECK A SUCCESS—Defense Supply Agency (DSA) reports success in its program to review manufacturers' part numbers that are cross-referenced with federal stock numbers. DSA reports that industry response has been excellent even though the program is strictly voluntary and non-reimbursible. As Project MAVERIC, the program is designed to validate, correct, add or withdraw obsolete manufacturers' numbers from federal catalog records.

AUTOMATION CHILLS STRIKES — It seems the more industry automates, the less likely it is to be struck. Fact is, the U.S. Mediation & Conciliation Service (chief labor mediation agency) says that as a weapon the strike has been made almost useless in certain heavily-automated industries. The government does not identify industries where automation is well advanced. Union leaders do admit, however, that the telephone and oil-refining industries have in effect become virtually strike-immune because of advanced automation.

BAN ON CONTRACTOR HELP—Defense and civilian agencies, plus a congressional committee, are seeking orderly ways to soften a recent ruling by government lawyers banning use of contractor personnel. The ruling, from the U. S. Civil Service Commission and General Accounting Office, could have sweeping effect on government contractors and defense programs. The ruling disclosed that use of contractor-supplied personnel working side-by-side with government employees can violate as many as a dozen federal laws, and substantially raise costs.

Astrodata's New Astrolock-loop FM Subcarrier Discriminator*

Stability

Within ±0.01% of center frequency for 24-hours after a 5-minute warm-up.

Linearity

Better than ±0.02% of full bandwith, best straight line.

The Astrodata Model 402-201, all solid-state FM subcarrier discriminator utilizes the new Astrolock phase-frequency detector, crystal-referenced, FET chopper-stabilized VCO, and current mode loop filter, which are proprietary developments of Astrodata, Inc.

This completely new and different type of locked-loop discriminator gives performance exceeding that of both conventional phase-locked-loop and pulse-averaging types of discriminators.

The new crystal-referenced, FET chopper-stabilized VCO provides state-of-the-art performance in stability and linearity, without a temperature controlled oven.

The Astrolock detector, with its composite phase-frequency characteristic, assures positive lock-in at any signal level within the 66 db dynamic range. True locked-loop performance is provided for deviations up to ±40%, with specified linearity. A quadrature detector mode of operation, selected by a switch on the front panel, provides correlation detection for extremely low S/N signals.

The Model 402-201 introduces a new method of tape-speed compensation in which the reference frequency is processed in the frequency domain. As a result, tape speed compensation is perfect at any fixed frequency from lower bandedge to upper bandedge, and is better than 30 db for intelligence frequencies up to a modulation index of 4. Deviations of more than ±3% anywhere in the band can be accommodated. No adjustments are necessary.

With this new Astrodata Tape Speed Compensation system, the over-all stability for a given data channel is that of the data discriminator alone, whereas in a conventional system the over-all stability is the sum of the stabilities of both the data discriminator and the reference discriminator.

A complete line of accessories is available for use with the Model 402-201. Channel Selectors and Low Pass Filters are provided for all standard IRIG and Constant Bandwidth center frequencies up to 300 kc. Six discriminators and one common power supply mount in a rack adapter which occupies a panel space of 7-in. x 19-in.

For complete technical information on Astrodata's unique Astrolock - loop FM Subcarrier discriminator and full line of telemetry components, call your local Astrodata engineering sales representative or write to us directly.

ASTRODATA INC.

P. O. Box 3003 • 240 E. Palais Road • Anaheim, California 92803

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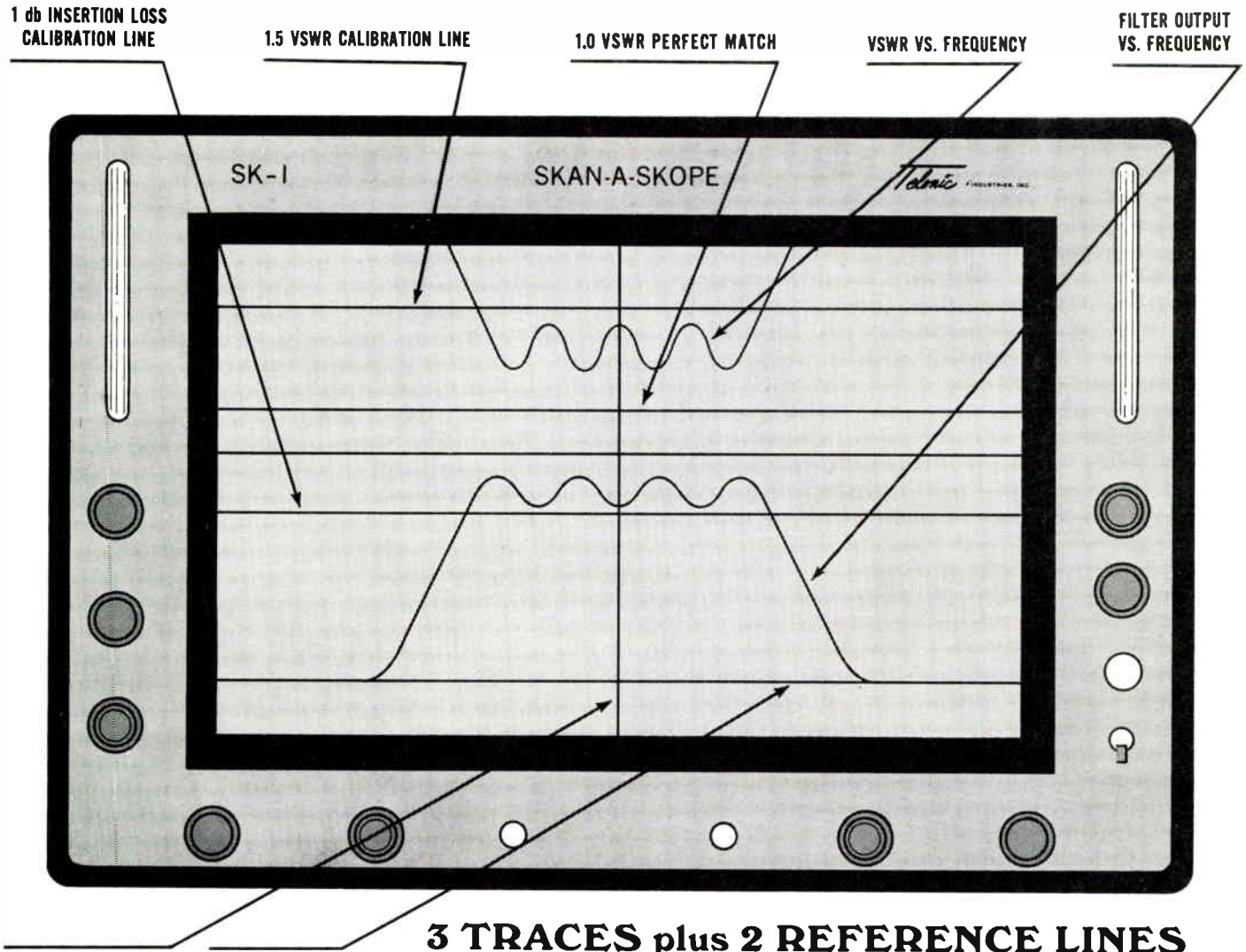
5 SIMULTANEOUS DISPLAYS



3 TRACES plus 2 REFERENCE LINES
2 TRACES plus 3 REFERENCE LINES
1 TRACE plus 4 REFERENCE LINES

SKAN-A-SKOPE

Telonic has advanced the state of the art through the introduction of a versatile new display unit. SKAN-A-SKOPE is capable of showing five displays on a single-gun **17 inch CRT** in a unit containing its own power supply. Traces may be shown in separate positions along the Y axis or may be superimposed. Birdy or pulse-type markers, which appear as vertical lines (electronic graticules), may also be displayed.

SKAN-A-SKOPE flexibility permits almost unlimited applications. Two standard wave forms can be displayed to provide upper and lower limits for a wave form generated by the test unit. This unique display unit may be used to monitor three inputs simultaneously from remote locations. The SKAN-A-SKOPE unit can check gain in an amplifier at three places in the circuit, and can show bandpass, VSWR, and insertion loss wave forms of filters at the same time. This amazing new display unit also has many applications in VHF/UHF tuner testing procedures.

SKAN-A-SKOPE accepts three Y inputs, one X input and one marker input.

SPECIFICATIONS

Number of Vertical (Y) inputs	3
Deflection Factor (Y_1 & Y_2) Inputs	1 mv/cm, 10 mv/cm, 100 v/cm, 1 v/cm Switch selected 10:1 cont. adj.
Bandwidth	DC to 10 kc (3 db point)
Deflection Factor Y_3	25 mv/cm
Bandwidth	DC to 10 kc
Reference Line Y_4 & Y_5	May be positioned at any vertical position to identify signal levels.
X Input	Medium gain DC coupled
Deflection factor	100 mv peak-to-peak/cm
Marker Input	Used with pulse or birdy type markers
Input Signal	50 mv @ 10 kΩ
Display	
CRT	17" Rect.
Screen Material	P-7 Double Layer
Usable Screen Area	8.64" x 12.58"
Price	$1495.00

Telonic® INDUSTRIES, INC.

60 North First Avenue, BEECH GROVE, INDIANA
Phone (317) State 7-3231/TWX 810-341-3202

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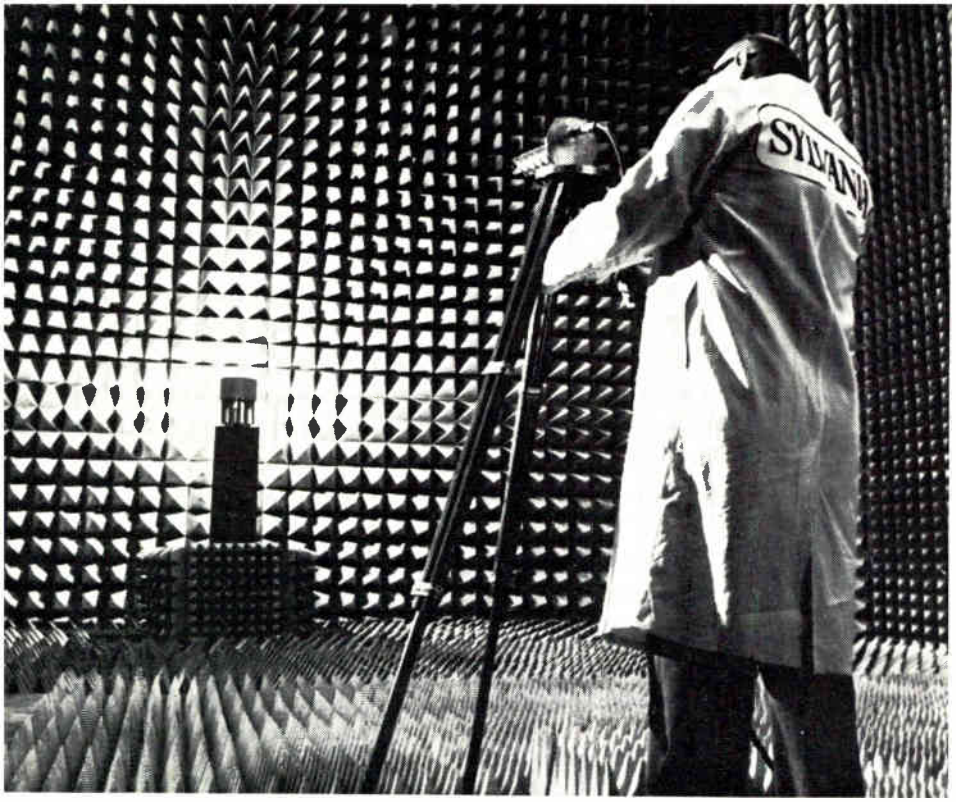
TELONIC—INTERNATIONAL LEADER IN SWEPT FREQUENCY MEASUREMENT

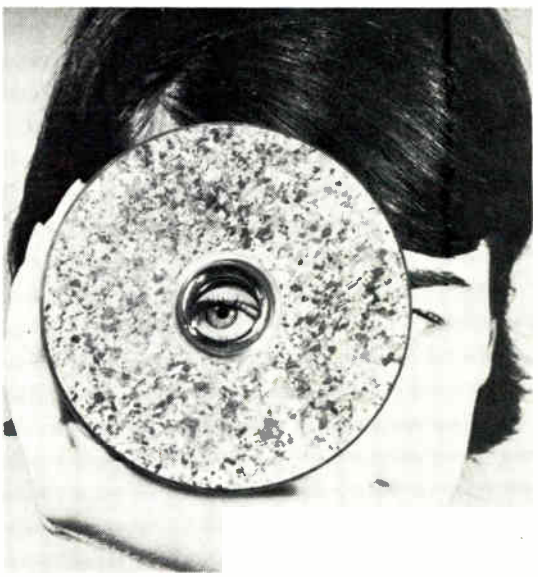


◀ **SPACE SIMULATOR**

Thousands of foam rubber spikes cover walls, ceiling and floor of ultra-quiet chamber built by Sylvania Electric Products Inc. to test aerospace antennas. Technician prepares to test efficiency of antenna at rear of echo-less, rubber-lined rf "dark room."

ELECTRONIC SNAPSHOTS

The Changing STATE-OF-THE-ART in the electronic industries



▲ **ONE OF 100,000**

About that many copper discs similar to the one the young lady is peering through will be used to form the world's largest linear electron accelerator at Stanford. It will be a two-mile long tube 25 feet below the ground. Electrons will be shot through the tube of copper, supplied by Anaconda American Brass Co., at a speed close to that of light.

◀ **INLAND TEST SITE**

Chicago-based Amphenol Connector, of Amphenol-Borg Corp., needed a place to test newly developed undersea antenna for Navy's atomic submarine fleet. Nearest ocean was almost 1,000 miles away. Porpoise tank at nearby Brookfield Zoo provided just the right spot with same salt water content and everything. A local resident observes the proceedings.

▲ **BEAM DEFLECTOR**

Electron-beam deflection system for directing beam from an electron-beam gun in a vacuum evaporator, developed by Consolidated Vacuum Corp., consists of feedthrough ring, power supply, electro-magnets to deflect beam in vertical or horizontal plane. Beam can be moved in any direction with only two controls.

COMPUTER TO TV ►

As operator keys in inquiry on new RCA Video Data Display Unit, answer from a computer 100 miles away is flashed instantly on the screen. Unit shown was in New York for recent showing and communicated over telephone lines with a computer at RCA's Cherry Hill, N. J., computer plant. Fourteen-inch screen displays up to 480 letters, numerals, or symbols at one time.

▼ **TINIEST COMPUTER**

New device transforms dots and dashes of Morse code into ordinary English; it is shown under field test by the Army. Designed and built by Regency Electronics, Inc., Translator allows the untrained to read messages in Morse code.

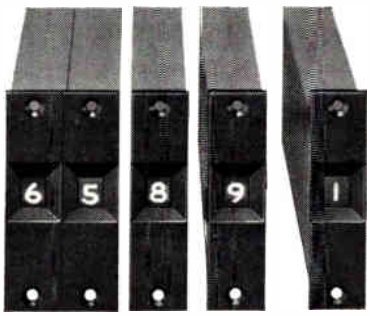
▼ **7-MILLION-BIT DISC**

In test as heart of high-capacity memory system, General Precision 24-inch magnetically-coated disc stores 7-million bits each side.

DURANT UNIPULSER®

count/control modules offer proven accuracy at speeds to 40 cps

(Actual Size)



2½ years of field service proves it!

ADVANCED DESIGN . . . These extremely versatile electromechanical count/control modules have been proven in years of field use and thousands of applications. Accuracy and long life are the result of five unique Durant design features, including a double-acting drive pawl and a "floating" armature. Unipulser modules can provide visual readout, electrical readout, electrical transfer switching, remote reset. Count is retained even if the power fails. Life is *not* determined by hours of usage.

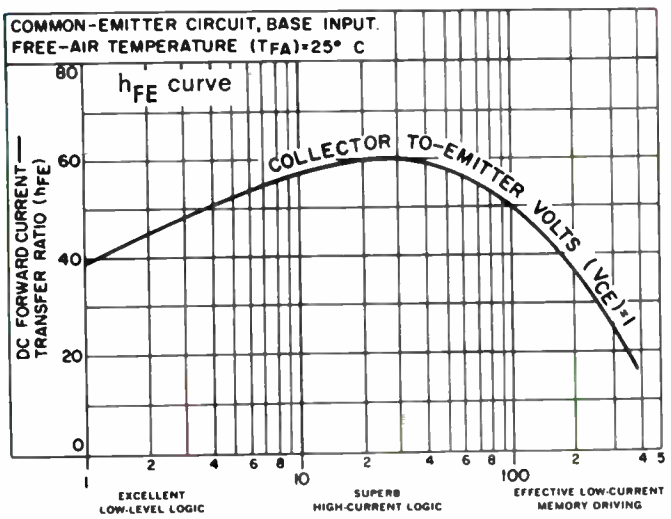
EASY TO MOUNT AND HOOK-UP . . . Durant Unipulser decades are self-contained, fully functioning units, designed for simplicity in mounting and ease of installation. All electrical connections terminate on the etched circuit, providing a plug-in arrangement that greatly simplifies installation. Flanges and mounting holes are provided in the front panel. Electrical connection provides the rear support. Mounting bezels, power supply, other chassis and circuitry components are available to simplify your designing.

APPLICATIONS UNLIMITED . . . Unipulser modules are in daily use in recording, data storage, readout, programming and predetermining jobs. Typical assignments are fluid metering, medical instrumentation, production control, wire processing and communication equipment to name a few. Unipulsers have found application in proportioning, timing and sequencing, processing, scaling, testing and remote controlling. Write for Catalog 90-F; Durant Manufacturing Co., 685 N. Cass St., Milwaukee, Wis. 53201.

DURANT®
MANUFACTURING COMPANY
MILWAUKEE, WISCONSIN

NOW YOU CAN DESIGN A WIDER VARIETY OF HIGH-SPEED COMPUTER LOGIC CIRCUITS WITH A SINGLE TRANSISTOR TYPE

THE NEW RCA 2N3261 COMPUTER LOGIC SWITCHING TRANSISTOR




RCA 2N3261 in TO-52 package, actual size. Extremely low silhouette permits closer placement of circuit boards for extra packaging density.

Provides better high-speed saturated switching performance above 100 ma than any other commercially available transistor

Here's the closest thing yet to a "universal" high-speed computer logic switch: the new RCA silicon N-P-N 2N3261 (formerly developmental type TA2332). Designed for use throughout the entire logic section of a high-speed computer, its exceptionally broad current capability fits it for all functions from low-level logic to high-speed, high-current logic to low-current memory driving. Interdigitated planar epitaxial construction assures low saturation voltages at high currents and extremely low leakage currents, and also provides excellent mechanical and electrical reliability.

EFFECTIVE CURRENT CAPABILITY ranges from less than 10 ma to over 250 ma. Because of its high current capability, logic circuits can be operated at higher current levels to minimize the effects of circuit capacitance. The 100 Mc h_{fe} at 100 ma I_C and only 1 volt V_{CE} is 4.4 (typical). The 2N3261 also offers 9 nsec turn-on time and 11 nsec turn-off time at 100 ma I_C.

BROAD CURRENT CAPABILITY PERMITS BROAD APPLICATION. In addition to high-speed computer logic applications, the 2N3261 is ideally suited to digital circuit applications in telemetry, communications equipment, digital test equipment and direct digital process control equipment.

READILY AVAILABLE AT LOW COST: RCA 2N3261 is available at $2.00 each in quantities of 1,000 and up. It can be used as a direct replacement for the popular 2N2369A—but offers better performance per dollar. For more information, fill out and mail the coupon at right.

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Commercial Engineering
415 South Fifth Street
Harrison, New Jersey

- ☐ Please send Technical Bulletin on RCA 2N3261
- ☐ Please send Technical Paper No. ST-2667 on RCA 2N3261
- ☐ Please have RCA Field Engineer telephone me at (No.)_____(Ext.)_____

Name_____ Title_____

Company_____

Address_____

City_____ State_____ Zip_____

Circle 12 on Inquiry Card

1965 COMPONENT SALES RISE MAY BE 4%, SAYS EIA HEAD

Sales for electronic components in 1965 are expected to rise about 4% from the record $3.8 billion in 1964; this was a 2.8% rise over 1963's $3.7 billion, reports Dr. Harper Q. North, president of the Electronic Industries Association.

Active components in general rose about $3.6% in dollar volume in 1964, while passive components increased by 10.6% in units but fell 1.6% in dollars.

Excluding semiconductor types, integrated circuit packages reached sales of $185 million, a 33% increase over 1963. Unit sales in semiconductor integrated circuits soared to 359%.

Component exports increased to $148 million from $128 million. Imports also increased—from $67 million to $79 million.

Tube sales continued their downward trend by dropping off 5.8% in units and 9.8% in dollars. The rising popularity of lower-priced tinyvision tubes hit hard on the picture tube market. Total 1964 unit sales gained 6.2% to 9,513,121 from 1963's 8,955,434. Value dipped 1.5% to $164,790,701.

The receiving tube market felt the transistor bite more deeply. Unit sales for tubes in 1964, including imports, fell 7.1% to 367,788,000 from 395,544,000 in 1963.

CENSUS SHOWS $2 BILLION IN 1963 RADIO-TV SHIPMENTS

Manufacturers shipments of radio and TV receivers in 1963 were valued at $2.05 billion, a rise of 39% from 1958, according to a preliminary report of the 1963 Census of Manufacturers issued by the Department of Commerce.

The most outstanding increase was in household and auto radios, and in radio-phonograph combinations. These climbed as a group from $345 million in 1958 to $540 million in 1963.

Value-added-by-manufacturers in 1963 was $933 million, up 57% over value-added for 1958.

SMALL FIRMS WILL HOLD SHARE OF COMPUTER MARKET

While the giants of the computer industry are in fierce competition, smaller firms continue to hold an important share of the market, according to Howard C. Warren, President of SCAM Instrument Corp.

"Demand will continue for the small companies' data-handling equipment, particularly for industries with special needs," Mr. Warren asserted.

SMALL BUT FAST

High-speed data sending system—"smaller and more reliable and economical"—introduced by GT&E. The system, Lenkurt 26C Duobinary-Datatel™ data set, transmits digital signals over conventional voice channels at fixed speeds of 2,400 and 1,200 bits/sec. The unit (atop the console above) includes integrated circuitry; is only 3½ inches high.

SALES IN MAGNETIC TAPES MAY HIT $200 MILLION IN 1970

Computers, space programs and the average citizen may consume magnetic recording tape at such an accelerated pace in the next five years as to nearly double current sales volume. Record annual sales may reach $200 million by 1970, predicted F. B. Cameron, vice president, Celanese Plastics Co.

Mr. Cameron also believes that the use of magnetic tape in computers will increase by more than 10% each year through 1970. He also predicted that amateur TV recording, more industrial-commercial use of TV recording, and audio recorders in new automobiles would help to expand the market. He said such developments could carry magnetic tape sales well beyond the conservative $200 million.

FACTOR ADVISES KEEPING UP WITH MARKETING TRENDS

A factoring firm official recently advised manufacturers that new trends in marketing and distribution are just as important as technological improvements.

Although Mr. Samuel Lipson, vice president of Meinhard-Commercial Corp., was speaking largely for the consumer manufacturer interested in department stores and shopping centers, his ideas, somewhat rephrased, could apply equally to the electronic industries.

Mr. Lipson suggests, in effect, that the manufacturer ask himself: in what direction is the market for his product headed? Can he stand pat or should he seek new outlets? What type of outlet promises the greatest growth for his products?

What methods and channels should he use to reach the most customers? Are most customers he hopes to reach buying through distributors, or direct from factories? How does trade and engineer journal advertising effect sales?

What technical or industrial or commercial group, or groups, are best suited to his product and is he reaching them? Can he reach those groups that are expanding most rapidly, whatever they are?

SWISS TRADE SHOW MAY BE GATEWAY TO SALES IN EUROPE

Switzerland offers itself as a "test market" for U.S. electronic industrial products. Entries are now being accepted for the U.S. exhibit at the Second International Exhibition of Industrial Electronics (INEL), September 7-11, 1965, at Basle.

INEL's first showing in 1963 attracted more than 300 exhibitors from 16 nations. Some 20,000 of Europe's leading buyers, distributors, engineers and public officials attended.

GENERAL DATA for RADIO and TELEVISION RECEIVING SETS 1958 to 1963

(In Thousands of Dollars)

	Value Added By Manufacturer	Cost of Materials	Value of Shipments	Capital Expenditures
1958	593,953	936,314	1,548,006	13,323
1959	727,108	1,079,111	1,781,133	16,610
1960	694,336	1,036,042	1,719,337	19,594
1961	728,832	1,105,866	1,849,180	28,670
1962	868,958	1,306,602	2,128,875	27,096
1963	933,484	1,401,484	2,287,605	30,533

Source: Bureau of the Census, U.S. Dept. of Commerce

ELECTRO INSTRUMENTS NOW SPANS ENTIRE PRECISION VOLTMETER FIELD WITH ACQUISITION OF CALIBRATION STANDARDS CORPORATION!

NOW, WITH THE ADDITION OF CALIBRATION STANDARDS CORPORATION, EI BECOMES THE SOLE SINGLE SOURCE OF SOLID STATE VOLTMETERS IN THE ENTIRE UNDER-AND-OVER $1,000 PRICE RANGE; TOGETHER WITH PRECISION DIGITAL CALIBRATOR AND PRECISION VOLTAGE SOURCES.

1. AC-DC VOLTMETERS

2. DC VOLTMETERS

3. CALIBRATORS & POWER SOURCES

Now there is no precision measuring job on which you should not get a quote from Electro Instruments! With acquisition of Calibration Standards Corporation, Electro Instruments becomes the first manufacturer of precision digital instruments to enter the lower price voltmeter field. With CSC's eleven new manual-type AC or DC differential voltmeters, Electro Instruments now spans the entire voltmeter spectrum — performance-wise and price-wise. Also, the Electro Instruments line now includes precision power sources of voltages from 0-2, 111VDC up to 20,000 VDC; precision calibrators; ultra-stable, low-sensitivity monitors. Ask your Electro Instruments representative for full information about E.I's expanded new product line. Or write:

Electro Instruments, Inc.
8611 Balboa Avenue, San Diego, California 92112
Electro International, Inc., Annapolis, Md.
Electro Instruments s. a., 512 rue de Geneve, Brussels 3, Belgium

New flexible lighting you can twist, coil, weave...

it's protected by ACLAR®

Panelescent® Tape-Lite—developed by Sylvania—makes lighting available in a continuous flexible ribbon only 1/32" thick. The electroluminescent light source consists of a thin strip of aluminum foil, a layer of phosphors and a transparent conductive coating—all sealed between protective layers of Allied Chemical Aclar fluorohalocarbon film.

Why did Sylvania choose Aclar? Because it protects better than any other transparent film! Aclar absorbs no water at all and transmits virtually no moisture vapor. It has excellent dielectric strength... withstands severe shock and pressure... resists tearing and pinholing, and is chemically inert to harshest chemicals. The film is fully transparent—all the brightness of Tape-Lite comes through!

Shielded by Aclar, Tape-Lite flexible lighting has many display and safety applications, as in decorative wall lighting, highway marking, and instrument panel illumination. What clear, strong, moisture-proof Aclar has done for lighting... it may be able to do for *your* product. To explore the possibilities, write to:

Allied Chemical

GENERAL CHEMICAL DIVISION
P.O. Box 353, Morristown, N.J.

Circle 14 on Inquiry Card

This Is Not the First 1 13/16" 10-Turn Precision Potentiometer. Just the Best.

Bourns Model 3400 is the rugged result of a fresh design approach. In punishing side-by-side environmental tests, it performed dependably long after competitive units had sagged, sogged or snapped under the strain. In rotation-life tests, it displayed a longer useful life than any other unit. In vibration and shock tests, it kept operating after fragile terminations had put competitive units out of commission.

This sturdy newcomer has a molded, all-plastic case for superior humidity performance... sliding contacts to eliminate fragile pigtails... an extra-thick slider block for high stability... a shaft supported at both ends... a husky dual-collector pickoff. And it has the exclusive, virtually indestructible SILVERWELD® termination that replaces vulnerable single-wire terminations to overcome the chief cause of potentiometer failure.

Model 3400 undergoes 100% in-process and final inspections, and is subjected to the famous Bourns Reliability Assurance Program. In reliability and performance, it is a premium potentiometer. One of its best features is that there is no premium in price.

Write today for complete technical data.

Model 3400, 1 13/16" Diameter, Bushing Mount

LINEARITY:	±0.15%, STANDARD
Resistances:	100Ω to 1 Meg., standard
Temp. Coeff.:	20ppm wire over entire resistance range
Power rating:	5.0W at 40°C
Humidity:	Steady state
Operating temp. range:	−65 to +105°C
Resolution:	0.005 to 0.045%
Body length:	1.75" (12% shorter than competitive units!)

ONE-HALF ACTUAL SIZE

BOURNS

BOURNS, INC., TRIMPOT DIVISION
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PHONE 684-1700 · TWX: 714-682 9582
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MANUFACTURER: TRIMPOT® & PRECISION POTENTIOMETERS, RELAYS; TRANSDUCERS FOR PRESSURE, POSITION, ACCELERATION. PLANTS: RIVERSIDE, CALIFORNIA; AMES, IOWA; TORONTO, CANADA

LETTERS

to the Editor

Caught Again . . .

Editor, ELECTRONIC INDUSTRIES:

Congratulations on your June issue. The color photomicrographs were especially striking. However, your terminology is in error once again. As reader Schell pointed out in his letter in that issue (p. 32), there is a difference between the definitions of the words microphotograph, "a very minute photograph of an object," and photomicrograph, "a photograph of a very minute object." Need I point out that there is also a distinction between the words microphotography, as misused in Slenker's article of that same issue (p. 47), and photomicrography? Shame on you.

Bruce T. Hall
HRB-Singer, Inc.
State College, Penna.

Ed. Note: We may have used four colors in the article, but our faces are only one color—Red!

My Thanks

Editor, ELECTRONIC INDUSTRIES:

Thank you very much for doing an outstanding job on my article on color photomicrography.

It seems to be quite rare for a magazine to edit an article without introducing some technical errors. Not only did you not introduce any technical errors, but your editing changes were of the highest quality.

Stephen Slenker,
President
Piconics Inc.
North Billerica, Mass. 01862

Photos Upside Down

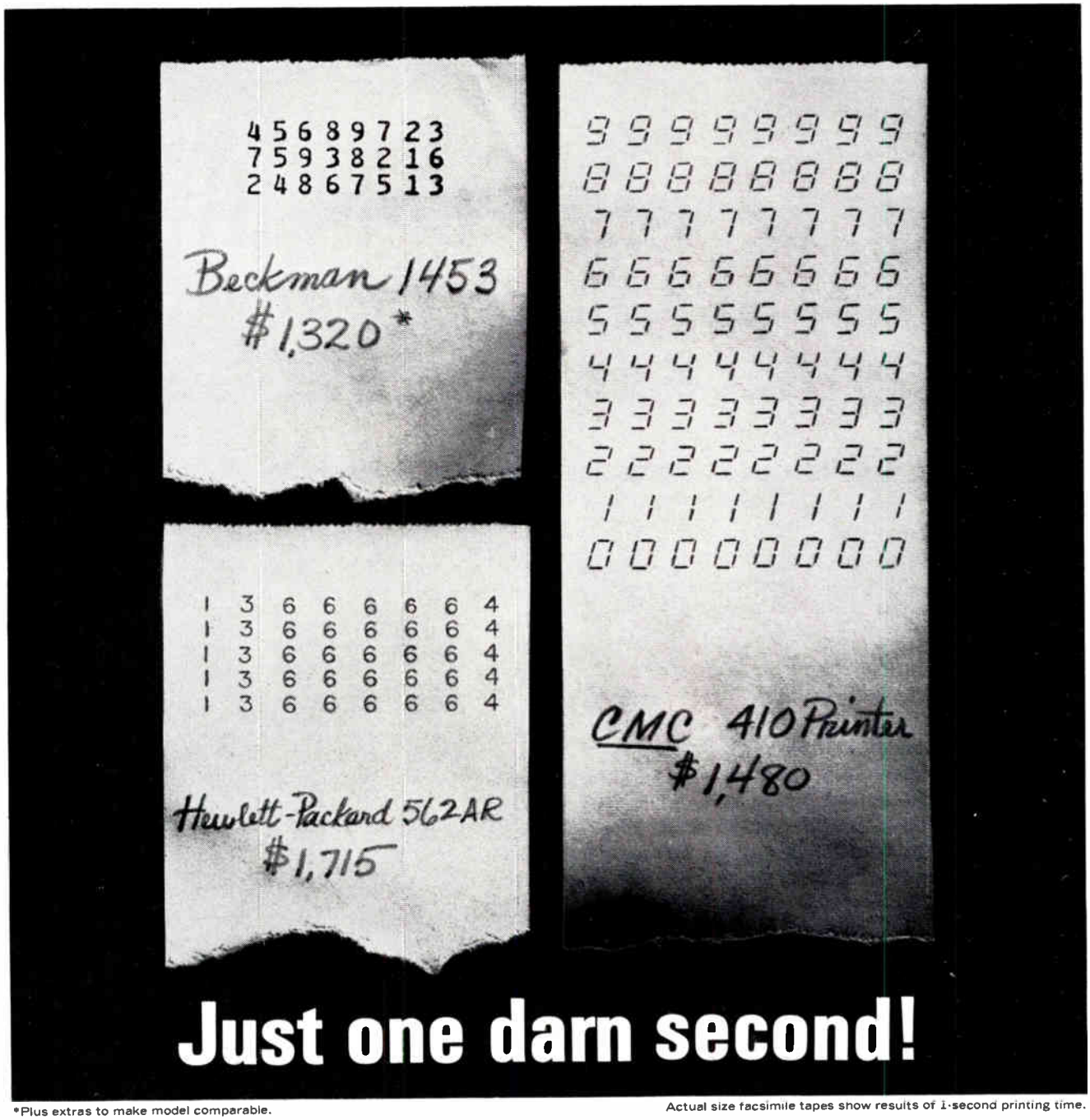
Editor, ELECTRONIC INDUSTRIES:

. . . You have probably noticed by now that the illustrations in the lower left of page 37, June issue, were upside down in relation to the caption.

All in all it turned out well and we are pleased with the layout, the cover, and the whole thing in general. We have received many nice compliments about the article.

Ralph Saunders
Senior Engineer
Burroughs Corp.
Great Valley Lab.
Paoli, Pa.

Ed. Note: The two photos should be treated as one and rotated 180°.



*Plus extras to make model comparable.

Actual size facsimile tapes show results of 1-second printing time.

Tear a piece of tape off all three big-name digital instrumentation printers. Compare speed and readability. One obviously prints at least twice as fast. Obviously one can be read without getting ink on your nose. One reason is, our new CMC 410 Printer is not just another rebuilt adding machine. Another reason: our logic conversion is all electronic. 35-millisecond data-gathering doesn't stall your source. The CMC 410 is quiet, compact (only half-rack size) solid-state, versatile, and all that. Our basic unit spews out 8-digit columns at 10 lines per sec. Column width expands to 12 digits. This new CMC 410 Printer is another step in our demoniacal plan to unseat some of the other big names in this business. Wait 'til you see what's next! Incidentally, we still have some of our glorious Crusading Engineer medals lying about. We'd sure be happy to send you this status symbol along with the specs for the new CMC 410 Printer. Just write and ask. If you already have a medal, pin this one on your secretary... or are you man enough?

CMC

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COMPUTER MEASUREMENTS COMPANY IS A LEADING DESIGNER AND MANUFACTURER OF ELECTRONIC INSTRUMENTATION TO COUNT, MEASURE, AND CONTROL.

COMPONENT, DESIGN AND RELIABILITY ENGINEERS

The Components and Materials Laboratory of Hughes Aircraft Company in Southern California has immediate needs for engineers to fill important positions in the following fields:

COMPONENT ENGINEERS APPLICATION
Provide technical consultation and liaison to design activities, assist in selection and application of component parts, participate in design reviews.

MICROELECTRONIC ENGINEERS
Evaluate integrated and thin film microelectronic devices, analyze failure modes, investigate effects of environments and materials on device characteristics, determine application criteria.

COMPONENT STANDARDS ENGINEERS
Coordinate component-equipment requirements, provide technical consultation, select vendors, determine evaluation programs, initiate procurement documentation.

RELIABILITY ENGINEERS
Coordinate reliability programs, conduct component failure analyses, define and direct experiments, establish mathematical models, investigate component performance.

COMPONENT DEVELOPMENT ENGINEERS
Develop components using advanced techniques, investigate new design concepts, study component phenomena, direct experiments and design evaluations.

MAGNETIC DESIGNERS
Design static magnetic components, develop new magnetic devices, investigate and apply new design concepts, initiate evaluation tests.

SUPERVISORS
In addition to requirements for both junior and senior engineers for these positions, several supervisory openings are available.

Requirements: B.S. degree in Physics or Electrical or Mechanical Engineering and a minimum of three years experience in one or more of the following or associated technical fields:

Display Tubes	Semiconductors
Servo	Potentiometers
Switches	Capacitors
Relays	Resistors
Microelectronics	Magnetics
Instruments	Mechanical

U.S. CITIZENSHIP IS REQUIRED

For immediate consideration, please airmail resume to:

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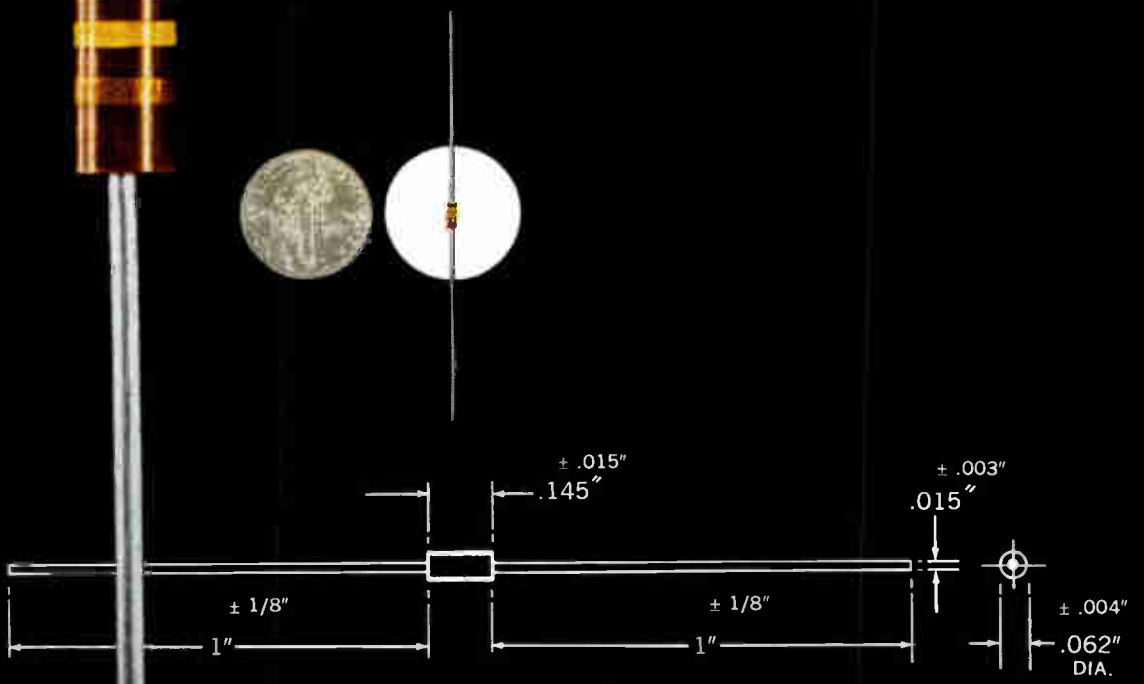
An equal opportunity employer

new

Allen-Bradley type BB resistor

⅛ watt insulated hot molded resistor having the identical dependability associated with all A-B hot molded resistors

shown 10 times actual size



ACTUAL DIMENSIONS

■ Here is the latest addition to the Allen-Bradley line of hot molded resistors—the new Type BB. Being so very small, they are ideal for today's miniaturized equipment—and offer a theoretical packaging density approaching 730,000 units per cubic foot. Quality has not been sacrificed for size—the new Type BB insulated resistor provides the same superior performance and reliability for which Allen-Bradley resistors are world famous.

For complete information on these new miniature Type BB resistors, please send for Technical Bulletin B-5005: Allen-Bradley Co., 222 West Greenfield Avenue, Milwaukee, Wisconsin 53204.

In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

CHECK THESE FULL SIZE SPECIFICATIONS

RESISTANCE VALUES: Standard EIA and MIL-R-11 from 2.7 ohms to 100 megohms

RESISTANCE TOLERANCES: Standard ± 5%, ± 10%, and ± 20%

MAXIMUM CONTINUOUS RATED VOLTAGE: 150 Volts RMS or DC

MAXIMUM CONTINUOUS RATED WATTAGE: 0.125 Watt at 70°C. Derate linearly to zero watts at 130°C maximum operating temperature

VOLTAGE CHARACTERISTIC: Less than 0.050% resistance change per volt

TEMPERATURE CYCLING: Resistance change less than 2% in five cycles from − 55°C to + 85°C

LOAD LIFE: Rated continuous working voltage for 1000 hours at 70°C ambient results in a resistance change of less than 8%, with the average not to exceed 6%

SHORT TIME OVERLOAD: Resistance change is less than 2.5% after 5 seconds at 2½ times continuous working voltage (200 volts max.)

EFFECT OF SOLDERING: Resistance change ± (3% + 0.05 Ω) maximum after 3-second test with leads immersed in solder to ⅛″ of body at 250°C

45-01-5ER

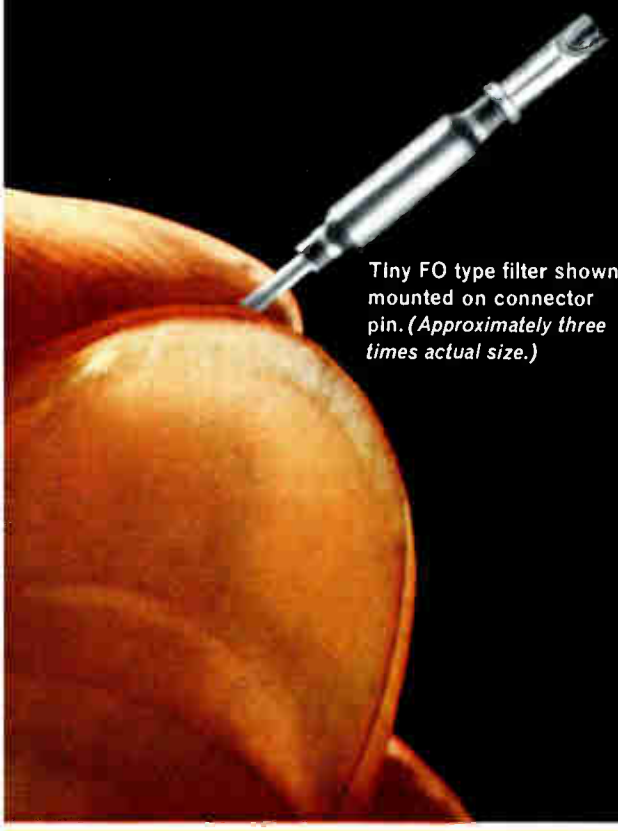
A-B QUALITY

ALLEN-BRADLEY
QUALITY ELECTRONIC COMPONENTS

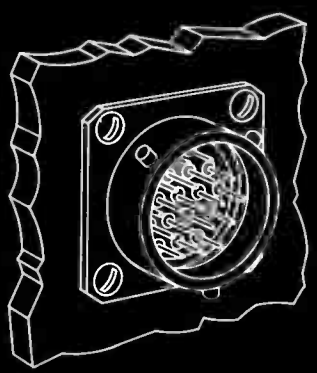
new

Allen-Bradley line of subminiature low pass filters provide...

HIGHER PACKAGING DENSITIES AND EFFECTIVE FILTERING TO 10 GHz



Tiny FO type filter shown mounted on connector pin. *(Approximately three times actual size.)*

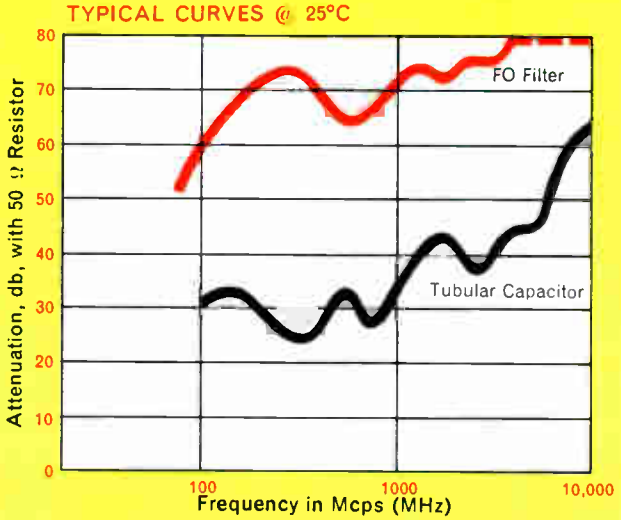


especially designed for use in cable connectors

TYPICAL SPECIFICATIONS

	A  ACTUAL SIZE	B  ACTUAL SIZE	 ACTUAL SIZE
Pin Size	#16 (0.062" dia.)	#20 (0.040" dia.)	#24 (0.030" dia.)
Max. O.D.	0.160"	0.100"	0.075"
Approx. Length	0.625"	0.450"	0.350"
Voltage Rating (V.D.C. max.)	500 v	200 v	100 v
Feed-thru current rating	25 amp	10 amp	5 amp
Attenuation, min. (at max. operating temp.)	50 DB	50 DB	50 DB
Temp. Range	−55°C to +125°C	−55°C to +125°C	−55°C to +85°C

TYPICAL CURVES @ 25°C



■ This new line of FO type subminiature low pass filters is designed to provide maximum reduction of RFI *in a minimum of space*—attenuation is greater than 50DB over the frequency range from 100 MHz to 10 GHz.

The exclusive Allen-Bradley design allows unusually close spacing. The filters can be introduced into connectors with no reduction in the number of terminals, still providing the possibility of individual replacement of filters if desired.

With these filters mounted through a ground plane in the connector, there's complete shielding to prevent the possibility of rf coupling between input and output.

A-B engineers will be pleased to cooperate with you in the application of these new subminiature filters. For more details, please write: Allen-Bradley Co., 222 West Greenfield Ave., Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Ltd., Galt, Ontario. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017.

ALLEN-BRADLEY

QUALITY ELECTRONIC COMPONENTS

50-07-5E

COMING EVENTS

July

July 12-15: Conf. on Nuclear & Space Radiation Effects, IEEE; Univ. of Mich., Ann Arbor, Mich.

July 13-15: Aerospace Vehicle Flight Control Conf., SAE, NASA; International Hotel, Los Angeles, Calif.

July 26-29: 2nd Annual AIAA Mtg. & Tech. Demonstration, AIEE; San Francisco Civic Ctr., San Francisco, Calif.

August

Aug. 18-20: Nat'l Mtg. of American Astronautical Soc., AAS; Sheraton-Palace Hotel, San Francisco, Calif.

Aug. 23-27: 6th Int'l Conf. on Medical Elect. & Biological Eng'g, IFMEBE; Tokyo, Japan

Aug. 24-27: Western Electronics Show & Conf., IEEE, WEMA; Cow Palace, San Francisco, Calif.

Aug. 30-Sept. 1: Antennas & Propagation Int'l Symp., IEEE; Sheraton Park Hotel, Washington, D. C.

'65-'66 Highlights

WESCON, Western Electronic Show & Conv. Aug. 24-27, IEEE, WEMA; Cow Palace, San Francisco, Calif.

Nat'l Electronics Conf., Oct. 25-27; McCormick Place, Chicago, Ill.

NEREM, Northeast Research & Eng. Mtg., Nov. 3-5, IEEE; Boston, Mass.

IEEE Int'l Conv., Mar. 21-24, 1966; Coliseum, New York Hilton, New York, N.Y.

September

Sept. 8-10: 13th Annual Indus. Elect. & Control Inst. Conf., IEEE; Sheraton Hotel, Phila., Pa.

Sept. 13-14: 13th Annual Joint Eng. Mtg. Conf., IEEE-ASME; New York Hilton Hotel, New York, N. Y.

Sept. 13-15: 12th Annual Petroleum Industry Conf., IEEE; Sheraton-Lincoln Hotel, Houston, Tex.

Sept. 13-17: 6th Int'l Elec'l Insulation Conf., IEEE; New York Hilton Hotel at Rockefeller Ctr., New York, N. Y.

Sept. 22-24: Int'l Conv. on Military Electronics (Mil-E-Con 9), IEEE; Washington Hilton Hotel, Washington, D. C.

Sept. 23-25: 15th IEEE Broadcast Symp., IEEE; Williard Hotel, Washington, D. C.

Sept. 24-25: 13th Annual Comm. Conf., IEEE; Cedar Rapids, Iowa

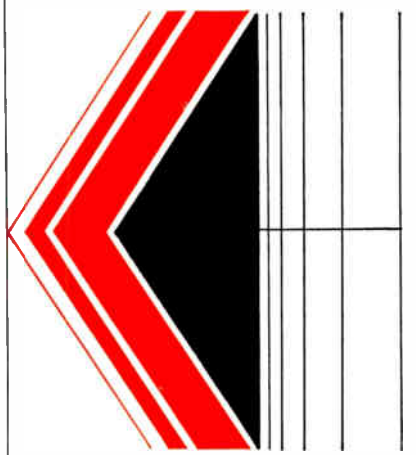
Sept. 28-29: 7th Biennial Heating Conf., IEEE; Hotel Carter, Cleveland, Ohio

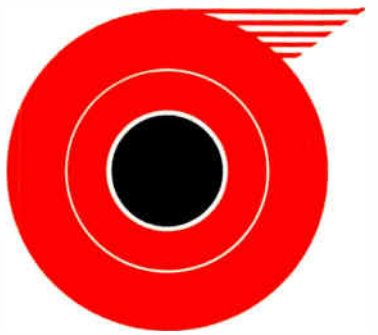
October

Oct. 4-6: 1965 Canadian Electronics Conf., IEEE; Automotive Bldg., Toronto, Canada

Oct. 4-6: Extra High-Voltage AC Transmission Conf., IEEE; John Marshall Hotel, Richmond, Va.

Oct. 4-7: Instrument Soc. of America Conf. & Exhibit, ISA; Los Angeles Sports Arena, Los Angeles, Calif.





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plus

■ **Compatibility with 17 Letter-Series Plug-Ins** to permit differential, multi-trace, sampling, other laboratory applications—when used with Type 81 adapter.

Type 585A Oscilloscope	$1725
Type RM585A Oscilloscope	$1825
Type 581A Oscilloscope	$1425
No sweep-delay capabilities, but other features similar to Type 585A.	
Type 82 Dual-Trace Unit	$ 650
Type 86 Single-Trace Unit	$ 350
Type 81 Plug-In Adapter	$ 135

Allows insertion of 17 Tektronix letter-series plug-ins. Band-width (up to 30 Mc) and Sensitivity depend upon plug-in used.

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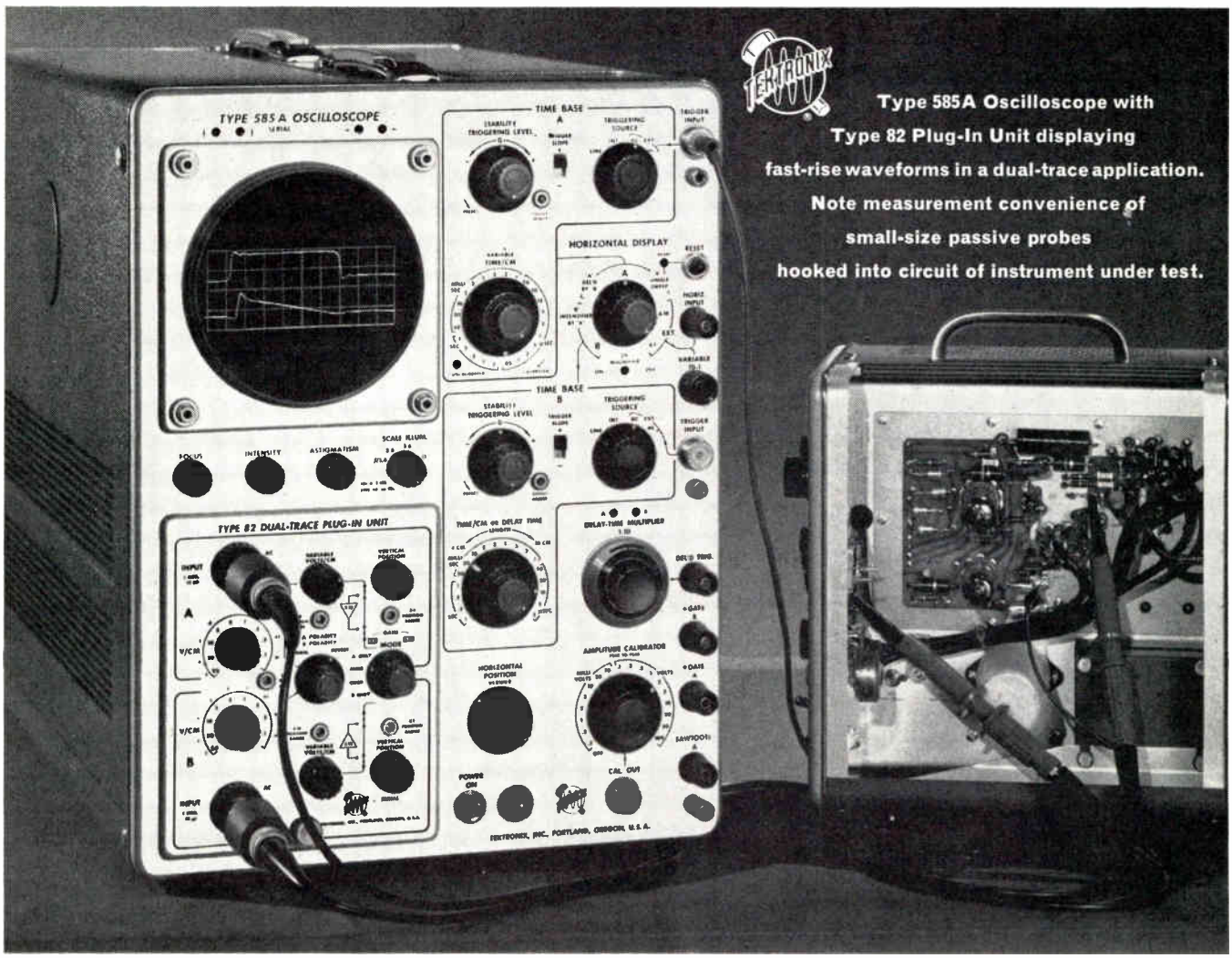

Type 585A Oscilloscope with Type 82 Plug-In Unit displaying fast-rise waveforms in a dual-trace application. Note measurement convenience of small-size passive probes hooked into circuit of instrument under test.

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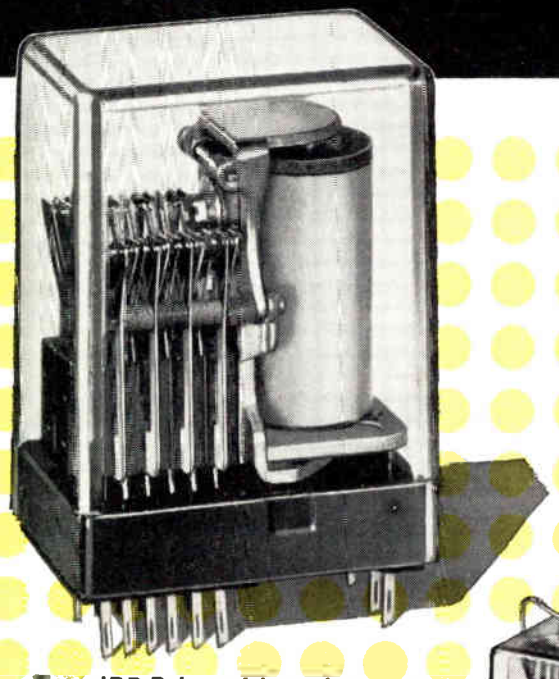
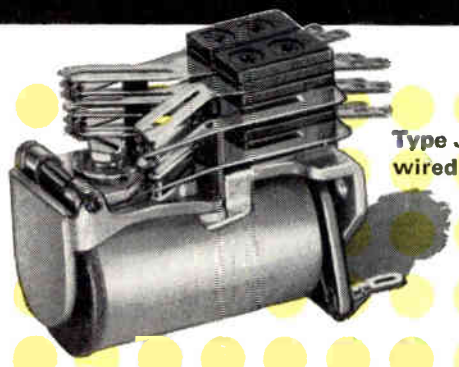
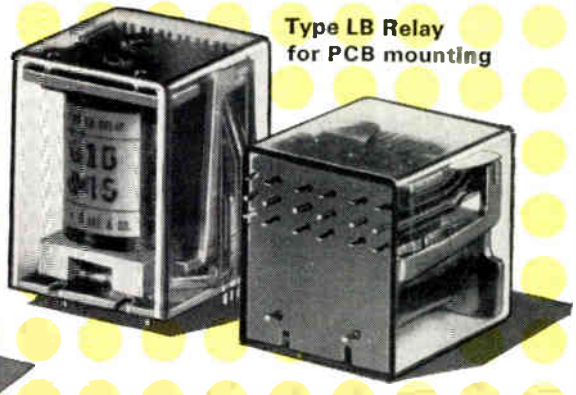


Type JDP Relay with mating socket for plug-in mounting

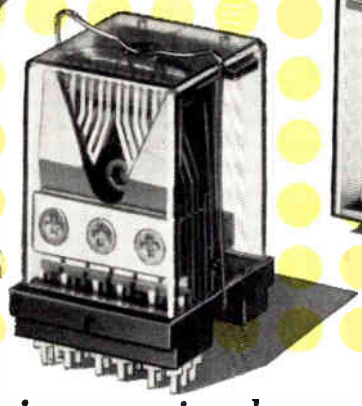


Type J Relay for wired assembly

Relays shown actual siz



Type LB Relay for PCB mounting



Type LBP with mating socket for plug-in mounting

for printed circuits, plug-in or wired assemblies!

■

Compact CLARE telephone type relays offer versatility of performance and flexibility of installation that meet the requirements of the widest variety of control designs.

■

Their stable operation and adjustment, together with consistently reliable performance, make them ideal components for applications where inches and ounces count. They have the same sturdy construction, large contact spring capacity, sensitivity and adaptability found in larger, more conventional relays of this type.

■

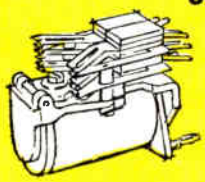
These features contribute to the reliable, long life operation of these relays: Independent twin contacts, enhancing contact reliability; Largest possible armature bearing surface, providing stable, adjustment-free operation; Extremely rigid heel-pieces, making fine adjustment practicable.

■

For commercial, industrial or military applications, CLARE telephone type relays solve a wide variety of switching problems.

TELEPHONE TYPE RELAYS

CLARE *TYPE J RELAY*

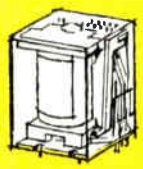


A general purpose relay whose consistent performance has been demonstrated in thousands of applications. It is available unenclosed, in dust covers, or hermetically sealed. Solder, taper-tab or direct plug-in terminals are provided for wired assembly mounting.

CLARE *TYPE JDP RELAY*

An assembly providing direct plug-in mounting of Type J Relay using contact springs and coil terminals as plug pins. This eliminates costly wiring and saves 20% in height over conventional octal plug relays. Clear plastic dust cover. Two socket sizes: 28 terminals for 24 contact springs; 16 terminals for 12 contact springs. Both with four coil terminals.

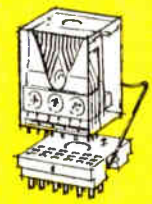
CLARE *TYPE LB RELAY*



Mounting height—1.24 inch maximum.

A high quality, low cost relay which meets the demands of functional PCB applications where small size (1.33 cubic inches), versatile contact arrangements, wide range of contact load capacities, high contact reliability and direct PCB mounting is desired. Clear plastic dust cover. Phenolic bottom plate with tinned nickel-silver terminals.

CLARE *TYPE LBP RELAY*



Mounting height: 1⅛ inches for wired assembly; 1¾ inches for PCB.

A plug-in version of the Type LB Relay with the same operating and design characteristics. Clear plastic dust cover. Choice of two socket styles: (1) solder type terminals with elongated slots for wired assembly mounting, or (2) tab terminals for PCB mounting.

ELECTRICAL AND MECHANICAL CHARACTERISTICS OF TYPE J, JDP, LB, AND LBP RELAYS

	Contact Arrangements	Contact Ratings	Coil Resistance	Nominal Operating Voltages	Operate Time	Release Time
Types J and JDP	Forms A, B, C, D, E with up to 24 contact springs max	Low level to 1000 watts, 10 amps	Up to 21,000 ohms	Up to 300 vdc Up to 220 vac 50-60 cps	Fast operate: 5 ms min Delayed operate: 60 ms max	Fast release: 5 ms min Delayed release: 125 ms max
Types LB and LBP	Forms A, B, C, D with up to 6 contact forms	Low level to 2 amps	Up to 6,550 ohms	Up to 100 vdc	6 ms min	2.5 ms min

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Choose from 3 Outstanding Models

Standard Model EMC-10

Fairchild's Interference Analyzer Model EMC-10 is the only RFI/EMC measuring instrument that can be electronically scanned over its frequency range. As a result, it can be remotely tuned over the complete 20 CPS to 50 KC spectrum, either manually, or by electronic sweep, and without mechanical linkages.

With its X-Y outputs, plus numerous other new features, it meets all new demands for automated testing.

Because it is a modern solid-state unit, operated from either its self-contained, rechargeable battery supply, or external AC or DC, it provides genuine portability and maximum reliability. Its extreme sensitivity—internal noise approximately 3 nanovolts in its 5-cycle bandwidth position—meets the requirements of the most stringent RFI/EMC sensitivity specifications.

With 170 DB dynamic range, including 40 DB on the front-panel meter, and excellent amplitude and frequency accuracies, many of the old low-frequency testing problems are gone. Especially important to the operator is the complete elimination of tedious calibration procedures.

Model EMC-10E With Built-In Scan

Model EMC-10E incorporates all features of standard Interference Analyzer Model EMC-10, but, in addition, includes within its own housing, electronic frequency scanning circuitry for automatically sweeping the range of 20 cps to 50 kc.

Sweep rate is automatically adjusted for the selected IF Bandwidth: one-minute sweep time in the 250-cycle position, five minutes in the 50-cycle position, and fifty-minutes in the 5-cycle position.

Electronic tuning, with the consequent elimination of motor-drive and other mechanical apparatus, is in conformance with newest Department of Defense requirements which emphasize need for automated and semi-automated data collecting.

EMC-10M for Economy

Model EMC-10M incorporates every important modern RFI/EMC feature of the standard Interference Analyzer Model EMC-10, but because some of the features of lesser importance have been omitted, it is available at a lower cost.

As a result, Fairchild can offer for a smaller investment, outstanding features found in no competitive instrument.

Model EMC-10M has a tuning range of 20 CPS to 50 KC (3 times the range of any competitive unit), extreme sensitivity, and the capability for electronic scanning and remote control without mechanical linkages.

INTERFERENCE ANALYZER MODEL EMC-25—14 KC to 1 GC

Now available for the first time is an RFI meter that in a single, compact package provides full coverage of 14 KC to 1 GC. The solid-state Model EMC-25 meets the latest military and commercial requirements for automated data acquisition.

The unit, in many ways similar to the lower frequency Model EMC-10, is capable of being electronically scanned over the entire frequency range, including remotely controllable band sequencing. It also incorporates its own internal battery supply in addition to capability for AC operation.

In addition to small size and light weight, EMC-25 provides extreme sensitivity and operational simplicity. A choice of two bandwidths at all frequencies is standard in the unit. Detector functions provided are Carrier, Peak, Quasi-Peak, 60 DB Scan, Slideback, and FM deviation. In 60 DB Scan, a full 60 DB can be read on the meter without changing input attenuator settings.

Outputs for phones, external meter, X-Y recorder, IF and video are incorporated in the new instrument.

Special versions of Model EMC-25 are also available with customer choice of any one or more of the 15 frequency bands.

TUNABLE REJECTION FILTERS MODELS TRF-11 to -15 14 KC to 1 GC

Each precision rejection filter in this series of five permits attenuation of an unwanted signal by at least 80 DB at any frequency within its tuning range. The entire set of filters provides continuous coverage from 14 KC to 1 GC. While they were especially designed for use with RFI/EMC instruments in this range, they can be used equally well in many other receiving systems to provide rejection of unwanted signals.

AUDIO WAVE ANALYZER MODEL EWA-88
20 CPS to 50 KC With Built-In Electro-Scan

Front-end overload against off-frequency signals, and full capability for electronic frequency control and scanning, internally, or from a remote location, are typical of the unique features found in Audio Wave Analyzer Model EWA-88.

This fully solid-state analyzer has overall dynamic range of more than 170 DB, with 40 DB on the front-panel meter. Other features include two bandwidths—5 cps and 50 cps—with AFC, and five special outputs including "Restored" and "Tracking."

All these features, together with high amplitude and frequency accuracies and extreme simplicity of amplitude and frequency calibration, make the EWA-88 the ideal solution for many applications now satisfied by compromise instrumentation.

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The field of electromagnetic compatibility (EMC) goes beyond the normal "interference" to communications. It now encompasses the effects of radiation on man, animals, plant life and materials, to cite a few. New problems on the horizon may be grouped into legal, legislative, and labor.

The Broad Aspects of EMC

By REXFORD DANIELS President,
Interference Consultants, Inc., 150 Causeway Street, Boston, Mass. 02114

ELECTRONIC INDUSTRIES
STATE-OF-THE-ART
FEATURE

ELECTROMAGNETIC COMPATIBILITY (EMC) is a term which is acquiring a broader and broader meaning, every day, as scientists and engineers push out the frontiers of the electromagnetic spectrum into other disciplines. They are discovering that everything in nature has a resonance which, when activated by magnetic or electromagnetic energy, can affect its molecular structure, its habits, its uses, and even its place in its own environment. What may, therefore, be compatible today in one environment may be found incompatible tomorrow if that environment is changed. EMC is still an art struggling to be a science with nature seeming to continually complicate matters.

With the introduction of "spectrum signatures" by the military, all aspects of electromagnetic energy have become officially included such as magnetic, inductive, Fresnel, and Fraunhofer regions, etc., as well as many terms in other disciplines which describe the reactions of this energy in those disciplines. EMC is also, therefore, no longer just an electronic term but is becoming an all-embracing figure of speech which includes its "side-effects" as they become known.

Studies Being Made

The electromagnetic (EM) spectrum has ceased to be an inexhaustible natural resource which can be indiscriminately used. It has to employ such things as time-sharing and propagation characteristic considerations, in addition to frequency allocation, to achieve compatibility. A good book on this subject is *Radio Spectrum Utilization*, 1964[1], by the Joint Technical Advisory Committee. The book discusses all aspects and gives the reasons why. At the IEEE Convention, March 1965, a panel of experts detailed the problems as they affected military and civilian uses, and fully justified the title of their discussion "Radio Spectrum Utilization as a National Problem." This panel also disclosed to the public, for the first time, the nationwide survey of all aspects of electromagnetic energy which is being made for the executive branch of the government, by the Joint Technical Advisory Committee, and which will probably have some bearing on what action Congress takes to amend the Communications Act of 1934, now before Congress and known as S. 1015.

Another article in this issue will give the electronic progress which is being made in EMC, thereby, leaving for discussion the increasingly important "side-effects" and, finally, the three Ls—legal, legislative and labor—which are beginning to appear on the horizons of those involved in the use of this energy.

Research into Other Disciplines

The EM spectrum is now being examined for a multitude of uses, many of which were not thought of ten years ago. The Department of Agriculture, for example, is exploring different frequency ranges to learn if EM energy can be used for the control of insects and pests. Educational and technical institutions, Foundations and industry are studying the biological effects of this energy on humans and animals. Other research groups are recording the operation of the brain and tapping in on muscle signals to control artificial limbs and guide fast-moving manned vehicles when the Gs render the pilots immobile. Most of this research, is unfortunately random in effort and not coordinated and, hence, the results often not available to those most interested.

The military has taken the first step in recognizing the importance of the side-effects of EM energy. They have established the tri-Service Radiation Hazards (RAD HAZ) program. This is divided into three-subprograms: BIO-EFFECTS (Hazards to personnel); HERO (Hazards to ordnance) and SPARKS (Hazards to flammable and volatile fluids). At present, there is no corresponding civilian groups—and there may never need to be, if technical information is made public and proper care is taken in its use.

Principles in Achieving EMC

With the discovery that everything in nature has a basic resonance, it indicates that everything can be-

89TH CONGRESS
1ST SESSION

S. 1015

IN THE SENATE OF THE UNITED STATES

FEBRUARY 8, 1965

Mr. MAGNUSON (by request) introduced the following bill; which was read twice and referred to the Committee on Commerce

A BILL

To amend the Communications Act of 1934, as amended, to give the Federal Communications Commission authority to prescribe regulations for the manufacture, import, sale, shipment, or use of devices which cause harmful interference to radio reception.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Communications Act of 1934, as amended, is further amended by adding thereto a new section 302 to read as follows:

"DEVICES WHICH INTERFERE WITH RADIO RECEPTION

"SEC. 302. (a) The Commission may, consistent with the public interest, convenience, and necessity, make rea-

II

ASPECTS OF EMC (Continued)

come an active component in a sympathetic magnetic or electromagnetic environment. Architects are finding out that buildings are no longer inert masses of metal and mortar, but can be active antennas for radiating or conducting EM energy. Industry is finding out that a component or a product may appear to be compatible in a low test ambient, but can become suddenly active when placed in a system, assembly or too near a "hot" element. Thus length, width and shape become important to the design engineer, and location to the packaging engineer.

From a systems circuitry standpoint there is no theoretical or practical reason which dictates the use of a connection to the earth's surface as a necessary part of an R-F systems circuit.[2] In fact, there is no consideration dictating the use of any reference point as a so-called "ground." However, the need for a single reference point, called a reference ground in R-F systems circuitry, is well established. But the location of such a single point depends on its position in the circuitry of the system and impedance characteristics, and with no relationship to an NEC ground. EMC, thus, means the complete use of all EM energy within a system itself and leaving no residue to be attenuated or to be conducted to a ground outside of the circuitry. In other words, all energy, except that which is supposed to do outside work, should be controlled in basic design.

A third basic principle is the simple one of using non-emitting components in place of those which have to be attenuated. For example, substituting incandescent lamps for fluorescent; induction motors for brush-type motors and non-sparking switches for sparking.

Scanning the Spectrum

It is not possible to include all the known research, which is being done in disciplines other than electronics, because they could fill volumes. However, we can start at the bottom of the spectrum and work up.

Man's last refuge for privacy, his brain, is now being invaded by laboratories all over the world. Russia is known to have eight groups working on all aspects of the brain, including thought transference. The number of those in the United States is unknown but more and more are continually coming to light. It seems that the speed of modern civilization is out-running muscular reaction time and demanding quicker controls for all kinds of work. The brain's alpha rhythm, from about 7 to 13 CPS, can now be controlled and, when a person alters the pattern of his thinking, it is possible to use binary digits for communication. Or, in other words, thought transference.[3] As brain activity climbs the spectrum, up to 150 KC, it can operate muscles by creating different frequencies.[4] These signals can be intercepted on the surface of the skin and fed into electronic devices which will duplicate the muscle action. Artificial arms and legs have been made to act normally by such methods, and controls of fast planes can now be operated by just thinking about them.[5] Some day it may be possible to sit in front of a TV set and direct explorations at the bottom of the ocean without even getting one's feet wet. The prospects seem limitless, once the basic principle is understood.

Electrical anesthesia has been discovered at 700 cycles; from 550 KC to 890 MC colloidal components of living cells have been found to resonate in the broadcast and TV bands; 5 MC, 10 MC and 39 MC were found to increase germination of alfalfa seeds which contained hard seed; 21 MC increased the germination of gladiolus bulbs; 26 MC caused polystyrene spherules to form a "pearl chain" reaction in water; 29 MC killed bugs in bread; 300 MC to 3,000 MC will expedite the regrowth of severed nerve tissue, while 400 MC to 450 MC caused a change in the nucleic acid of common strains of bacteria and so on up the spectrum. These reactions often have to be obtained under laboratory conditions, so there is not much need for man to worry, at this time, that his life will be much affected.

The same is not true, it seems, for insects, bacteria and pests. At the 131st Annual Meeting of the American Association for the Advancement of Science, Montreal, December 26-31, 1964, S. O. Nelson and J. L.

Seubert delivered a paper "Electromagnetic Energy and Sound for Use in Control of Certain Pests." In the paper they summarized the research results which had been done to date.

There are future possibilities of man's unbalancement of nature if proper controls are not concurrently studied. The electromagnetic attraction of fish could eventually wipe out whole species—to man's detriment. The discovery of the resonances of nature has, by several scientists, been declared to be of more eventual importance to man than the discovery of nuclear energy.

Too much radiation is hazardous to biological cells and that limits for bodily absorption have been established where very high powers are generated—as near certain radar and communication antennas. These same frequencies have been found upsetting to migratory birds; have been claimed to reduce the percentage of return of homing pigeons, in some areas, down to 2% to 5%; and, these same waves can trigger flash bulbs and erase intelligence from magnetic tape. These are examples of the manifold effects of just one frequency range.

More Than a Technical Problem

Of less interest to the technical side but of more concern to management, are those considerations which are appearing in the legal, labor and legislative fields. They originate as more and more evidence is obtained of harmful radiation; the losses suffered from interference with established communications; reimbursement for material and personal damage, and the introduction of local and national regulatory controls. A good example is the admonition at blasting sites to "Turn Off Two-Way Radios." This raises the question of who could be held responsible if someone did not turn off his two-way radio and an explosion resulted. At the present time, it is a "user beware" psychology which puts the responsibility on the user of electromagnetically affected equipments, materials and components. But this will probably change as people become more concerned with safety and realize that an electric spark can be just as destructive as an incendiary spark. Already legal controls are expanding as the FCC's powers are increased; Public Law 200 (Presidential control of transmissions in a national emergency) is being publicized; West Virginia's National Radio Quiet Zone is becoming a pattern for similar areas, and the Chicago-O'Hare International Airport has adopted the following zoning regulation:

"Section 10.5: Use Restrictions: (1) General—Notwithstanding any other provisions in these zoning regulations, no use may be made of land within any zone in such a manner as to create electrical or electronic interference with radio or radar communication between the airport and aircraft. . . ."

When it is understood that the zoning area takes in a width of 16,000 ft at a distance of 50,200 ft from the end of a runway, it is realized that quite a bit of territory is affected. As this zoning is to become a pattern for other airports, the question of EMC and responsibility will be introduced into every city and large town in the country.

So that buildings and whole industrial areas may be electromagnetically compatible, companies are protecting themselves with special clauses in rental contracts.

Labor

Radars, since the last war, and then nuclear radiation, have made labor conscious of the destructive capabilities of EM radiation. Naturally, the labor unions want protection for their members and also wish to have a margin of protection so that unknown hazards will be covered. Labor officials contend that this is a subject for collective bargaining and should be reinforced by a federal law. They also wish improved Workmen's Compensation legislation making injury pay available even when symptoms do not materialize for seven or more years after ending employment.

It is logical to presume that, ultimately, some protection and some indemnity will have to be provided for everybody, including executives as well as union members. Some companies are already anticipating the possibilities of claims for possible present injury and are running annual tests on all emitters to have evidence in their files.

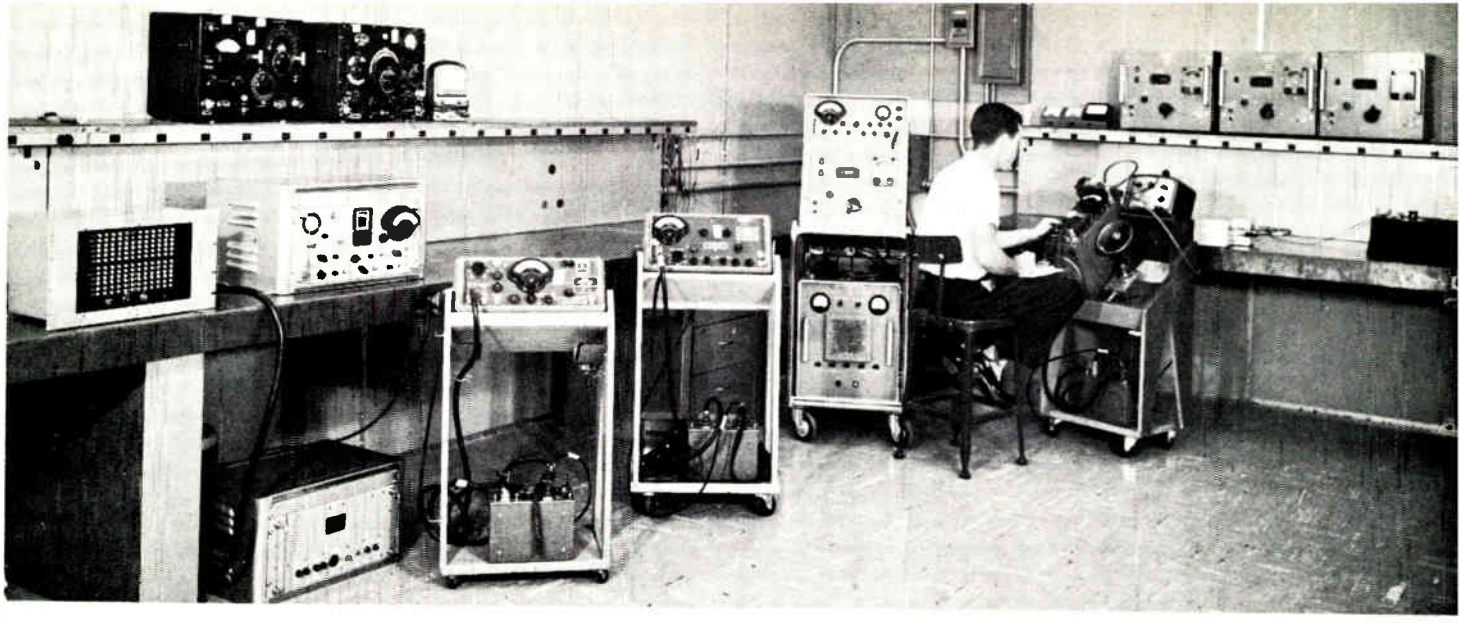
Labor can also be affected by loss of jobs due to FCC violations where a company considers it cheaper to move to a new location rather than to try to shield or reduce radiation to acceptable levels in its present location. On the other hand, labor will probably benefit, for a short time at least, from the establishment of radiation limits on civilian products and equipments. It should also increase the market for "suppression" components and for the shielding of emitters which are too expensive to suppress.

What of the Future?

If we are going to try and create a microvolt civilization in a millivolt world, electromagnetic progress will have to be fitted into incompatible environments. As there seems to be no effort being made on the part of man to reduce his use of the spectrum, those, who have studied the problems which will arise, state that EMC is the next big step in electronics and those, who can master the techniques involved, will benefit. The others will suffer in proportion to their opposition or lack of recognition of what is coming.

References

1. *Radio Spectrum Utilization*, A Report of the Joint Technical Advisory Committee, 1964, 345 East 47th St., New York, 10017, Price $10.00.
A Bill to amend the Communications Act of 1934, S. 1015.
"Electromagnetic Energy and Sound for Use in Control of Certain Pests," S. O. Nelson and J. L. Seubert, American Association for the Advancement of Science, Montreal, Canada, Dec. 1964.
RAD HAZ Program, US Navy, BuShips Journal, Sept. 1959.
"The Frequency Spectrum and the Principle of Resonance Absorption," L. J. Baranski, California Museum of Science and Industry Lecture, Los Angeles, January 1963.
2. "Study and Evaluation of Radio Frequency Grounding Systems," BuDocks U. S. Navy Contract NBy-17828, ITRL. Inc., Boston, Mass.
3. "Communication by Brain Waves," Microwave Physics Laboratory, AFCRL, Research Review, Office of Aerospace Research. Nov. 1964.
4. "Muscle Voltage Moves Artificial Hand"—G. W. Horn, *Electronics*, October 11, 1963.
5. Same as above.



New Developments in EMC

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STATE-OF-THE-ART
FEATURE

HISTORICALLY THE DEVELOPMENT of electromagnetic compatibility from an art to a science can be traced through the words used to describe it. During the decade of the thirties, "static" was the term used to describe the program and the effort at that time was on static elimination. The forties brought a more sophisticated term, "radio noise," and a concern with control over its source. In the fifties there was a consolidation and organization of effort to fight the problem which became known as "radio frequency interference" (RFI). In the sixties there is a realization that the problem is one that we must live with and the term "electromagnetic compatibility" (EMC) is used to describe it. The compatibility aspect has been mainly concerned with the operation of communication, detection and control systems in a common spectrum with acceptable reliability. But recently, reports of side-effects of electromagnetic energy indicate that the area of interest, and ultimately the area of control, will be much broader than could have been anticipated.

Control Measures

The latest specification on EMC is MSFC-SPEC-279 issued June 1, 1964, by NASA's George C. Marshall Space Flight Center at Huntsville, Alabama. It provides system and subsystem interference test, and subsystem susceptibility test requirements. The methods of test and the limits for radiated and conducted interference are set. The limits in some cases are at a frequency as low as 25 cycles. The upper bracket of the spectrum is 10 GC. An unusual feature is the requirement for transient response measurements using a transient generator. It can be constructed from a schematic included in the specification. An evidence of the new approach to EMC is the requirement for a contractor-prepared detailed EMC control plan, as well as a detailed EMC test plan. Each of these plans is subject to review and approval by the procuring unit.

The Air Force has made a step in the direction of a universal specification through the new MIL-STD-826 "Electromagnetic Interference Test Requirements and Test Methods" effective January 20, 1964. This has been introduced to replace MIL-I-26600 with a specification having updated test methods to insure that interference control designs are in new equipment. It is generally believed that MIL-STD-826 will eventually be accepted by the Army and Navy to replace MIL-I-11748 and MIL-I-16910 and become a true Tri-Service Compatibility Specification.

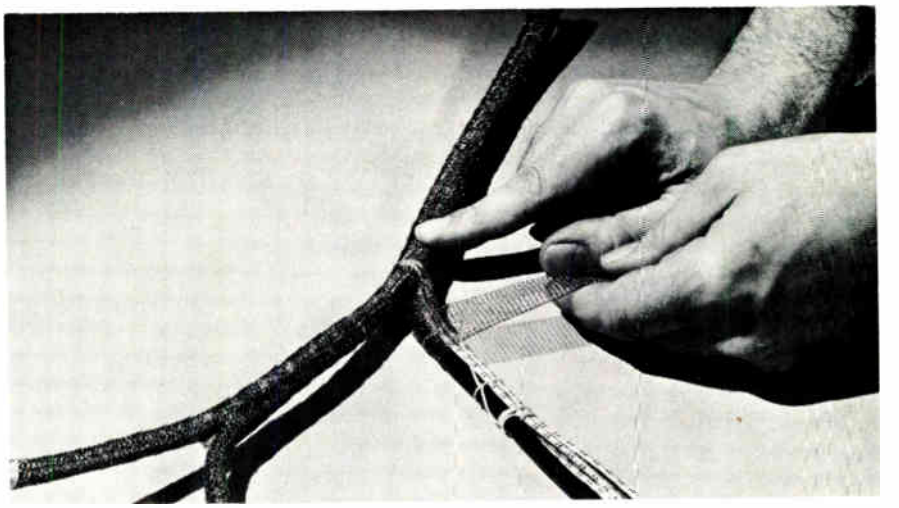
Concern over RFI has caused a bill (S. 1015) to be introduced in the Senate of the U. S. The bill, in effect, proposes to amend the Communications Act of 1934 to give the Federal Communications Commission (FCC) authority to prescribe regulations for the manufacture, import, sale, shipment, or use of devices which cause harmful interference to radio reception, either by radiation or conduction. The bill, further, would exempt devices for use by the federal government agencies from the jurisdiction of the FCC. But it would require that devices for use by the federal government agencies be developed or procured under specifications designed to reduce interference, taking into account the needs of national defense and security. In March of 1965 an associated bill (HR. 5864) was introduced in the House of Representatives.

Spectrum Signature Program

A measurement program was started to furnish r-f

Fig. 1 (left): Typical instrumentation that is required for qualification tests.

Fig. 2 (right): EMC shielding tape can be applied to cables for good shielding.



By JAMES C. SENN and JAMES S. HILL

Applied Research Div.
Genistron, Inc.
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The field of electromagnetic compatibility has been in a constant state of change. New instrumentation, new specifications, better control measures, and advanced methods of protecting ordnance devices are among the most recent changes. Here is a chance to be brought up-to-date.

spectrum characteristics of military electronic equipment. This is for the prediction of interference and compatibility in the planning of installations, and in dealing with interference problems which may occur with changes in operational procedures. Uniform measurement methods for this program are given in MIL-STD-449B. The Army, Navy, and Air Force have been making spectrum signature measurements and reporting the results to the Electromagnetic Compatibility Analysis Center (ECAC) where they are cataloged. The ECAC Catalog of Data and Analytical Service, dated December 1964, lists 191 spectrum signatures in the library. The number of equipments listed is somewhat less than this. In many cases, more than one serial number of an equipment has been measured and listed. Where feasible, the Army has made measurements on three serial numbers of each equipment, while the Navy and Air Force have limited sampling to two. Some of these reports are available from the Defense Documentation Center.

The investment in measurement and report effort is large. The minimum cost of a signature report under MIL-STD-449B is around $10,000. Spectrum signature reports on more sophisticated systems may cost three to five times this minimum.

A signature is costly because of the number of man hours involved in manually scanning the frequency spectrum and manually recording data. The spectrum signature includes the measurement of seven transmitter, ten receiver, and antenna spatial directivity characteristics. Not every signature has all of these measurements. Nevertheless, the investment is large and means of cost reduction have been investigated.

One system of cost reduction that has gone into effect is in the synthesization of signature information in the ECAC catalog. Certain patterns of emission and response associated with transmitter and receiver circuitry and components have become evident. The methods used to synthesize spectral characteristics entail both theoretical and empirical methods. Not all of these can be reliably synthesized. A limited number of characteristics still require measurement, and in some cases, a complete spectrum signature is measured because either the design is new, or there is need for validation of the synthesis method. The synthesis method is also used for antenna characteristics, where a probability distribution can be synthesized from measured data on similar equipments.

Another means of signature cost cutting is by using instrumentation to automatically spectrum scan and record characteristics. Automatic measurement systems are available, but they do not meet MIL-STD-449B because this spec requires a substitution method of measurement, a method which has implied accuracy but which does not lend itself to automation. This stumbling block will, do doubt, be removed in the future.

White Electromagnetics, Incorporated (WEI) has been active in the development of systems to automatically scan and record data in the measurement of radiated and conducted interference under specs such as MSFC-SPEC-279, MIL-STD-826, and similar specifications. The WEI Model 120A Auto-Spectrum Plotter uses the Empire NF-105-F receiver, but any other standard radio interference receiver can be used. A similar system, Model 130A, is designed around the use of surveillance receivers where the interest may be in an EMC environmental study.

Instrumentation

In the field of instrumentation for EMC-RFI meas-

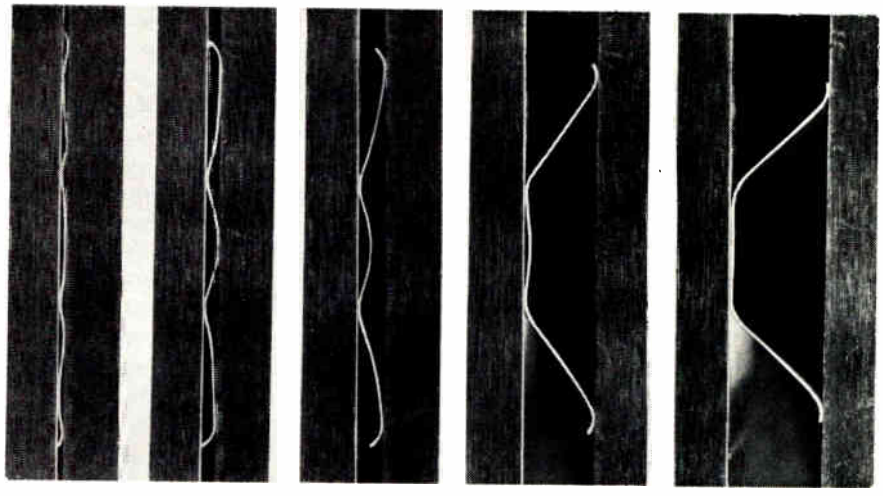


Fig. 3: The development of multiple lines of contact during compression of a single RFI floating finger strip for doors.

urement competition is keen. This has fostered new, improved instruments with better sensitivity, reduced size and weight, motorized scanning, and a number of other features. Relative newcomers in the field are EMC Instrumentation, Electro International, and Fairchild Electro-Metrics.

The EMC Instrumentation Model EM A910 covers a range of 1 to 10.5 GC and features all solid state circuitry, high case shielding, AFC, high sensitivity, and a remote control arrangement that can be automated. The Electro International line of instruments includes a number of specialized devices, including a group of preamplifiers to give a 20 db improvement in the sensitivity of existing instrumentation in the range of 150 KC to 1 GC. There is also a subaudio detector for use in the 3 to 45 CPS range to detect low level electric and magnetic fields.

Fairchild Electro-Metrics broke into the field last year with the solid state Model EMC-10 which features a built-in electronic frequency scan from CPS to 50 KC. The Model EMC-25 recently added to the line measures from 14 KC to 1 GC, with electronic scanning and remote control band switching. A prototype of this unit was shown in March.

The Stoddart Company, long active in the field, has acquired rights to the White Auto-Plot Controller. This is an attachment for any tunable RFI measurement instrument. It can be used to automate measurements and record the results on an x-y plotter. Through the use of the Auto-Plot Controller, the full requirements of MIL-STD-826 and other interference specs can be met, including transient measurements. Stoddart announced a new solid-state line of instruments last March. The line consists of a set of 3 units, which together cover the frequency range of 10 KC to 1 GC. Also, there is a single unit, the LF/SHF-2T, which tunes from 10 KC to 10 GC with improved sensitivity and reduced spurious responses. Stoddart has also announced the NMC-1040 converter unit which tunes from 10 GC to 40 GC in three bands, with a 9 GC output. Automatic scanning is provided which can allow a panoramic display of the entire frequency spectrum.

The Empire Division of Singer Metrics is continuing their basic line instrumentation with some additions to the packaging. Interchangeable tuning heads have been arranged in one package, with filament heating supplied to all heads. A switching arrangement allows instant selection of any one head for the tuning function. Equipments of this type are the NF-105F for 14 KC to 1 GC and the NF-112F for 1 to 10 GC, with an extender available for coverage up to 22 GC.

Polarad has added a number of improvements to the solid state model CFI. The frequency range has been extended so that the range of 1 to 21 GC is covered with six interchangeable heads. For the user who wants instant access to any part of this spectrum, there is a rack mounting arrangement with band switching between heads. Motorized tuning, sector scanning, and programmable operation are other new features.

One of the most impressive and widely accepted developments in the RFI instrument field is the Hewlett Packard Model 8551A/851A Spectrum Analyzer. This unit has opened up a wide panoramic window in the spectrum with a sweep width adjustable from 100 KC to 2 GC. With accessory mixers and adapters, it can be used as a receiver from 10 MC to 40 GC. This is such a convenient tool in spectrum monitoring that every procurement for a mobile van or a fixed monitoring station has included at least one of these units.

McDonnell Aircraft has established an Electronic Equipment Division to enter the EMC instrumentation field. One of their first products is the Model 35 G001 Transient Generator. This is a high voltage type generator capable of an output of 200 volts, suitable for use as a susceptibility tester. In testing susceptibility to radiated fields it is capable of output fields of up to 20,000 volts per meter or up to 0.67 gauss.

At Ft. Monmouth the USAEDL has developed the use of Yttrium, Iron, Garnet (YIG) filters for microwave receivers for spectrum scanning and signal level measurement. This is now in a very promising stage. The YIG filter has been voltage tuned to provide a scan through the 1 to 12 GC portion of the spectrum in a nsec time interval. The bandwidth can be controlled

from a wide mode, about a megacycle to a narrow mode of kilocycles. It is possible to sweep the frequency range in the wide mode to find a signal and then examine it in detail with the narrow mode. This system has a 90 db dynamic range with an attenuator controlled in 10 db steps. Thus, a number of cuts can be made through the spectrum at 10 db intervals. A computer type readout is incorporated so that in a rapid, continuous scanning mode, signals can be recorded as part of a spectrum search program, or the system can be used for rapid recording of spectrum signature measurements.

Signal Processing

Developments in signal processing have come about through a review of old established theories. For example, the well known FM "capture effect," in which the strong signal causes a rejection of the weak signal, is now used in signal processing system to separate and retain a weak signal. The two co-channel signals are processed concurrently in two FM receivers. One receiver has a strong limiting action which rejects the weak signal; the other receiver has marginal limiting action which is adjusted to produce both the weak and strong signals in its output. The outputs of these two receivers are combined so that the two strong signals are in phase opposition and cancel, leaving the weak signal at the output of the combiner.

In another development the local oscillator input to the mixer has been increased to improve signal discrimination. An increase in oscillator drive produces an undesirable increase in noise figure and an increase in intermodulation products. The increase in intermodulation products occurs out of the channel and can be controlled with a bandpass filter. An increase of 10 db in local oscillator injection will reduce co-channel signal intermodulation products by as much as 20 db within the channel.

Shielding

An interesting and novel shielding material has just been introduced by Tecknit. It is an EMC shielding tape of knitted steel wire. It comes in a one inch width and can be wrapped as a bandage as shown in Fig. 2. When wrapped with an advance of one-half layer per turn it gives four layers of single knit thickness. More shielding can be provided by wrapping with a smaller advance. This is a very convenient shielding device for lab. and prototype use.

Finger stock is a standard type gasket material on shielded room doors. Its drawback has been its vulnerability to mechanical damage and the difficulty of repair or replacement. Instrument Specialties Company has a "floating" type of finger stock which can be loosely or tightly fastened with rivets, screws, or with a special spring clip. Fig. 3 shows the gasket in progressive stages of compression. As it is compressed there is a wiping contact action, and the number of lines of contact increases from three, as shown at the top of Fig. 3, to at least nine as shown in the lower part. Since this new type of gasket does not require soldering to the door or frame, it can more readily be replaced when damaged.

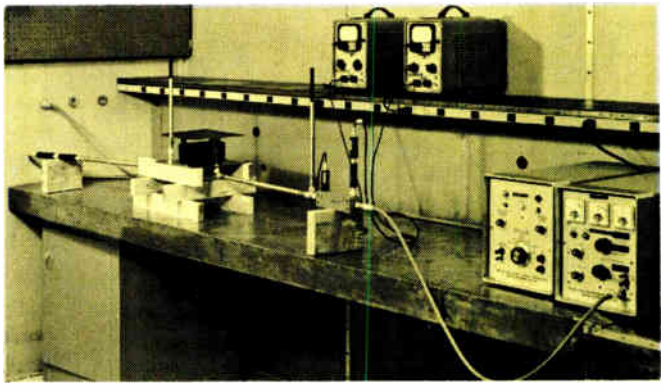
HERO (RADHAZ) Programs

A special area of EMC problems has been designated variously as "HERO" (Hazards of Electromagnetic Radiation to Ordnance) or "RADHAZ" (Radiation Hazard). The HERO or RADHAZ problem arises mainly because of the possible susceptibility of electro-explosive initiator devices (EED) in both weapons and aerospace vehicles to the electromagnetic environment. Other serious problems are the danger of injury to personnel by r-f radiation, and the problems of interaction among complex control systems.

Several government agencies are very active in analyzing these problems and seeking solutions. One agency has sponsored development of a number of in-line protective devices and special electric squib designs, as well as development of instrumentation and methods for evaluating these items. They have sponsored development of methods for laboratory evaluation of the devices. They also conducted their own test programs to evaluate hazards under full-scale conditions of simulation.

Some devices developed under the sponsorship of this agency include absorptive attenuators, special relays and semiconductor devices, shielded transformers, and special types of r-f-insensitive squibs. Special instrument developments include a miniature r-f current

Fig. 4: Experimental setup for development of EED test methods.



sensor and recorder system and a special field-intensity meter for use in intense fields very near a large radiator.

This agency is also intensely active in both experimental and theoretical studies with the objective of analyzing, predicting, and minimizing interaction among weapon systems and subsystems. Studies are carried out with the aid of systems in operation, as well as simulated systems on several large-scale ground plane facilities.

Another agency is active in development of protective devices, particularly absorptive attenuators, and evaluation methods for such devices. They are developing

EMC DEVELOPMENTS (Continued)

large scale r-f environment generating facilities covering almost the entire usefule r-f spectrum at high power levels. This facility may be used for testing of complete weapon systems.

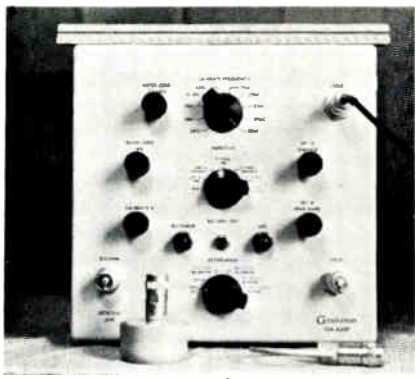
A third agency is developing a complete specification covering allowable r-f environments, allowable EED sensitivity ranges, and test needs for electroexplosives. The various services have previously developed environmental exposure limits for electroexplosive systems.

Special Problems of HERO

The problem of guaranteeing safety of electroexplosives is aggravated by the necessity of proving that the device will be safe under worst-case conditions at all frequencies. The insertion loss of an in-line device, or the power accepted by an "insensitive" device are functions of the source impedance. Unfortunately, the source impedance cannot be specified or closely controlled. A government-sponsored study has proven that it is possible to predict the worst-case insertion loss at any frequency, knowing only the impedance of the squib and the protective device, and the voltage transfer ratio of the protective device.

The sensitivity of an electroexplosive to r-f energy cannot be stated as a simple number which will hold true for every similar EED. The sensitivity is a statistical quantity which can be found to a specified confidence level. The most commonly-used methods of statistical analysis are the Bruceton and the Probit methods, each of which has peculiar advantages, depending on the type of information desired. Both methods require exposure of a number of random samples to dc or r-f quantities. The statistical analysis is based on the record of "fires" and "no-fires" in the sample. Results can be expressed, at a given confidence level, as the voltage, current, power, or energy for specified percentages of fires.

Full-scale field simulation and evaluation require an accurate knowledge of the field strength or



Probe unit of a near field-field intensity meter that is made by Genistron, Inc.

power density, along with accurate measurements of the resulting power at the electroexplosive. The high power levels and near-field distribution of the radiator environment make field intensity measurements very doubtful with standard field intensity meters. This is the result of disturbance of the field by the meter, and penetration of the meter case and overloading of the meter by the intense fields present. A 2 to 30 MC near field-field intensity meter, recently developed by Genistron under government contract, has made accurate measurements up to 500 v per meter or 1½ a per meter practical.

The measurement of r-f power, or a quantity related to r-f power, at the electroexplosive is complicated by the very small space available, and by the necessity for measurement over a wide frequency range without disturbance of the measured quantity. This problem, too, has been alleviated by a current sensing and recording system developed by Jansky and Bailey, R & E Division of the Atlantic Research Corp. under government sponsorship. The system is designed to ride in a rocket package without outside leads. At the termination of a mission the recorder is played back through a console for analysis of the data.

As we have shown, government agencies have been extremely active in HERO and related programs. These agencies have been supported very widely by university and industry programs, both government- and privately-sponsored. Some examples of university and industry leaders include Aerojet-General, Bendix-Scintilla, Elgin, Franklin Institute,

EMC DEVELOPMENTS (Concluded)

Genistron, Hughes Aircraft, North American Aviation, Weston, Metavac, Denver Research Institute and Jansky and Bailey (ARC). While this listing is not all-inclusive, it shows the wide university and industry participation in developing scientific solutions to a problem of vital concern to the military and space programs of the United States.

Many of these private concerns have invested their own funds in the development of devices, research, and development of instrumentation and evaluation methods. Fig. 6 shows a typical experimental setup at Genistron used for development of EED susceptibility test methods.

RFI LEAKS ELIMINATED

THE RADIO FREQUENCY INTERFERENCE (RFI) LEAK is a problem that has long plagued front-panel components such as indicator lights and switches. In conventional designs, these components contain mechanical discontinuities that are isolated from the panel ground circuit; such discontinuities form ideal points for emission and absorption of r-f interference. Typical trouble spots are filaments of lamps and internal moving parts of pushbuttons.

The RFI-shielded components, developed by Control Switch Div., Controls Co. of America, Folcroft, Pa., incorporate internal bonding and grounding techniques to eliminate these mechanical gaps. They furnish a low-impedance path from isolated internal parts to the mounting panel, thus effectively grounding out spurious r-f in the 0.15 to 1000MC range.

The indicator lights contain a metal mesh shield within the plastic indicator lens to absorb any RFI emitted by filaments. This shield is bonded to the indicator case in sealed models; in removable-lens models, it is connected by a special conductive gasket. A cadmium-plated brass case completes the path to ground.

The pushbutton switches use various forms of multi-point contact

(*Continued on page 52*)

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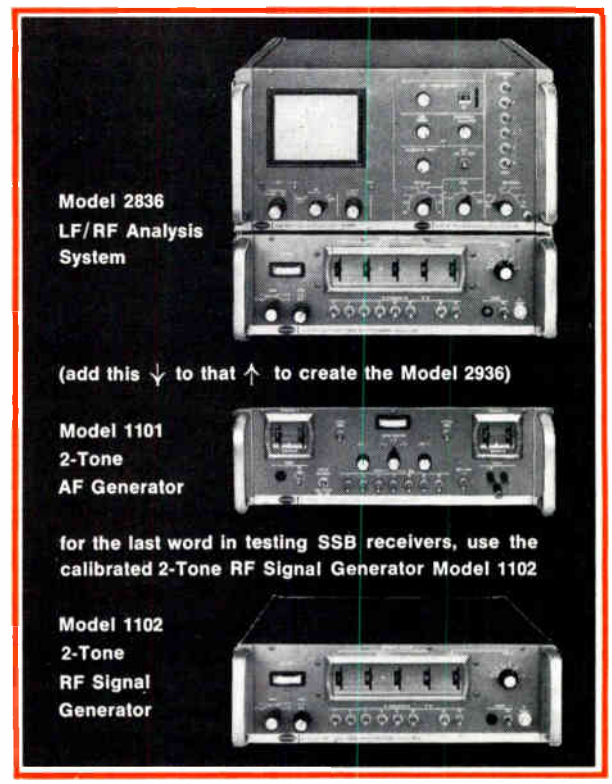

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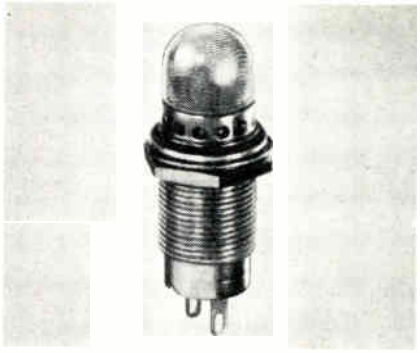
RFI Leaks (Continued)

spring wipers to connect all non-current carrying metal parts within the switch to the switch case. The wiper surrounds the inner metal button of the switch and maintains continuous contact with the case througout switch travel. Again, the metal case completes the path to ground.

Shielded indicator lights are currently produced in 2 basic styles: standard-size indicators with replaceable incandescent or neon lamps; and permanently-sealed 50,000 hr. subminiature indicators measuring within 9/16 in. overall and weighing less than 0.032 oz. each. Both types are available with a wide selection of standard lens colors.



Mesh shield within the transparent lens eliminates stray RFI.

TV FROM AN LP

AN ELECTRONIC SYSTEM THAT plays TV pictures from a phonograph record! Its name, Phonovid. This is not just an audio recording that triggers pictures from a slide projector; both the audio signal and the video signal are present in the grooves of the record, and both are picked up by the phonograph needle.

Up to 400 pictures and 40 min. of voice and music are present on the two sides of a 12 in., 33⅓ RPM recording, called a Videodisc. The pictures can be line drawings, charts, printed text, or photographs. The recording is played on an ordinary turntable and the pictures and sound appear on any number of TV receivers.

Any part of the recording can be held, skipped or repeated by manually lifting the tone arm. During interruption of the sound, the picture continues to appear on the TV screen.

The record player and the TV set to display the pictures are entirely conventional. However, the key component which links the two and makes possible the TV display consists of specially developed circuits called a scan converter. Information coming from the phonograph record is stored in the scan converter's electronic storage tubes. The tubes build up and display a complete TV picture every 6 sec. One picture is read out repeatedly and displayed during the time that the next one is being formed from the video information in the grooves of the recording.

More information concerning the system is available from Westinghouse Electric, Box 2278, Pittsburgh, Pa.

The recording is played on an ordinary turntable and the pictures and sound appear on any number of television receivers.

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		T_J	θ	P_T Watts	BV_{CBO}	BV_{CEO}	BV_{EBO}	h_{FE}		V_{BE} (sat) Volts	V_{CE} (sat) Volts	I_{CBO} μA	f_T
		°C	°C/W	@100°C Case	Volts	Volts	Volts	@I_C = 1A		@I_C = 1A	@I_C = 1A	@V_{CB} = 60V	mc
		Max.	Max.	Max.	Min.	Min.	Min.	Min.	Max.	Max.	Max.	Max.	Min.
2N3744	7/16	200	3.33	30	60	40	7.0	20	60	1.2	0.25	0.1	30
2N3745	7/16	200	3.33	30	80	60	8.0	20	60	1.2	0.25	0.1	30
2N3746	7/16	200	3.33	30	100	80	8.0	20	60	1.2	0.25	0.1	30
2N3747	7/16	200	3.33	30	60	40	7.0	40	120	1.2	0.25	0.1	40
2N3748	7/16	200	3.33	30	80	60	8.0	40	120	1.2	0.25	0.1	40
2N3749	7/16	200	3.33	30	100	80	8.0	40	120	1.2	0.25	0.1	40
2N3750	7/16	200	3.33	30	60	40	7.0	100	300	1.2	0.25	0.1	50
2N3751	7/16	200	3.33	30	80	60	8.0	100	300	1.2	0.25	0.1	50
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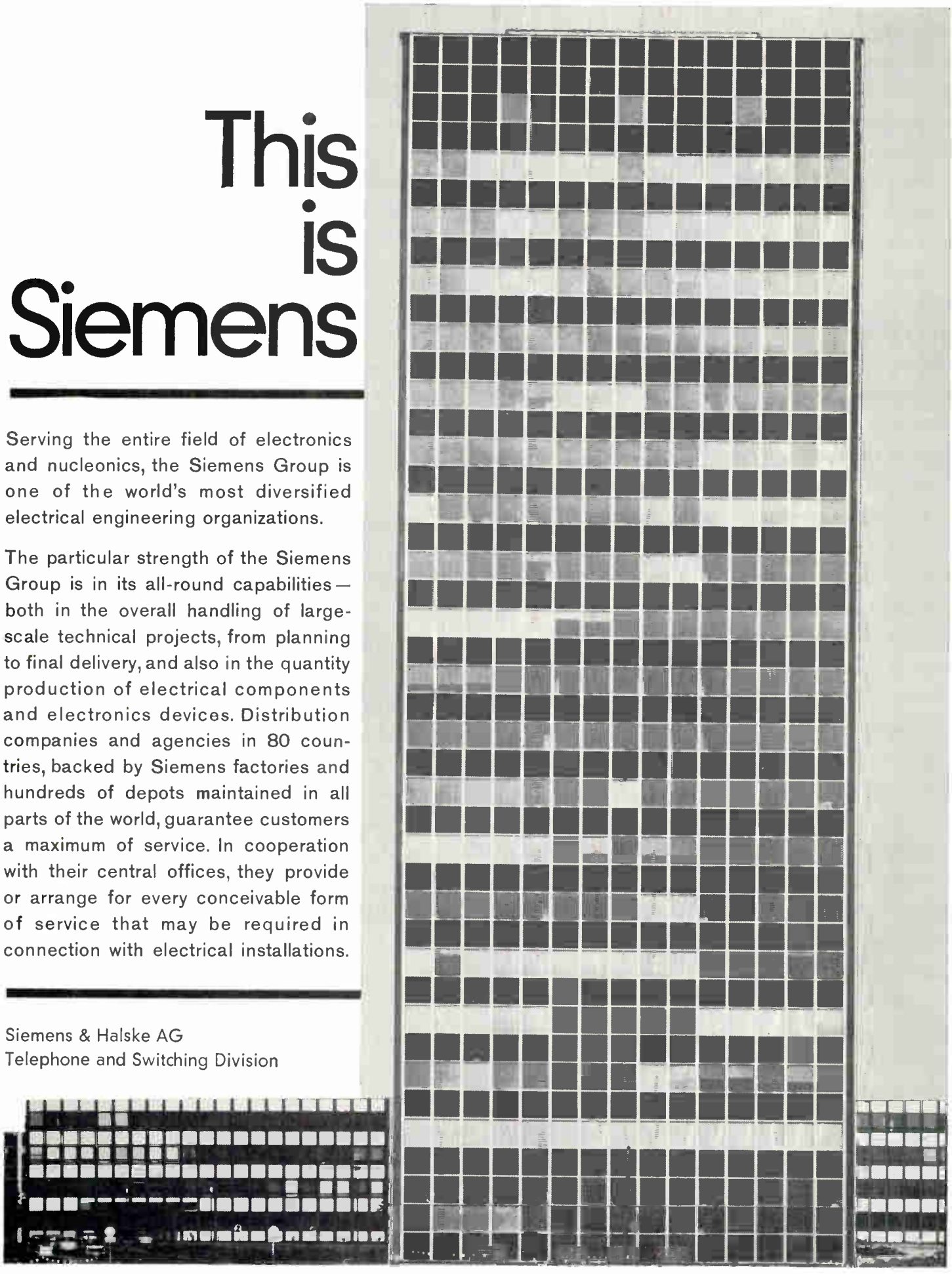

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Siemens surge voltage protectors

The cost of surge voltage damage to delicate equipment runs high. Telecommunications and signaling apparatus, the entire range of solid state circuitry are completely vulnerable to uncontrolled surges, causing immediate damage. Due to short circuits, lightning flashes, electrical overloads or static charging, surge voltages may range from 200 to several thousand volts. In a community wide test, up to 600 surge voltages were recorded in a 10,000 hour period.

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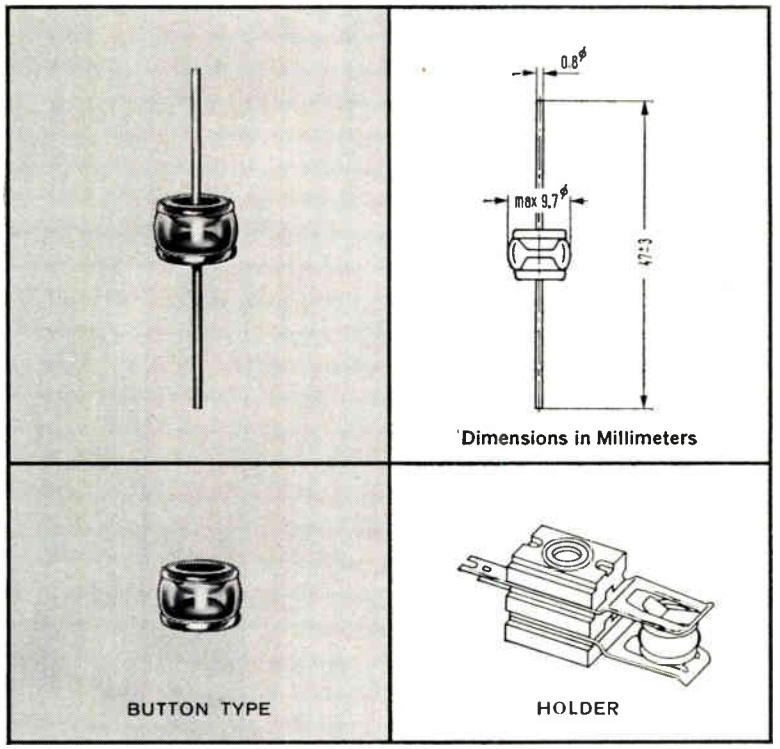

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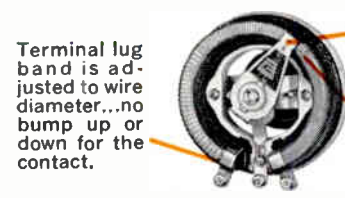

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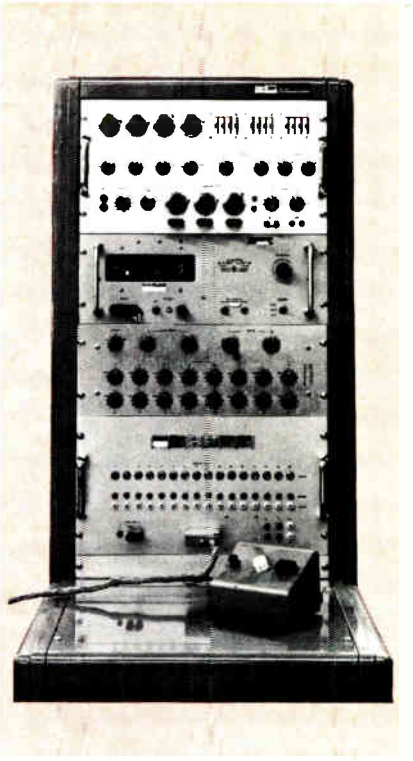
Microcircuits are complex and so is the equipment that tests them. However, they all generally operate on the same techniques. The strengths and weaknesses of these techniques are discussed frankly in this report.

Evaluating DC Testers For Integrated Circuits

By R. BOOHER, S. BOSCIA, and J. PETRUSKA

Equipment Engineering Dept., Philco Corp., Lansdale Div., Lansdale, Penna.



The engineering tester is used to find and solve problem areas. A control panel provides the selection of automatic or manual timing functions for the varipus engineering studies.

The problem of testing microcircuits is complicated by the intricacies of these devices and their packaging. Because of these intricacies, one universal test set is not practical. There are, however, four general areas where testing and consequently test sets are needed: presorting or die sorting; engineering evaluation; final test and classification; and quality control.

Presorting or Die Sorting

An integrated circuit is made of a wafer which contains hundreds of identical circuits. The processing cost to this point is small. A presorting or die sorting test set is used to identify the defective circuits on the wafer so that only the good ones are processed further. In the sorting, different tests are applied to the circuits. Sensitive probes are used with a high-speed tester. The tester can be programmed to stop when the first defect in a circuit is found, or to test an entire circuit and record where the failures occurred.

Engineering Evaluation

The engineering-evaluation test set is used to find and solve problem areas or evaluate circuits. The set must be re-programmed with little inconvenience, and allow the device characteristics to be plotted as conditions are varied.

Final Test and Classification

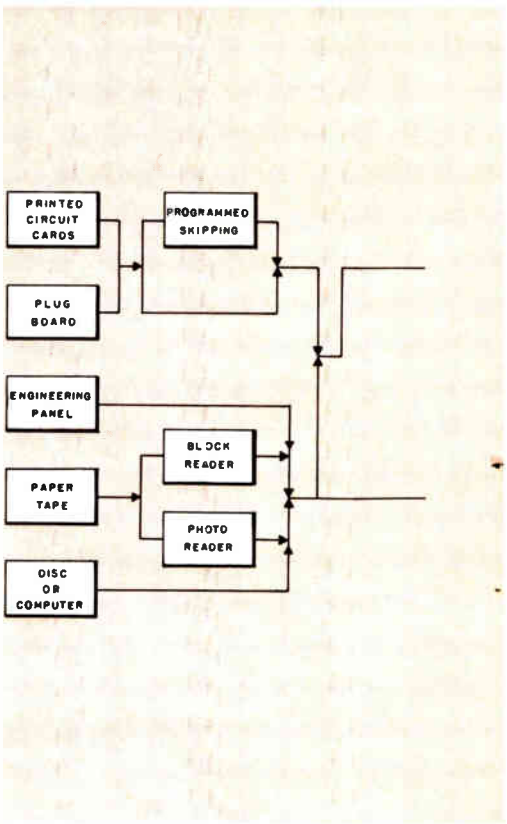
After processing, it is necessary to make a final check on the device and classify it into a proper category. A test set for this area must have accuracy, reprogramming speed, operating speed, and repeatability. Accuracy is needed so that the devices can be separated into the best classification with a high reliability. Reprogramming speed is necessary because the finished circuits vary and many types may be checked. Operating speed is needed for volume. Repeatability is important since it is the last check on the device.

Classifying circuits into more than one type speeds processing, since rehandling of the units is minimized. The classification can be as simple as a person making a decision on the basis of go-no go lights, to many preset matrix readers.

Quality Control

A quality control test set does not need the operating speed of a

Fig. 1. Block diagram below shows the tester options available on most microelectronic circuit testers. The options used are determined by the testing functions it will be required to perform.



production set. It does need repeatability, accuracy, and stability. The ability of this set to log test results is helpful when the total quantities begin to rise.

Testing Methods

There are two basic methods of testing microcircuits: dc parameters and transition time. The dc parameter testing will be covered in this article.

DC testing can be divided into five distinct areas: programming; comparison; biasing; readout; and data acquisition. The whole dc testing problem can be broken down into a flow chart which is easily understandable (Fig. 1). A complete test set can be defined from the flow chart, which illustrates choices and techniques. The chart is intended as a guide to specifying and shows the ability to use digital and analog methods.

Data Programming

There are five basic methods of inserting program data into a tester: printed-circuit board; plugboard; engineering panel; perforated tape; and magnetic.

Printed-Circuit Board

With printed-circuit (PC) board programming, a single PC board can define either one test or a sequence of tests. Advantages of using PC board are: it is simple to interchange tests; tests are easily modified; and the combination of programmed values is unlimited. Disadvantages are: the cards are bulky to store; program changeovers are relatively long; the number of tests are fixed; and analog programming results in long lines and many relay contacts in series, thus causing line-voltage drops in the test leads.

Electronic Industries has tabulated the operating characteristics of some of the dc integrated-circuit testers currently available. This appears on page 62. The data contained in this tabulation ties in directly with the data presented in this article.

PC boards offer testing flexibility because additional test components (resistors, diodes, relays) can be easily added. If the entire program is put on one or more boards, the test sequence is fixed but the number of boards is small. On the other hand, if a single PC board/test is used, the number of tests in a sequence is limited to the space and tests built into the tester. The tests, sequence and number of tests, however, can be changed easily.

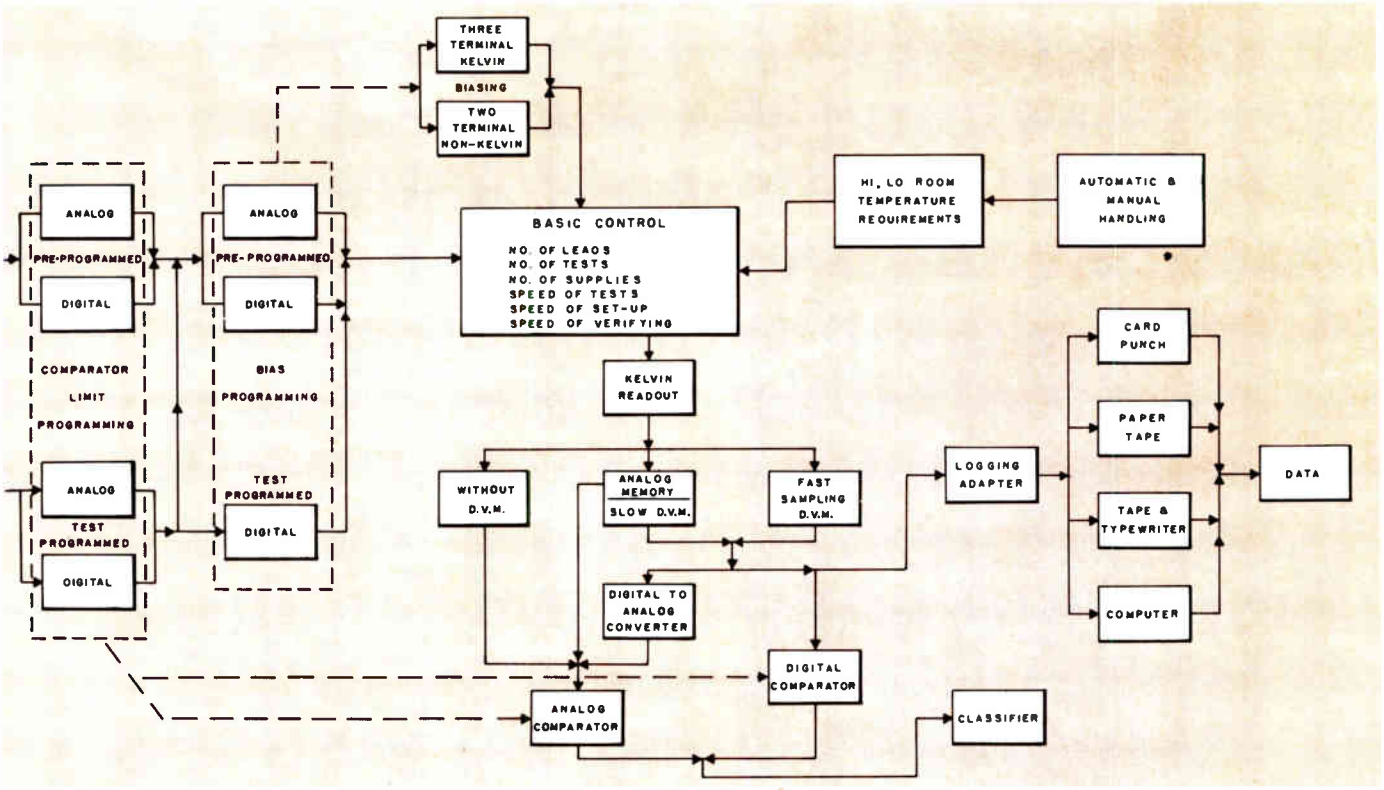
Plugboard

The plugboard is similar to programming with one master PC board. The main difference is that moveable jumper wires were used.

Advantages of using a plugboard are: the test can be modified quickly by moving the wire jumpers; and the plugboard changeover from one board to another is very fast. Disadvantages are: the test sequence is fixed; the number of tests that can be made is relatively small; and the plugboard is bulky to store.

In analog operation, voltages and currents are tied directly to module pins. Digital programming of module pins is not practical because too many jumpers are needed. For relay data a one-to-one jumper is used.

A technique which is applicable only to PC and plugboard programming is programmed skipping. In a skip program several test routines can be stored simul-



DC INTEGRATED-CIRCUIT TESTERS

TESTER	Fairchild 4000M	Non-Linear 24788	Optimized Devices 5000	Philco	Teradyne M230	Texas Instruments 662
PC BOARD PROGRAMMING:						
1. Card programming avail.	No	No	—	Yes	*	Yes
2. Tests per card	—	—	—	1	—	1 to 36
3. Card function	—	—	—	Select limits; apply bias; select readout lines	—	Bias programming, sorting, timing
4. No. of tests run sequentially	—	—	—	1 to 34	—	1 to 36
PLUGBOARD:						
1. No. of tests run sequentially	Not Used	39	—	22	*	—
2. Skip scheme used		Yes (accessory)	—	Yes	—	—
ENGINEERING PANEL:						
1. Panel inserted into test sequence	Not Used	—	—	Yes on tape programmed testers	*	—
2. Digital voltmeter on panel		Yes	Yes	Yes on engineering tester	—	—
PERFORATED TAPE:						
1. Bits/block to define test	Accessory	—	192	208	*	—
2. How is tape read	Block	—	Block	Block reader		—
3. Reading time and testing time with and without logging and tape advance	1/sec.	—	7 tests/sec. incl. tape advance 20 tests/sec. using mag. disc	Read time: 10msec. Test time: 20msec. without logging. With logging: 350msec. using DVM	—	—
MAGNETIC (Tape, disc, drum):						
1. Bits/word	4	—	9	Not avail.	*	—
2. Words/test	60 (characters)	—	40	—	—	—
3. Word capacity	—	—	80,000 (normal)	—	—	—
PRE-PROGRAMMING:						
1. Analog & digital avail.	Yes	—	—	Yes	*	Digital
2. No. of pre-program test limits	Unlimited	—	—	15	—	72
TEST PROGRAMMING: No. of digits provided for limit programming	4	4	6 decimal digits	4 decimal digits	*	5

DC Testers (Concluded) . . . *from page 61*

For data acquisition, a system using a digital readout is required. Here, the operating speed depends on the digital voltmeter specified, since the digital voltmeter usually supplies the timing sequence for the entire system. A high-speed digital voltmeter is referred to here as being faster than 5msec. and a slow speed greater than 100 msec.

Classifier

A classifier takes test-bit data and groups them into two categories: one is a good category, where many tests and conditions must be met; the other is a reject category, where a specific test failure is a type. The complexity of the classifier is determined by the kind of data desired. A simple classifier is a go-no go system based on all the tests made in a cycle. An additional relatively simple classification is the monitoring of tests that have failed.

Sorting into more than one category is more complex. This operation could be controlled by using a card reader or a PC board.

Data Acquisition

Data acquisition is required for several reasons. Immediate on line data may be desired to correct processing, or the circuit-design engineer may need specific data at some later date. A device for acquiring data is a data logger (or logger). In some cases a logging adapter may be required to act as an interface between the actual sampler and logger. The adapter would provide the coding and timing.

There are several methods of collecting data or logging. Four of the most commonly used methods are

DC INTEGRATED-CIRCUIT TESTERS (Continued)

TESTER	Fairchild 4000M	Non-Linear 24788	Optimized Devices 5000	Philco	Teradyne M230	Texas Instruments 662
BIAS PROGRAMMING:						
1. Supplies avail/test	6 (digitally programmed)	6	5	5 or 8	4 to 16	10
2. No. of constant voltage and constant current supplies/test	6 to 36	6	5	4 to 7 voltage 1 to 2 current	—	8
3. No. of levels avail/supply	6	4 (0–10v), 1 (0–20v), 1 (0–40v)	1000	3 preprogrammed levels for analog programming infinite for test programming	—	Programmable
BIASING TECHNIQUES:						
1. Are 2, 3, and 4-terminal supplies avail.	Yes	—	4 terminal	Yes	4 terminal	2 and 4 terminal
2. Programming accuracy	0.01%	—	0.05%	0.05% of range	0.5% to 1%	0.1% and 0.01% for 4 terminal
3. Load regulation of 2-terminal supply	0.05%	—	0.05%	0.5mv/ma	—	0.5%
READOUT:						
1. Types of readout provided	Go-No Go-data logging verification, 5-digit readout	Record all tests; record no-go; stop at no-go test	Go-no Go and digital	Go-no Go, punched card or typewriter	Teletype	Go-No go, DVM, data logging
2. Digital voltmeter speed	50msec. (max.)	50msec. to 150msec.	Balance time 1msec.	1 to 10msec.	—	30msec. to 70msec.
COMPARATORS:						
1. Digital and analog avail.	Digital	Digital	Digital	Yes	Yes	Digital
2. Analog comparison made simultaneously with digital	No	—	No	Yes	No	—
3. High and low decisions made simultaneously	No	Yes	Yes	Yes	—	Yes
4. Speed, accuracy, and number of digits of A-D Converter	—	100sec.; ±0.01% plus 1 digit; 4 digits	4 digits; ±0.01%; 60 readings/sec.	10msec. sample; 0.1% plus 1 digit; 4 digits	36μsec.; 12 bits	30msec.; ±0.02%; 4 digits
BASIC CONTROL: Number of leads unit under tests can have	16 leads	14	20 dual terminal connections	16 on wafer testers; 20 on final testers	16	14
PRICE:	$36,000	$27,500	$40,000	—	$60–$80,000	Below $35,000

* Computer Programmed

card punch; tape; tape and typewriter; and computer.

The card punch is the most used. The card generally contains dry data or information such as date, operator, temperature batch, etc. Also on the card are actual test values. At the same time a hole is punched, a letter or number is typed across the card; thus, the card will show immediate results.

The data punched on the card is easily reproduced in a variety of hard copies. A disadvantage of using the card punch is that it is a relatively slow machine and the cards are bulky to store. Each card must also be identified and the number of tests that can be put on a single card is limited (a single device might require 6 cards for test results).

Another area of data logging is perforated tape. Although tape is a high-speed logging device, it cannot be easily read without decoding equipment. This problem is easily solved by using a typewriter which is adapted to give a printed readout. Biggest advantage of using perforated tape is that it is easily stored and the amount of data it will hold is limited only by the tape length. A method similar to the approach is a tape and typewriter combination. Here tester time is controlled by the typewriter and may result in a slow system.

The highest speed logging system and the highest density storage device is the computer-controlled magnetic tape. Its operation is similar to perforated tape.

Conclusion

This article is the result of the authors' investigation into the design and development of dc microcircuit testers. In presenting the preceding techniques, it is hoped that the user and manufacturer of microcircuits will be guided in their selection of testing methods and equipment.

In a forthcoming issue Electronic Industries will publish an article on Dynamic testing of integrated circuits. Authored by Everett Hanlon of Texas Instruments, it will discuss some of the problems encountered when performing these tests.

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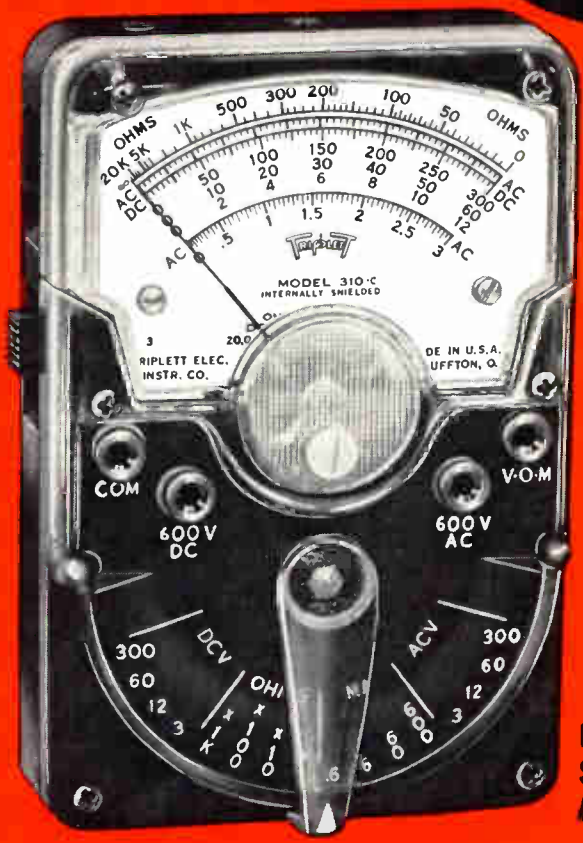

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By NORBERT SEIDEN,

Electronic Components, Unit Head,
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General Precision Aerospace,
Little Falls, N. J.

Reliability Through Redundancy

There are certain basic approaches to increasing the reliability of equipment. They are covered here, and a simplified approach to the evaluation of redundancy techniques is developed.

THIS ARTICLE COVERS THE BASIC RELATIONSHIPS used in reliability. It points to an approximation (Equation 10) which can be made to greatly simplify the evaluation of redundancy.

* * *

Because of the increasing complexity of electronic and electro-mechanical equipment a continuous effort in reliability studies and improvements is needed. Such improvements have been achieved by reliability programs that encompass basic parts improvements, design reviews, manufacturing controls and failure analyses. But, many also attribute such successes to management approaches that develop a sense of responsibility and pride in all personnel associated with product development and manufacture. One such approach is the STAR (Successful Teamwork Achieves Results) Program now in progress at General Precision's Aerospace Group.

Additional Techniques

The above approaches to reliability are sound and very effective but are sometimes not enough. As a result, more methods have to be used. Improvements by means of redundancy techniques have been advocated over the past decade. But, the trade-off factors, e.g., power consumption, weight, size, cost, etc., prohibited their use in most instances. Recent advances in microelectronics have now made redundancy methods a realizable reliability improvement. In fact, these methods are now in the transition stage from theory to practice. As such, it becomes important to be able to quickly evaluate the effect of redundancy in selective areas of a system.

Reliability Relationships

To develop a simple approach for this evaluation, a brief review of the basic reliability relationships is in order. The failure rate, λ, is the average failure rate inherent in a device. Its dimension is the reciprocal of unit-time and it is normally stated in terms of either failures per million unit hours or in terms of percent per thousand hours. The reciprocal of failure rate is the Mean Time Between Failure (MTBF). For example, if a device has a failure rate of 10,000 failures per one million unit hours, the MTBF is 100 hrs.; that is, if one unit is operated continuously it can be expected to fail on an average every 100 hrs. If 10 of these devices are operated continuously, one can be expected to fail every 10 hrs. Although the average failure rate for any device is assumed to be constant, the occurrence of a failure is a random event. And, the occurrence of a specific failure can only be predicted by statistical methods. The reliability, that is, the probability that a unit will complete its intended mission successfully is described by

$$R\ (t) = \epsilon^{-\lambda T}$$

where $R\ (t)$ = Probability of successful completion of mission
λ = Failure rate
T = Mission time
ϵ = Natural log

For example, a unit that has a failure rate of 10,000 failures per million hours and is to be operated for 5 hrs. has a probability of success equal to $\epsilon^{-0.05}$ or 0.95. This means that 95 out of 100 missions are expected to be successful.

The probability of many independent events, each having its own probability, occurring simultaneously is equal to the product of all the individual probabilities. Thus, if a system is made up of two subsystems having probabilities of success equal to $R_1(t)$ and $R_2(t)$, the system probability of success is equal to $R_1(t)R_2(t)$.

Predicting Reliability

In predicting reliability of a system one normally

uses the basic failure rates of the parts that comprise the system. The system reliability is

$$R_s(t) = R_1(t)\, R_2(t)\, R_3(t) \cdots \quad (1)$$

where $R_1(t)$, $R_2(t)$ . . . are the probabilities of success of each part. In the majority of systems all parts are used at 100% duty cycle and thus

$$R_s(t) = R_1(t)\, R_2(t)\, R_3(t) \cdots = \prod_{i=1}^{n} R_i(t) \quad (2)$$

Substitution of Eq. 1 into Eq. 2 yields

$$R_s(t) = \epsilon^{-\lambda_1 T}\, \epsilon^{-\lambda_2 T}\, \epsilon^{-\lambda_3 T} \cdots = \epsilon^{-(\lambda_1 + \lambda_2 + \lambda_3 + \cdots) T} \quad (3)$$

This shows that the reliability of a system can be found by summing the failure rates of the piece parts and applying it to Eq. 1. This holds true for a simple non-redundant system only.

Fig. 1 shows a redundant path in which either block $R_1(t)$ *or* $R_2(t)$ can successfully transfer signal A to output B, independent of one another. Probabilities of success for each block are $R_1(t)$ and $R_2(t)$ respectively. Since the sum of probability of failure and probability of success is 1 or 100%,

$$R(t) + Q(t) = 1 \quad (4)$$

That is, there is a 100% assurance that the block will either fail or succeed. The system of Fig. 1 fails only when both blocks fail, and the probability of this occurring is $Q_1(t)Q_2(t)$. The probability of success for the redundant system thus becomes

$$\begin{aligned} R_{sp}(t) &= 1 - Q_1(t)\, Q_2(t) \\ &= 1 - [1 - R_1(t)]\, [1 - R_2(t)] \\ &= R_1(t) + R_2(t) - R_1(t)\, R_2(t) \end{aligned} \quad (5)$$

Normally, redundant paths are identical and $R_1(t) = R_2(t)$. Thus

$$\begin{aligned} R_{sp}(t) &= 2\, R(t) - R^2(t) = R(t)\, [2 - R(t)] \\ &= \epsilon^{-\lambda T}\, (2 - \epsilon^{-\lambda T}) \end{aligned} \quad (6)$$

Redundancy

The above expression is no longer in the simple form of Eqs. 1 or 3 and as such does not permit the simple addition of failure rates in a system that contains redundancy. But, by introducing an approximation it will be shown that an equivalent failure rate for a redundant pair can be calculated. This can then be used to sum the failure rates of a system and determine its reliability.

By applying the exponential expansion to the basic reliability equation,

$$R(t) = \epsilon^{-\lambda T}$$

it becomes

$$= 1 - \lambda T + \frac{\lambda^2 T^2}{2!} - \frac{\lambda^3 T^3}{3!} \cdots \quad (7)$$

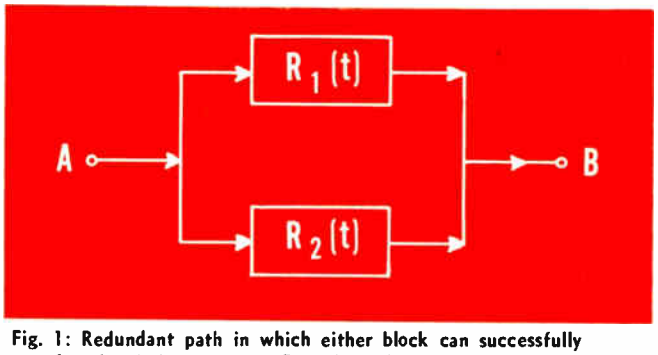


Fig. 1: Redundant path in which either block can successfully transfer signal A to output B, independant of one another.

For values of $\lambda T > 0.1$ this series converges rapidly and can thus be approximated by

$$R(t) \approx 1 - \lambda T \quad (8)$$

From Eqs. 6 and 8

$$\begin{aligned} R_{sp}(t) &\approx 1 - \lambda^2 T^2 \\ &\approx 1 - (\lambda^2 T)\, T \end{aligned} \quad (9)$$

A comparison between Eqs. 8 and 9 shows that a parallel redundant path can be replaced by an equivalent single path that has an effective failure rate as shown below

$$\lambda_p(t) \approx \lambda^2 T \quad (10)$$

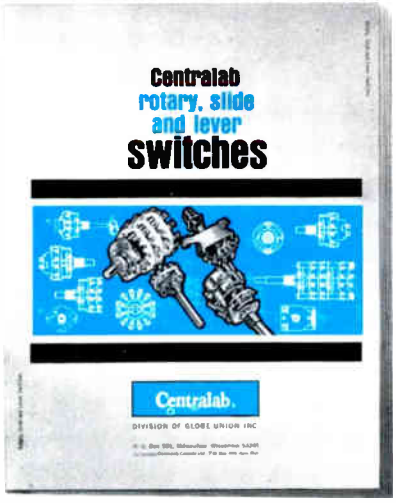
This effective failure rate can now be treated as any other failure rate and can easily be used in Eq. 3.

To show the effectiveness of redundancy the following example is cited. A device having a failure rate of 100 failures per million hours and which is operated for 50 hr., has in a redundant configuration an effective failure rate of 0.5 failures per million hours.

It is interesting to note that whereas a non-redundant system has a failure rate independent of time, a system containing redundancy has an effective failure rate that is time dependent.

Reference

Bazovsky, Igor, "Reliability Theory and Practice," *Prentice Hall*, 1962.



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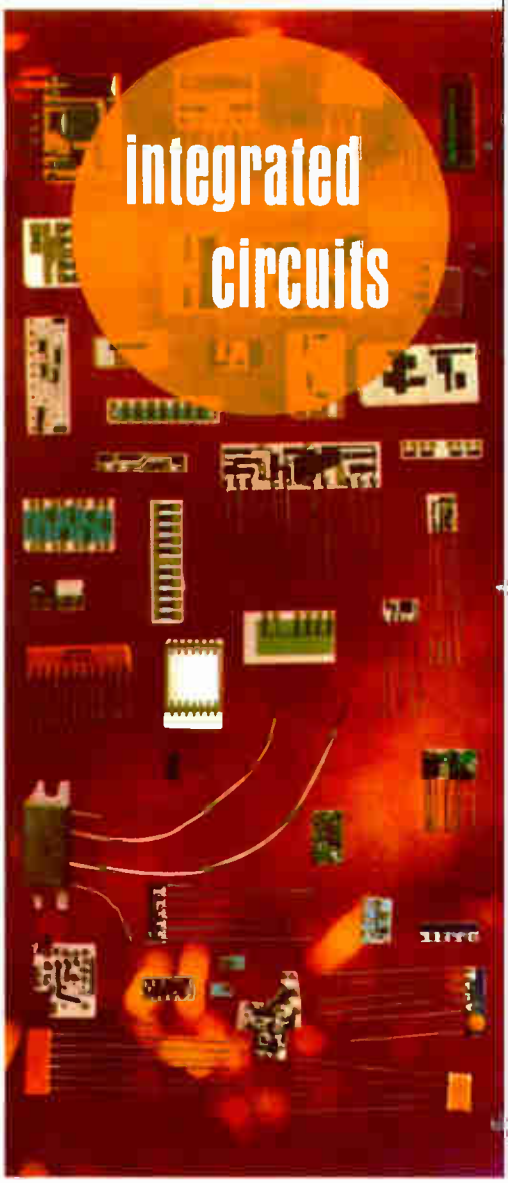

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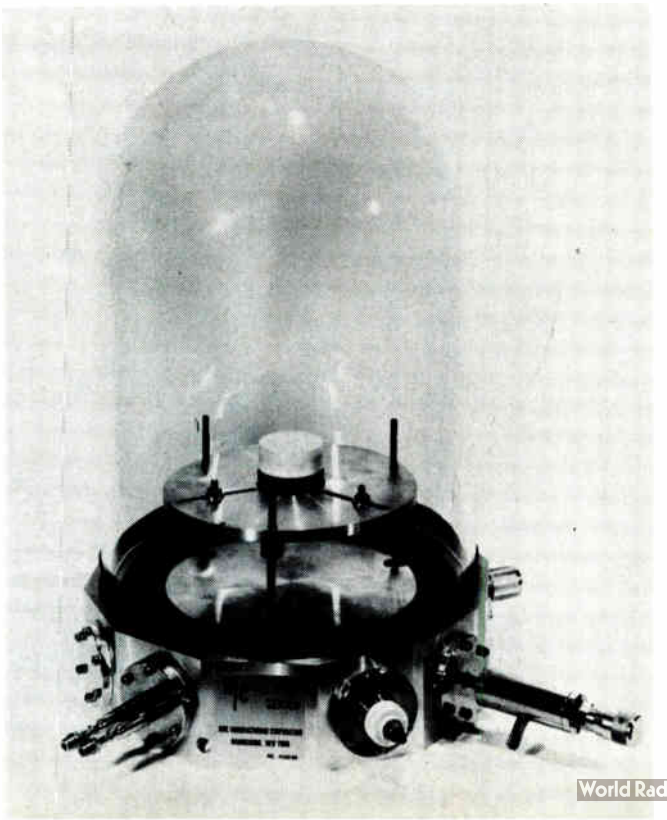
Principal part of the sputtering module is a cathode assembly, which accepts sputtering discs up to 7 in. in dia. A 3-point lava holder allows various shapes to be used as sputtering discs. The water-cooled substrate holder is capable of accepting up to 7 in. dia. slides.

System flexibility is provided since the cathode assembly may be removed from the inside of the bell-jar system. The same collar and feedthroughs can be used with a variety of items, including shadowing apparatus for electron microscopy, electron beam evaporation guns, etc. About 100 different types of guns and feedthroughs are available for use with the basic vacuum collar. (*More What's New on page* 112)

Unit deposits films not readily handled by standard methods.



The well-known feedback equation for the conventional feedback amplifier is not normally applied to the negative feedback operational amplifier. This approach explains how the feedback equation, with one simple substitution, can be used to determine the exact response equation for two commonly used operational amplifier configurations.

By **FON R. BROWN**, Director, Luminescence Laboratory, Electro-Dynamics Laboratories, Utah State University
and **BRUCE R. SAVAGE** Electrical Engineering Dept., Utah State University

A Simple Approach to Operational

IN RECENT YEARS MUCH ATTENTION HAS BEEN GIVEN to operational amplifiers. This interest has been stimulated because of the wide applicability to dc amplification needs and because the circuit has inherently good stability characteristics. This discussion gives the basic relationships between the operational amplifier and the usual feedback amplifier and explains how the well-known equations for the feedback type apply to the operational type. Also, the frequency response of the operational amplifier is discussed, and the effect of feedback ratio β, the open-loop gain A, and the feedback impedance Z_f, are examined.

* * *

The usual equation for the gain of a feedback amplifier has been given by Millman and Taub[1] as

$$A_f = \frac{A}{1 - \beta A} \tag{1}$$

where A_f is the closed-loop gain, A is the open-loop gain and β is the feedback ratio. This equation can be derived from the voltage feedback amplifier setup shown in Fig 1. Note that the voltage fed back is proportional to the voltage appearing across the load Z_L and is introduced to the amplifier in series with the externally impressed voltage e_i.

The operational amplifier uses a feedback voltage which is applied in parallel with the externally applied voltage, Fig. 2. The common operational amplifier of Fig. 2 cannot be operated with a voltage source at the amplifier input. In every case the input signal voltage must be made to appear as a current source by use of a series impedance[2].

Eq. 1 simplifies the calculations for feedback amplifiers. It is useful in analyzing the operational amplifier, provided the equivalence of the input voltage e_i of Fig. 1 to the input signal current i_s of Fig. 2 can be determined. This is done best by making the calculations for an operational amplifier so that the output voltage for any given input current as a function of the feedback impedance and the feedback ratio β is determined.

The equivalent circuit for Fig. 2 is shown in Fig. 3. The voltage at node 1 is e_o/A and A carries its own sign. The assumption that the output impedance of the amplifier is much less than Z_1 or Z_f is also used.

From the equivalent circuit, the following can be written.

$$e_1 = i_s Z_s + i_s Z_1 + i_2 Z_1$$
$$e_o = i_2 Z_f + i_2 Z_1 + i_s Z_1$$
$$e_1 = i_s Z_s + e_o/A$$

Substituting and solving

$$e_o = \frac{i_s (Z_1 A) (Z_f)}{Z_1 + Z_f - Z_1 A} \tag{2}$$

This equation can be compared with Eq. 1 if the value of β is introduced. For the passive feedback network β is $\leqslant 1$ and is defined as the fraction of the output voltage fed back to the input[3]. This ratio can be written in terms of the impedances Z_f and Z_1 from Fig. 2, so that

$$\beta = \frac{Z_1}{Z_1 + Z_f} \tag{3}$$

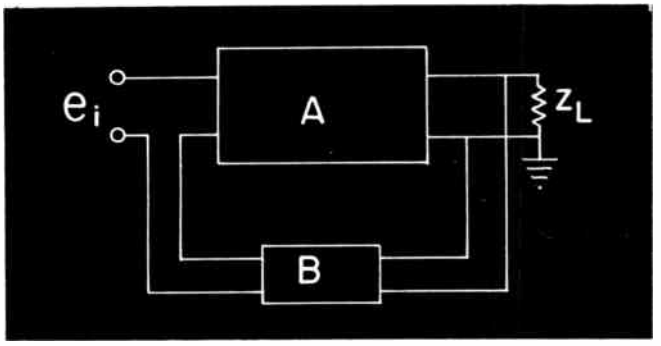
where it has been assumed that $Z_s >> Z_1$ or Z_f. Remembering this value for β and operating on Eq. 2 by dividing numerator and denominator by $(Z_1 + Z_f)$ it can be shown that

$$e_o = \frac{i_s Z_f A\beta}{1 - \beta A} \tag{4}$$

The equivalence of Eq. 4 and Eq. 1 is seen when Eq. 1 is rewritten as

$$e_o = e_{in} \frac{A}{1 - \beta A} \tag{5}$$

where the substitution $A_f = e_o/e_{in}$ has been made.



Amplifier Design

When the numerators of Eqs. 4 and 5 are equated, it is found that

$$e_{in} = i_s Z_f \beta$$

or

$$e_{in} = i_s \frac{Z_f Z_1}{Z_1 + Z_f}$$

This means that Eq. 5, which is the usual feedback amplifier equation for the voltage gain, can be applied directly to the operational amplifier. This can be done if the input voltage e_{in} is replaced by the voltage developed across the parallel combination of Z_1 and Z_f by the signal current when the amplifier is removed or the output is grounded. Eq. 4 is thus analogous to Eq. 5 where Eq. 4 handles feedback amplifiers which are driven from current sources, i.e., the feedback is applied in parallel with the input; and Eq. 5 works for feedback amplifiers which are driven from voltage sources, i.e., the feedback is applied in series with the input.

The Operational Amplifier

The operational amplifier is used in two configurations, as shown in Figs. 4 and 5. For the circuit of Fig. 4, the input is obtained from a current source, i.e., multiplier phototube, photodiode, etc., where Z_1 is assumed $>> Z_f$ at all frequencies of concern. In this case β approaches 1 and Eq. 4 becomes

$$e_o = i_s Z_f \frac{A}{1 - A}$$

If A is high compared with unity so that $|A| \approx |1\text{-}A|$,

$$e_o = - i_s Z_f \qquad (6)$$

In the case of Fig. 5 where the signal is a voltage source (the value of Z_1 is not large compared with Z_f), Eq. 5 is more applicable. Remembering that e_{in} is the voltage that appears at the amplifier input in the absence of the amplifier, or with the amplifier output grounded so the $e_{in} = e_1 Z_f / Z_1 + Z_f$, then Eq. 5 becomes

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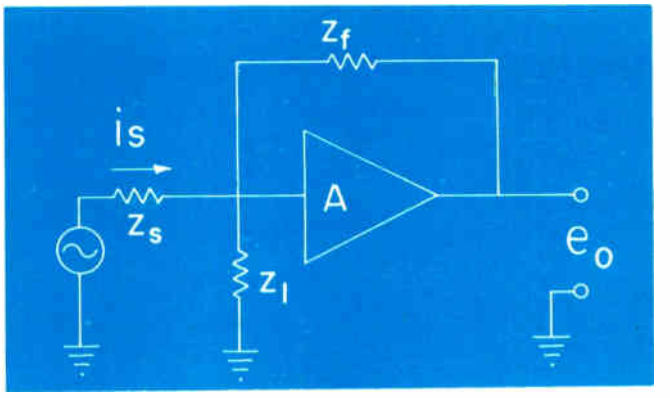


Fig. 1: Conventional feedback amplifier (above left).

Fig. 2: Operational amplifier configuration (above).

Fig. 3: Equivalent circuit of an operational amplifier.

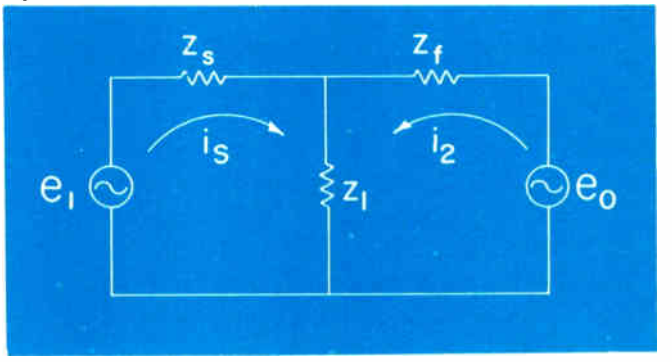


Fig. 4: Operational amplifier operating from a current source.

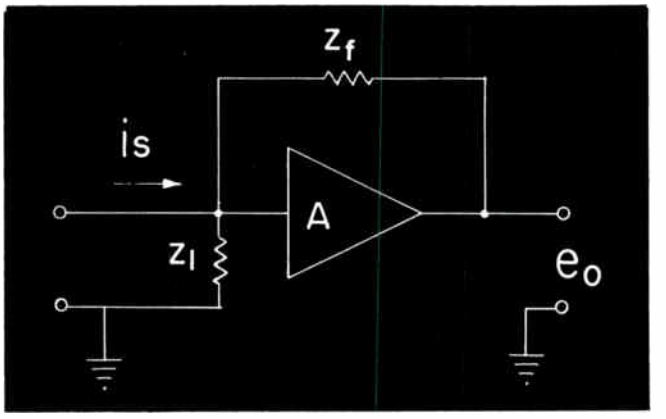
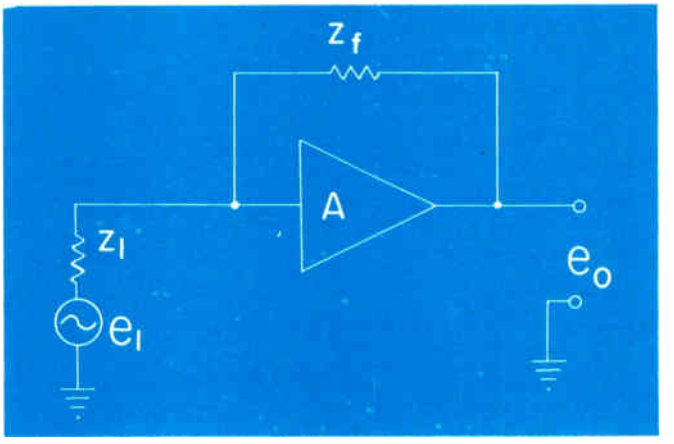


Fig. 5: Operational amplifier operating from a voltage source.



$$e_o = e_1 Z_f \frac{A}{Z_f + Z_1 (1 - A)} \quad (7)$$

where $\frac{Z_1}{Z_1 + Z_f}$ has been substituted for β. If A is large so that $Z_1(1\text{-}A)$ is large compared with Z_f and $|A| \approx |1\text{-}A|$, then

$$e_o = - e_1 \frac{Z_f}{Z_1} \quad (8)$$

The above approach puts the approximate equations of the operational amplifier at hand. But, more important, it gives the rigorous response equations immediately from the common equation of the feedback amplifier with only one simple substitution.

Frequency Response

Eqs. 4 and 7 allow an evaluation of the frequency response by noting the possible complex values in the equations. In Eq. 4 Z_f, A and β are frequency sensitive. In Eq. 7 Z_1, Z_f and A affect the frequency response.

Practical considerations should be applied to the circuit before a frequency analysis is attempted. Under practical considerations for the configuration of Fig. 4, Z_f is the parallel impedance of a resistance R_f and a capacitance C_f and for Z_1 is the reactance of a capacitance C_1.

The f_2 point can be calculated if the imaginary part and the real part of the transfer impedance are equated[4]. The transfer impedance is expressed as

$$Z_T = \frac{Z_f \beta A}{1 - \beta A}$$

which comes directly from Eq. 4.

The value of β for Fig. 4 is given by

$$\beta = \frac{1 + j \omega C_f R_f}{1 + j \omega R_f (C_f + C_1)}$$

If the following assumptions are made, $|A| \approx |1\text{-A}|$, and A is real for all frequencies of concern. The equation for the f_2 frequency can be easily calculated[5] using the above procedure, so that

$$f_2 = \frac{|A|}{2 \pi R_f [C_f |A| + C_1]} \quad (9)$$

This equation supplies the necessary information to calculate the gain needed for the circuit of Fig. 4 for a given f_2 point. Note that the gain in this equation is the magnitude of the gain at the f_2 frequency and not the dc or low frequency gain. Any additional increase in the open-loop gain above the value calculated is not necessary unless the value calculated is so small that the approximation $|A| \approx |1\text{-}A|$ is jeopardized. In this case the gain must be determined by the accuracy that is needed in the approximate Eq. 6.

For the circuit of Fig. 5, the practical components for Z_f are R_f and C_f and for Z_1 are R_1 and C_1. In this case

$$\beta = \frac{R_1 (1 + j \omega R_f C_f)}{R_1 (1 + j \omega R_f C_f) + R_f (1 + j \omega R_1 C_1)}$$

and

$$Z_f = \frac{R_f}{1 + j \omega R_f C_f}$$

By substituting the above into the equation for the transfer impedance and solving, it can be shown that

$$f_2 = \frac{(1 - A) R_1 + R_f}{2 \pi R_1 R_f [C_f (1 - A) + C_1]}$$

This equation is rigorous for an ideal amplifier, i.e., indefinitely high input impedance and zero output impedance. Again assuming that $|A| \approx |1\text{-}A|$, then

$$f_2 = \frac{AR_1 + R_f}{2 \pi R_1 R_f [\,|A| C_f + C_1]}$$

Note that this equation simplifies to Eq. 9 if $R_1 >> R_f$.

Conclusions

The operational amplifier can be treated with the usual feedback amplifier equations by substituting for e_{in} the voltage that would appear at the input of the amplifier with the amplifier removed or the output grounded.

The operational amplifier can be designed for a particular frequency response by the proper selection of the open-loop gain A, the feedback impedance Z_f and the feedback ratio β. The magnitude of the open-loop gain is determined either by the frequency response needed or the allowable deviation in the approximate Eqs. 6 and 8.

This research was supported by the Air Force Cambridge Research Laboratories. The contributions and suggestions of D. J. Baker, A. T. Stair, Jr., L. S. Cole, and C. L. Wyatt are acknowledged.

References

(1) Millman, J., and H. Taub, *Pulse and Digital Circuits*, McGraw-Hill Book Co., Inc., New York, N. Y., pp. 4-5; 1956.
(2) Gass, G., "Understanding High Speed Operational Amplifier," *Electronic Industries*, 23 (2): 106; Feb. 1964.
(3) Millman, J., and H. Taub, op. cit., p. 5; 1956.
(4) Praglin, J., and Nichols, W. A., "High Speed Electrometers for Rocket and Satellite Experiments," *Proc. IRE* 48:771-779; 1960.
(5) Baker, D. J., Wyatt, C. L., and Brown, F. R., "A Direct-Coupled DC Amplifier Compensated to 20 kc for Use with Photoemissive Device," submitted for publication by IEEE.

ELECTRONIC INDUSTRIES

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1965 Survey of Commercial Semiconductor Photosensitive Devices

This material will be presented in three parts—
Part 1: Photoconductors; Part 2: Photovoltaic Diodes; and
Part 3: Phototransistors & PNPN Light Activated Devices.
Also included in Part 3 will be a complete table of manufacturers, their general categories of devices and complete mailing addresses.

Part 1: Photoconductors

PHOTOCONDUCTORS ARE PASSIVE, high-impedance devices composed of thin single-crystal or polycrystalline films of compound semiconductor materials. Since no PN junction effects are used, photoconductors are non-polarized—their characteristics are independent of which terminal is biased positive with respect to the other. When the sensitive surface is illuminated, the conductivity increases due to an increase in the number of mobil carriers (electron-hole pairs) available for the conduction process. Generally, with a fixed cell voltage, the cell current and conductivity increases linearly with light intensity on a logarithmic plot.

Photoconductors can be divided into two basic categories; the first is composed of devices predominantly sensitive to infrared radiation (infrared photoconductors), whereas devices in the second category are predominantly sensitive to visible radiation (visible photoconductors).

Infrared photoconductors are not included in this report since many of them require cooling to achieve desirable noise and "dark" characteristics.

The presence of electron and hole trapping levels in the forbidden energy gap, causes photoconductors to be susceptible to light history effects—variations of light sensitivity and response times with prior history of light and dark exposure. Long exposure to high light-levels prior to excitation temporarily reduces sensitivity and response times. Dark storage prior to excitation has the reverse effect of temporarily increasing sensitivity and response times.

In addition to light history effects, which necessitate preconditioning before measurements are made, most photoconductors exhibit light fatigue effects—their resistance increases with time under steady illumination.

Because of the long carrier lifetimes, photoconductors have response times in milliseconds, and sensitivities about one thousand times that achieved with photovoltaic diodes. Photoconductors respond more quickly to high illumination levels; the rise time is usually longer than the decay time. Generally, cadmium selenide is faster than cadmium sulfide, but cadmium selenide demonstrates extreme susceptibility to temperature variations.

True hermetic sealing is extremely important, since photoconductive materials, namely cadmium sulfide, undergo severe degradation of sensitivity and dark resistance when subjected to moisture.

The author wishes to acknowledge those manufacturers who supplied data for this survey. All data are the manufacturers; the author has not measured or otherwise verified this information. The author has converted data wherever necessary for consistency in the listings.

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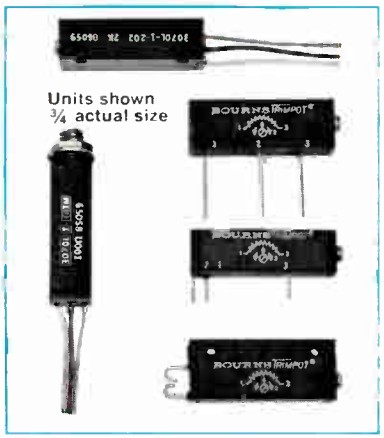

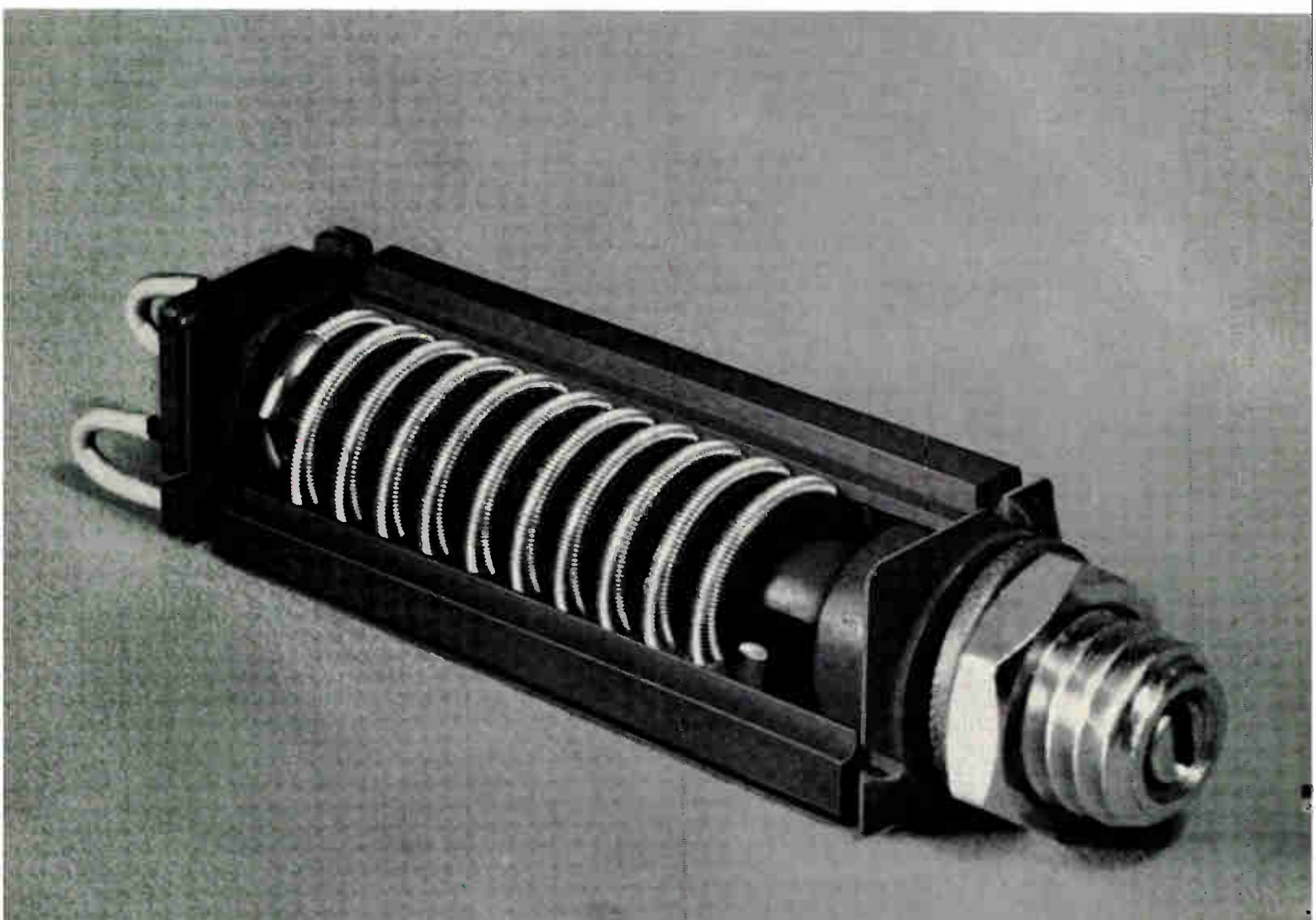

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Circle 34 on Inquiry Card

Abbreviations used in Table 1

Material

CdS—Cadmium Sulfide
CdSe—Cadmium Selenide
CdSSe—Cadmium Sulfoselenide
Ge—Germanium
InSb—Indium Antimonide
PbS—Lead Sulfide
PbSe—Lead Selenide

Dimensional Coding

P—Specified dimensions refer to the package and/or amount. For devices in transistor type cans, the package diameter includes the flange. Device depth excludes flexible leads.

Package Description

Primed quantities designate the device is hermetically sealed in the specified package.

A —Glass encapsulated.
AR —Glass encapsulated, plug-in type.
C —Metal case.
D —TO-5 case.
DD —Epoxy resin encapsulation.
EE —Lacquer coating.
FF —Ceramic case.
G —TO-18 case.
H —Plastic coating.
I —Plastic case.
P —TO-8 case.
T —Potted in high-temp. clear epoxy.
X —Varnish encapsulation or coating.
Y —TO-6 case.
Z —Plastic filled metal case.

Radiation Source Type

measured at an illumination level measured at an illumination level equiv-equivalent to 1 ft-c of sunlight.

F—Heated tungsten filament at 2870°K color temperature filtered through a Corning C. S. No. 1-62 filter (13.3% effective transmission of luminous flux).

NE—NE2H neon lamp.

T—Heated tungsten filament (incandescent lamp).

Notes for Table 1 (Characteristics of Photoconductors)

a. Two package types; RPY 11f-end illuminated, RPY 11s-side illuminated.

b. Sensitive area at a 45° angle with respect to the longitudinal axis of the device. Light resistance measured subsequent to preconditioning in complete darkness for 16 hr.

c. Side illuminated. Light resistance measured subsequent to preconditioning in complete darkness for 16 hr.

d. Light resistance (measured from room light history) equals the nominal value cited, ±33.3%.

e. Light resistance and response times measured with the cell about 0.08 in. from, and perpendicular to, the NE2H neon lamp.

f. Three-terminal dual-element photoconductor, containing two separate light-sensitive elements. Total power dissipation of dual element specified.

g. Rated power dissipation with heatsink held at 30°C.

h. Light resistance measured subsequent to preconditioning at 50 to 100 ft-c for 30 min. Dark for 1 min. prior to rise time test. Illuminated for 30 sec. prior to decay time test.

i. Rise times measured after 5 min. storage in dark prior to excitation.

j. Side illuminated. Depth includes pins. Light resistance measured subsequent to preconditioning in complete darkness for 16 hr.

m. Side illuminated. Depth includes pins.

n. Glass window. Light resistance (measured subsequent to preconditioning at 30 to 50 ft-c of room light for at least 60 min.) equals the nominal value cited, ±40%. Response time measurements taken with light cycled 5 sec. ON, 5 sec. OFF.

o. Light resistance equals the nominal value cited, ±40%.

p. Glass window. Light resistance (measured after aging at 1 ft-c) equals the nominal value cited, ±40%. Response time measurements taken with light cycled 5 sec. ON, 5 sec. OFF.

q. Light resistance equals the nominal value cited, ±40%. Response time measurements taken with light cycled 5 sec. ON, 5 sec. OFF.

r. Glass window. Light resistance or sensitivity equals the nominal value cited, ±33.3%.

s. Glass window. Light sensitivity and/or resistance measured from 50 to 100 ft-c (white fluorescent lamp) light history (16 to 24-hr. exposure). Rise times measured after 5 min. storage in dark prior to excitation.

t. Glass window. Light sensitivity and/or resistance measured from 500 ft-c (white fluorescent lamp) light history 16 to 24-hr. exposure). Rise times measured after 5 min. storage in dark prior to excitation.

u. Light resistance (measured subsequent to maintaining the cell in a light adapted state) equals the nominal value cited, ±33.3%.

v. Glass window. Light resistance (measured subsequent to maintaining the cell in a light adapted state) equals the nominal value cited, ±33.3%.

w. Specified at 60°C ambient test temperature.

x. Light resistance measured subsequent to preconditioning at about 50 ft-c illumination (ambient room light) for at least 60 min.

y. Glass window. Light resistance (measured from room light history) equals the nominal value cited, ±33.3%.

z. Light resistance (measured subsequent to preconditioning at 30 ft-c for 16 hr.) equals the nominal value cited, ±33.3%.

aa. From 2 ft-c to an unspecified dark illumination level after 5 sec.

bb. Light resistance measured subsequent to preconditioning in complete darkness for 16 hr.

cc. Sensitive area at a 45° angle with respect to the longitudinal axis of the device.

dd. Side illuminated.

ee. Glass window.

ff. Light resistance measured subsequent to preconditioning at 30 to 50 ft-c for at least 60 min. Response time measurements taken with light cycled 5 sec. ON, 5 sec. OFF.

gg. Depth includes pins.

hh. Glass window. Light resistance measured subsequent to preconditioning in complete darkness for 16 hr.

ii. Measured at an irradiation level of 64μw/cm^2, which originates from the 2527 A mercury resonance line of a low pressure arc and after 60 min. minmum exposure to about 50 ft-c of fluorescent illumination (ambient room light).

jj. Ultraviolet sensitive photoconductor.

kk. Specified at 40°C ambient test temperature.

ll. Light sensitivity and/or resistance measured from 500 ft-c (white fluorescent lamp) light history (16 to 24-hr. exposure). Rise times measured after 5 min. storage in dark prior to excitation.

mm. Light sensitivity and/or resistance measured from 50 to 100 ft-c (white fluorescent lamp) light history (16 to 24-hr exposure). Rise times measured after 5 min. storage in dark prior to excitation.

nn. Glass window. Device not for new equipment design; for renewal use only. Light sensitivity and/or resistance measured from 500 ft-c (white fluorescent lamp) light history (16 to 24-hr. exposure). Rise times measured after 5 min. storage in dark prior to excitation.

oo. Light resistance measured subsequent to preconditioning at 50 ±5 ft-c for at least 3 hr. Dark for 1 min. prior to rise time test. Illuminated for 30 sec. prior to decay time test.

pp. Glass window. Light resistance measured subsequent to preconditioning at 50 ±5 ft-c for at least 3 hr.

qq. Device can also be supplied in spectral type 55 (PW-5530GG) or spectral type 6 (PW630GG) upon request.

TABLE 1: CHARACTERISTICS OF PHOTOCONDUCTORS

Manufacturer	Type Number	Material	Spectral Response		Physical Dimensions						Package Description	Dark Characteristics						Ambient Test Temperature
			Spectral Limits (10% Points)	Sensitivity Peak	Diameter	Depth	Length	Width	Dimensional Coding	Sensitive Area		Previous Light Intensity	Minimum Dark Time	Applied Voltage	Maximum Dark Current	Dark Resistance	Dark Illumination Level	
			micron	micron	in.	in.	in.	in.		sq. in.		ft-c	sec	v	μa	meg	ft-c	°C
Amark Corp.	PW514	CdS		0.51	0.552	0.236			P	0.122								
	PW514N	CdS		0.51	0.552	0.236			P	0.122								
	PW530GG	CdS		0.51			1.65	0.59	P	0.387						1		
	PW606G	CdSSe			0.413	0.236			P	0.00465						200		
	PW606M	CdSSe			0.315	0.315			P	0.00465						200		
	PW614	CdSSe			0.552	0.236			P	0.122						10		
	PW614N	CdSSe			0.552	0.236			P	0.122						10		
American Elite, Corp.	RPY10	CdS	0.44-0.86	0.67	0.197	0.276			P	0.00124	A			100	5	20		25
	RPY11	CdS	0.44-0.86	0.67	0.75	1.575			P	0.155	A			100	20	5		25
	RPY12	CdS	0.44-0.86	0.67	0.75	2.12			P	0.465	A			100	20	5		25
Amperex Electronic Corp.	ORP11	CdS			0.67	2.28			P		AR					20		25
	ORP30	CdS			1.54	2.95			P		AR					60		25
	ORP50	CdS	0.46-0.85	0.67	0.63	1.74			P		A		1800	30-300		8		25
	ORP60	CdS	0.47-0.87	0.67	0.24	0.71			P	0.0004	A		20	300	1.5	200		25
	ORP61	CdS	0.47-0.87	0.67	0.24	0.71			P	0.0004	A		20	300	1.5	200		25
	ORP62	CdS	0.46-0.86	0.67	0.236	0.91			P	0.0023	A		20	300	2	150		25
	ORP63	CdS	0.43-0.83	0.55	0.24	1.18			P		A		20	75	10	7.5		25
	ORP90	CdS			0.24	1.18			P		A					120		25
	RPY14	CdS		0.55		0.827	0.394	0.138	P	0.099	A		20	75	25	3		25
	RPY17	CdS	0.43-0.83	0.55		0.827	0.394	0.165	P	0.078	A		20	400	16	25		25
	RPY18	CdS		0.55		1.0	0.642	0.185	P		A		20			3		25
	RPY19	CdS		0.55		1.0	0.642	0.185	P		A		20			10		25
	RPY20	CdS		0.55		1.63	0.65	0.185	P		A		20			6.5		25
	RPY27	CdS		0.55	1.24	0.285			P		C		20			6		25
Angstrom Electronics Corp.	1A	CdSe		0.73	0.375	0.24			P		FF							
	1B	CdSe		0.73	0.5	0.28			P		FF							
	1C	CdSe		0.73	1.0	0.35			P		FF							
	1T	CdSe		0.73							D							
	10A	CdSe		0.73	0.375	0.24			P		FF							
	10B	CdSe		0.73	0.5	0.28			P		FF							
	10T	CdSe		0.73							D							
	11A	CdSe		0.73	0.375	0.24			P		FF							
	11B	CdSe		0.73	0.5	0.28			P		FF							
	11T	CdSe		0.73							D							
	100A	CdS		0.58	0.375	0.24			P		FF							
	100B	CdS		0.58	0.5	0.28			P		FF							
	100C	CdS		0.58	1.0	0.35			P		FF							
	100T	CdS		0.58							D							
	101A	CdS		0.58	0.375	0.24			P		FF							
	101B	CdS		0.58	0.5	0.28			P		FF							
	101T	CdS		0.58							D							
	110A	CdS		0.58	0.375	0.24			P		FF							
	110B	CdS		0.58	0.5	0.28			P		FF							
	110T	CdS		0.58							D							
Clairex Corp.	CL503	CdSe	0.65-0.86	0.735	0.49	0.5			P	0.0816	A					83.3	0.01	25
	CL504	CdSe	0.61-0.87	0.69	0.49	0.5			P	0.0816	A					0.16	0.01	25
	CL504L	CdSe	0.61-0.87	0.69	0.49	0.5			P	0.0705	A					0.0267	0.01	25
	CL505	CdS		0.55	0.49	0.5			P	0.0816	A					0.833	0.01	25
	CL505L	CdS		0.55	0.49	0.5			P	0.0705	A					0.136	0.01	25
	CL507	CdS		0.615	0.49	0.5			P	0.0816	A					0.944	0.01	25
	CL5M2	CdS		0.515	0.555	0.183			P	0.0815	C							25
	CL5M2L	CdS		0.515	0.555	0.183			P	0.0705	C							25
	CL5M3	CdSe	0.65-0.86	0.735	0.555	0.183			P	0.0815	C							25
	CL5M4	CdSe	0.61-0.87	0.69	0.555	0.183			P	0.0815	C							25
	CL5M4L	CdSe	0.61-0.87	0.69	0.555	0.183			P	0.0705	C							25
	CL5M5	CdS		0.55	0.555	0.183			P	0.0815	C							25
	CL5M5L	CdS		0.55	0.555	0.183			P	0.0705	C							25
	CL5M7	CdS		0.615	0.555	0.183			P	0.0815	C							25
	CL602	CdS		0.515	0.245	0.5			P	0.0068	A					170	0.01	25
	CL603	CdSe	0.65-0.86	0.735	0.245	0.5			P	0.0068	A					1500	0.01	25
	CL603A	CdSe		0.735	0.245	0.5			P	0.0068	A					750	0.01	25
	CL603AL	CdSe		0.735	0.245	0.5			P	0.014	A					39.5	0.01	25
	CL604	CdSe	0.61-0.87	0.69	0.245	0.5			P	0.0068	A					3.2	0.01	25
	CL604L	CdSe	0.61-0.87	0.69	0.245	0.5			P	0.014	A					0.16	0.01	25
	CL605	CdS		0.55	0.245	0.5			P	0.0068	A					15	0.01	25
	CL605L	CdS		0.55	0.245	0.5			P	0.014	A					0.715	0.01	25
	CL607	CdS		0.615	0.245	0.5			P	0.0068	A					17	0.01	25
	CL702	CdS		0.515	0.36	0.18			P	0.012	D					170	0.01	25
	CL702L	CdS		0.515	0.36	0.18			P	0.028	D					3.4	0.01	25
	CL703	CdSe	0.65-0.86	0.735	0.36	0.18			P	0.012	D					1500	0.01	25
	CL703A	CdSe		0.735	0.36	0.18			P	0.012	D							25
	CL703C	CdSe		0.735	0.36	0.18			P	0.012	D							25
	CL703CL	CdSe		0.735	0.36	0.18			P	0.028	D							25
	CL703L	CdSe	0.65-0.86	0.735	0.36	0.18			P	0.028	D					30	0.01	25
	CL703 2	CdSe	0.65-0.86	0.735	0.36	0.18			P		D							25
	CL703L 2	CdSe	0.65-0.86	0.735	0.36	0.18			P		D							25
	CL704	CdSe	0.61-0.87	0.69	0.36	0.18			P	0.012	D					3.2	0.01	25
	CL704L	CdSe	0.61-0.87	0.69	0.36	0.18			P	0.028	D					0.064	0.01	25
	CL704 2	CdSe	0.61-0.87	0.69	0.36	0.18			P		D							25

Light Characteristics		Dark – Light Resistance Ratio	Radiation Source		Sensitivity			Maximum Ratings			Temperature Characteristics			Response Times		Response Time Test Parameters			Notes
Incident Illumination	Light Resistance		Type	Color Temperature	Applied Voltage		Illumination Sensitivity	Power Dissipation at 25 °C.	Ambient Operating Temperature	Voltage Rating	Incident Illumination	Relative Room Temp. Resistance	Temperature	Rise Time (0-63.2%)	Decay Time (100-36.8%)	Supply Voltage	Series Resistance	Incident Illumination	
ft-c	K			°K	v ac rms	v dc	ma/ft-c	mw	°C	v	ft-c	%	°C	m sec	m sec	v	K	ft-c	
37.2	1		T	2850				200		150				<1					
37.2	1		T	2850				200		300				<1					99
4.65	6		T	2850				200		300				<1					
18.6	55		T	2850				70		300				<1					
18.6	55		T	2850				70		300				<1					
27.9	0.5		T	2850				200		150				<1					
27.9	0.5		T	2850				200		300				<1					
4.65	40-200		T	2850				100	60	350									
4.65	0.835-5		T	2850				250	60	250									a
4.65	0.33-1.67		T	2850				1000	60	350									
							1.2	200		100									gg
							6	1200		350									gg
5	>1.3, <6.2		T	2700		20	0.645, 3.05	400	70	300				~80	~18			10	b
4.6	>37.5, <150		T	2700		30	0.106	70	70	350									bb
4.6	37.5, <150		T	2700		30	0.106	70	70	350									c
5	>29, <86		T	2700		30	0.14	100	70	350				~70	~13			9.39	c
5	0.75, <2.5		T	2700		10	1.6	150	70	75				~40	~13	5		9.39	c
							6	1000		350									dd
5	0.33, <1.67		T	2700		5	1.6	225	70	75									c
5	>2, <6		T	2700		10	0.6	225	70	400									c
5	0.35, <1.2		T	2700		10	3	500	70	100		91	70						c
5	>1.4, <6.6		T	2700		10	0.7	500	70	400									c
5	>0.7, <3.3		T	2700		10	1.5	1000	70	400		91	70						c
5	1.2		T	2700		10	2	1000	70	400		91	70						hh
2	3							150	80	150				8				10	ee
2	5							400	80	350				8				10	ee
2	2							1000	80	400				8				10	ee
2	3							150		150				8				10	ee
2	70							150	80	300				8				10	ee
2	1							400	80	200				8				10	ee
2	70							150		300				8				10	ee
2	140							150	80	400				8				10	ee
2	0.5							400	80	100				8				10	ee
2	140							150		400				8				10	ee
2	5							150	80	150				40				10	ee
2	5							1000	80	350				40				10	ee
2	2.5							2000	80	400				40				10	ee
2	3							150		150				40				10	ee
2	70							150	80	300				40				10	ee
2	2							1000	80	200				40				10	ee
2	70							150		300				40				10	ee
2	140							150	80	400				40				10	ee
2	0.75							1000	80	100				40				10	ee
2	140							150		400				40				10	ee
2	7.2	11,550	T	2854				250	75	250	0.01	193	75	4	3			10	d
2	1.5	107	T	2854				250	75	250	0.01	2000	75	10	10			10	d
2	0.25	107	T	2854				250	75	60	0.01	2000	75	10	10			10	d
2	9	92.5	T	2854				250	75	250	0.01	87.7	75	20	20			10	d
2	1.5	90.5	T	2854				250	75	60	0.01	87.7	75	20	20			10	d
2	7.2	131	T	2854				250	75	250	0.01	193	75	10	10			10	d
2	55	>100aa	T	2854				500	75	300	0.01	110	75	40	20			10	y
2	9	>100aa	T	2854				500	75	60	0.01	110	75	40	20			10	y
2	7.2	>10,000aa	T	2854				500	75	300	0.01	193	75	4	3			10	y
2	1.5	1,000aa	T	2854				500	75	300	0.01	2000	75	10	10			10	y
2	0.25	1,000aa	T	2854				500	75	60	0.01	2000	75	10	10			10	y
2	9	100aa	T	2854				500	75	300	0.01	87.7	75	20	20			10	y
2	1.5	>100aa	T	2854				500	75	60	0.01	87.7	75	20	20			10	y
2	7.2	1,000aa	T	2854				500	75	300	0.01	193	75	10	10			10	y
2	1000	170	T	2854				75	75	300	0.01	110	75	40	20			10	d
2	133	11,300	T	2854				75	75	300	0.01	193	75	4	3			10	d
2	75	10,000	T	2854				75	75	300									d
2	3.5	11,300	T	2854				75	75	60									d
2	30	107	T	2854				75	75	300	0.01	2000	75	10	10			10	d
2	1.5	107	T	2854				75	75	60	0.01	2000	75	10	10			10	d
2	166	90.5	T	2854				75	75	300	0.01	87.7	75	20	20			10	d
2	7.5	95.3	T	2854				75	75	60	0.01	87.7	75	20	20			10	d
2	133	128	T	2854				75	75	300	0.01	193	75	10	10			10	d
2	1000	170	T	2854				125	75	300	0.01	110	75	40	20			10	d
2	20	170	T	2854				125	75	60	0.01	110	75	40	20			10	d
2	133	11,300	T	2854				125	75	300	0.01	193	75	4	3			10	d
2	67		T	2854				125	75	300									d
	50		NE					125	75	250				<0.4	<3		1000		e
	2.3		NE					125	75	60				<0.4	<3		1000		e
2	2.7	11,100	T	2854				125	75	60	0.01	193	75	4	3			10	d
2	50		T	2854				125	75	300	0.01	193	75	4	3			10	f
2	6.5		T	2854				125	75	60	0.01	193	75	4	3			10	f
2	30	107	T	2854				125	75	300	0.01	2000	75	10	10			10	d
2	0.6	107	T	2854				125	75	60	0.01	2000	75	10	10			10	d
2	17		T	2854				125	75	300	0.01	2000	75	10	10			10	f

TABLE 1: CHARACTERISTICS OF PHOTOCONDUCTORS (Continued)

Manufacturer	Type Number	Material	Spectral Response		Physical Dimensions						Package Description	Dark Characteristics						Ambient Test Temperature
			Spectral Limits (10% Points)	Sensitivity Peak	Diameter	Depth	Length	Width	Dimensional Coding	Sensitive Area		Previous Light Intensity	Minimum Dark Time	Applied Voltage	Maximum Dark Current	Dark Resistance	Dark Illumination Level	
			micron	micron	in.	in.	in.	in.		sq. in.		ft-c	sec	v	μa	meg	ft-c	°C
Clairex Corp. (Continued)	CL704L 2	CdSe	0.61-0.87	0.69	0.36	0.18			P		D							25
	CL705	CdS		0.55	0.36	0.18			P	0.012	D					15	0.01	25
	CL705HL	CdS		0.55	0.36	0.18			P	0.028	D					6.4	0.01	25
	CL705L	CdS		0.55	0.36	0.18			P	0.028	D					0.3	0.01	25
	CL705 2	CdS		0.55	0.36	0.18			P		D							25
	CL705L 2	CdS		0.55	0.36	0.18			P		D							25
	CL707	CdS		0.615	0.36	0.18			P	0.012	D					17	0.01	25
	CL707L	CdS		0.615	0.36	0.18			P	0.028	D					0.34	0.01	25
	CL902	CdS		0.515	0.21	0.15			P	0.0039	G					170	0.01	25
	CL902L	CdS		0.515	0.21	0.15			P		G							25
	CL902N	CdS		0.515	0.21	0.15			P	0.013	G					85	0.01	25
	CL903	CdSe	0.65-0.86	0.735	0.21	0.15			P	0.0039	G					1500	0.01	25
	CL903A	CdSe		0.735	0.21	0.15			P	0.0039	G					750	0.01	25
	CL903C	CdSe		0.735	0.21	0.15			P	0.0039	G							25
	CL903L	CdSe	0.65-0.86	0.735	0.21	0.15			P		G							25
	CL903N	CdSe	0.65-0.86	0.735	0.21	0.15			P	0.013	G					750	0.01	25
	CL904	CdSe	0.61-0.87	0.69	0.21	0.15			P	0.0039	G					3.2	0.01	25
	CL904L	CdSe	0.61-0.87	0.69	0.21	0.15			P		G							25
	CL904N	CdSe	0.61-0.87	0.69	0.21	0.15			P	0.013	G					1.6	0.01	25
	CL905	CdS		0.55	0.21	0.15			P	0.0039	G					15	0.01	25
	CL905HL	CdS		0.55	0.21	0.15			P		G					25	0.01	25
	CL905HLL	CdS		0.55	0.21	0.15			P		G					2.6	0.01	25
	CL905L	CdS		0.55	0.21	0.15			P		G							25
	CL905N	CdS		0.55	0.21	0.15			P	0.013	G					7.5	0.01	25
	CL907	CdS		0.615	0.21	0.15			P	0.0039	G					17	0.01	25
	CL907N	CdS		0.615	0.21	0.15			P	0.013	G					8.5	0.01	25
Delco Radio	LDR-25	CdS		0.6		0.165	1.0	0.845	P	0.139	C		10			0.5		25
Ferroxcube Corp. of America	940 004 00	CdS			0.546	0.323			P		DD					10		
	940 005 00	CdS			0.546	0.323			P		DD					10		
	940 006 00	CdS			0.546	0.323			P		DD					10		
	940 007 00	CdS			0.546	0.323			P		DD					10		
	940 008 00	CdS			0.546	0.323			P		DD					10		
	940 009 00	CdS			0.546	0.323			P		DD					10		
	940 501 00	CdS				0.142	0.48	0.425	P		DD					10		
	940 502 00	CdS				0.142	0.48	0.425	P		DD					10		
	940 503 00	CdS				0.142	0.48	0.425	P		DD					10		
	940 701 00	CdS			0.342	0.071			P		EE					10		
	940 702 00	CdS			0.342	0.071			P		EE					10		
	940 703 00	CdS			0.342	0.071			P		EE					10		
General Electric	A33	CdS		0.55	0.375	0.225			P		C	2	30	30	100	0.3		25
	A33P1	CdS		0.55	0.315	0.085			P		I	2	30	30	100	0.3		25
	A35	CdS		0.55	0.375	0.225			P		C	2	30	50	100	0.5		25
	A36M1	CdS		0.55	0.375	0.225			P		C	2	30	60	60	1		25
	B425P1	CdS		0.61	0.47	0.1			P		I	2	30	250	80	3.13		25
	B430	CdS		0.61	0.65	0.35			P		C	2	30	300	100	3		25
	B46	CdS	0.46-0.76	0.61	0.65	0.35			P		C	2	20	12	80	0.15		25
	B425	CdS	0.46-0.76	0.61	0.65	0.35			P		C	2	30	250	80	3.13		25
	B1035	CdS		0.61	1.24	0.305			P		C	1	30	50	40	1.25		25
	B1035M1	CdS	0.46-0.76	0.61	1.24	0.305			P		C	1	30	50	40	1.25		25
	B1035M2	CdS	0.46-0.76	0.61	1.24	0.305			P		C	1	30	50	40	1.25		25
	B1035M3	CdS	0.46-0.76	0.61	1.24	0.305			P		C	1	30	50	40	1.25		25
	C425P1	CdSe		0.73	0.47	0.1			P		I	2	30	250	50	5		25
	Y-1136	CdS		0.61	0.44	0.07			P		I	50	30	110	40	2.75		25
	Y-1206	CdSe		0.73	0.65	0.35			P		C	50	30	250	100	2.5		25
	Y-1332	CdSe		0.73	0.375	0.225			P		C	20	30	30	15	2		25
International Electronics Corp. (Mullard)	ORP11	CdS	0.46-0.86	0.67	0.67	1.85			P	0.194				300	37.5	8		25
	ORP12	CdS	0.46-0.86	0.67	0.55	0.315			P	0.093				110	11	10		25
	ORP16	CdS			0.335	0.059			P	0.0775	X			110	11	10		25
	ORP50	CdS	0.46-0.86	0.67	0.63	1.73			P					300	37.5	8		25
	ORP52	CdS	0.46-0.86	0.67	0.623	1.73			P	0.17			10			1		25
	ORP60	CdS	0.46-0.86	0.67	0.236	0.65			P	0.0388				300	1.5	200		25
	ORP61	CdS	0.46-0.86	0.67	0.236	0.65			P	0.0388				300	1.5	200		25
	ORP90	CdS								0.279								25
	ORP93	CdS	0.46-0.86	0.67	0.75	2.15			P	0.387	AR			400	80	5		25
	ORP94	CdS	0.46-0.86	0.67	0.75	2.15			P	0.387	AR			70	140	0.5		25
	RPY14	CdS	0.43-0.83	0.55		0.827	0.394	0.165	P	0.0775	A			10	3.33	3		25
	RPY15	CdS	0.36-0.82	0.62	0.638	0.256			P	0.194	I			300	37.5	8		25
	RPY28	CdS				0.197	0.572	0.452	P	0.124				35	70	0.5		25
National Semi-conductors Ltd.	NSL-45	CdS	0.37-0.68	0.57	1.26	0.3			P	0.3	C		60			40		25
	NSL-46	CdS	0.37-0.68	0.57	1.26	0.3			P	0.3	C		60			5		25
	NSL-47	CdS	0.37-0.68	0.57	1.26	0.3			P	0.3	C		60			1		25
	NSL-52	CdS														4		25
	NSL-53	CdS														0.5		25
	NSL-54	CdS														0.1		25
	NSL-55	CdS														40		25
	NSL-56	CdS														5		25
	NSL-57	CdS														1		25
	NSL-62	CdS														10		25
	NSL-63	CdS														1.25		25
	NSL-64	CdS														0.25		25

Light Characteristics		Dark – Light Resistance Ratio	Radiation Source		Sensitivity			Maximum Ratings			Temperature Characteristics			Response Times		Response Time Test Parameters			Notes
Incident Illumination	Light Resistance		Type	Color Temperature	Applied Voltage		Illumination Sensitivity	Power Dissipation at 25 °C.	Ambient Operating Temperature	Voltage Rating	Incident Illumination	Relative Room Temp. Resistance	Temperature	Rise Time (0-63.2%)	Decay Time (100-36.8%)	Supply Voltage	Series Resistance	Incident Illumination	
ft-c	K			°K	v ac rms	v dc	ma/ft-c	mw	°C	v	ft-c	%	°C	m sec	m sec	v	K	ft-c	
2	1.5		T	2854				125	75	60	0.01	2000	75	10	10			10	f
2	166	90.5	T	2854				125	75	300	0.01	87.7	75	20	20			10	d
2	28	228	T	2854				125	75	60	0.01	196	75	4	2			10	z
2	3.3	91	T	2854				125	75	60	0.01	87.7	75	20	20			10	d
2	166		T	2854				125	75	300	0.01	87.7	75	20	20			10	f
2	7.5		T	2854				125	75	60	0.01	87.7	75	20	20			10	f
2	133	128	T	2854				125	75	300	0.01	193	75	10	10			10	d
2	2.7	126	T	2854				125	75	60	0.01	193	75	10	10			10	d
2	1000	170	T	2854				50	75	250	0.01	110	75	40	20			10	d
2	68		T	2854				50	75	60									z
2	500	170	T	2854				50	75	75	0.01	110	75	40	20			10	d
2	133	11,300	T	2854				50	75	250	0.01	193	75	4	3			10	d
2	67	11,200	T	2854				50	75	250									d
	50		NE					50	75	250				<0.4	<3		1000		e
2	5.9		T	2854				50	75	60									z
2	66	11,350	T	2854				50	75	75	0.01	193	75	4	3			10	d
2	30	107	T	2854				50	75	250	0.01	2000	75	10	10			10	d
2	2		T	2854				50	75	60									z
2	15	107	T	2854				50	75	75	0.01	2000	75	10	10			10	d
2	166	90.5	T	2854				50	75	250	0.01	87.7	75	20	20			10	d
2	100	250	T	2854				50	75	60	0.01	196	75	4	2			10	z
2	11	236	T	2854				50	75	60	0.01	196	75	4	2			10	z
2	10		T	2854				50	75	60									z
2	83	90.5	T	2854				50	75	75	0.01	87.7	75	20	20			10	d
2	133	128	T	2854				50	75	250	0.01	193	75	10	10			10	d
2	66	129	T	2854				50	75	75	0.01	193	75	10	10			10	d
10	0.4		T	2800		25	9.65	25,000@	60	200				~40	~9			10	ee
	0.135-0.25							200	60	150									
	0.19-0.32							200	60	150									
	0.26-0.44							200	60	150									
	0.36-0.55							200	60	150									
	0.45-0.82							200	60	150									
	0.7-1.04							200	60	150									
	0.095-0.315							200	60	150									
	0.285-0.525							200	60	150									
	0.475-1.05							200	60	150									
	0.095-0.315							200	60	150									
	0.285-0.525							200	60	150									
	0.475-1.05							200	60	150									
2	2.5, 10		T	2854		10	0.5, 2	75	65	30				160	50			5	h
2	6.3		T	2854				50	65	30									
2	4.8, 19		T	2854		10	0.263, 1.04	75	65	50				140	40			5	h
2	30		T	2854				75	65	60									ee
2	9.1		T	2854				200	65	250									
2	15		T	2854				250	65	300									ee
2	0.5, 2		T	2854		10	2.5, 10	250	80	60				160	90			5	h
2	3.6, 14.3		T	2854		10	0.35, 1.39	250	65	250				110	20			5	h
2	6.5		T	2854				300	65	350									ee
1	15.6, 50		T	2854		50	1, 3.2	600	65	350				50	20			5	h
1	7.14, 16.7		T	2854		50	3, 7	600	65	350				50	20			5	h
1	3.12, 7.35		T	2854		50	6.8, 16	600	65	350				50	20			5	h
2	5, 25		T	2854		10	0.2, 1	50	65	250				7.7	8.8			5	oo
2	9		T	2854				200	65	110				~350	~26			5	i
10	0.5		T	2854				250	65	250									pp
2	1		T	2854				75	65	30									pp
4.65	0.75, 3		T	2700		10	3.33, 13.3	400	70	300									bb
93	0.075-0.3		T	2700		10	33.3, 133	200	60	110									
93	0.075, 0.3		T	2700				200	70	110									
4.65	1.3, 6.2		T	2700		20	3.23, 15.4	400	70	300				~80	~17			9.3	b
2.79	0.8, 4		T	2000				400	70	200									cc
4.65	40, 160		T	2700		30	0.187, 0.75	70	70	350									bb
4.65	40, 160		T	2700		30	0.187, 0.75	70	70	350									c
5	1		T	2700		10	2	1000	70	350									dd
4.65	0.75, 3		T	2700		10	3.33, 13.3	1000	70	400									m
4.65	0.09, 0.36		T	2700		10	27.8, 111	1000	70	70									i
4.65	0.4, 1.3		T	2700		1	0.167, 0.543	20	60	10									c
4.65	0.75, 3		T	2700		10	0.725, 2.9	400	70	300									bb
0.93	1, 4		T	2700		10	2.5, 10	200	50	35									bb
1	26		T	2870				1000	75	420	0.01	238	60	20	6			10	n
1	11.4		T	2870				1000	75	420	0.01	200	60	20	6			10	n
1	5.5		T	2870				1000	75	420	0.01	200	60	20	6			10	n
1	4		T	2870				500	75	70									o
1	1.7		T	2870				500	75	70									o
1	0.75		T	2870				500	75	70									o
1	40		T	2870				500	75	420									o
1	17		T	2870				500	75	420									o
1	7.5		T	2870				500	75	420									o
1	28		T	2870				100	75	70									o
1	12		T	2870				100	75	70									o
1	5.2		T	2870				100	75	70									o

TABLE 1: CHARACTERISTICS OF PHOTOCONDUCTORS (Continued)

Manufacturer	Type Number	Material	Spectral Response		Physical Dimensions						Package Description	Dark Characteristics						Ambient Test Temperature
			Spectral Limits (10% Points)	Sensitivity Peak	Diameter	Depth	Length	Width	Dimensional Coding	Sensitive Area		Previous Light Intensity	Minimum Dark Time	Applied Voltage	Maximum Dark Current	Dark Resistance	Dark Illumination Level	
			micron	micron	in.	in.	in.	in.		sq. in.		ft-c	sec	v	μa	meg	ft-c	°C
National Semiconductors Ltd. (Continued)	NSL-65	CdS														>160		25
	NSL-66	CdS														>20		25
	NSL-67	CdS														>4		25
	NSL-364	CdSe	0.64-0.78	0.71	0.296	0.185			P	0.013	C′	30-50	15			200		25
	NSL-367	CdSe	0.64-0.78	0.71	0.296	0.185			P	0.004	C′	30-50	15			3000		25
	NSL-531	CdS	0.36-0.72	0.52	<0.52	<0.33			P	0.07	T		60			>0.5		25
	NSL-561	CdS	0.36-0.72	0.52	<0.52	<0.33			P	0.07	T		60			>5		25
	NSL-3531	CdSe	0.64-0.77	0.71	<0.52	<0.33			P	0.07	T	30-50	15			>2		25
	NSL-3561	CdSe	0.64-0.77	0.71	<0.52	<0.33			P	0.07	T	30-50	15			>20		25
Opto-Electronic Devices, Inc.	3H5	CdSe		0.72												>100		25
	3H18	CdSe		0.72												>100		25
	3L5	CdSe		0.72												>100		25
	3L18	CdSe		0.72												>100		25
	4H5	CdSSe	0.48-0.8	0.68	0.365	0.175			P		D	100	20			>100		25
	4H6	CdSSe	0.48-0.8	0.68	1.24	0.265			P		Y	100	20			>100		25
	4H18	CdSSe	0.48-0.8	0.68	0.21	0.147			P		G	100	20			>100		25
	4L5	CdSSe	0.48-0.8	0.68	0.365	0.175			P		D	100	20			>100		25
	4L18	CdSSe	0.48-0.8	0.68	0.21	0.147			P		G	100	20			>100		25
	5H6	CdS	0.46-0.73	0.58	1.24	0.265			P		Y	100	20			>0.5		25
	5H6A	CdS	0.46-0.73	0.58	1.24	0.265			P		Y	100	20			>2		25
	5HC1	CdS		0.58												>2		25
	5HC2	CdS		0.58												<0.5		25
	42H1	CdSSe		0.62												>100		25
	42L500	CdSSe		0.62												>2.5		25
Pioneer Electric & Research Corp.	CDS-701	CdS			0.5	0.28			P	0.107	C′	50	5	100	25	>4		25
	CDS-702	CdS			0.5	0.28			P	0.107	C′	50	5	100	25	>4		25
	CDS-703	CdS			0.5	0.28			P	0.107	C′	50	5	100	40	>2.5		25
	CDS-704	CdS			0.5	0.28			P	0.107	C′	50	5	100	70	>1.43		25
	CDS-710	CdS			0.5	0.28			P	0.107	C′	50	5	100	25	>4		25
	CDS-711	CdS			0.5	0.28			P	0.107	C′	50	5	100	25	>4		25
	CDS-712	CdS			0.5	0.28			P	0.107	C′	50	5	100	40	>2.5		25
	CDS-901	CdS			1.25	0.25			P	0.442	C′	50	5	100	25	>4		25
	CDS-902	CdS			1.25	0.25			P	0.442	C′	50	5	100	25	>4		25
	CDS-903	CdS			1.25	0.25			P	0.442	C′	50	5	100	40	>2.5		25
	CDS-904	CdS			1.25	0.25			P	0.442	C′	50	5	100	70	>1.43		25
	CDS-910	CdS			1.25	0.25			P	0.442	C′	50	5	100	25	>4		25
	CDS-911	CdS			1.25	0.25			P	0.442	C′	50	5	100	25	>4		25
	CDS-912	CdS			1.25	0.25			P	0.442	C′	50	5	100	40	>2.5		25
	CDS-913	CdS			1.25	0.25			P	0.442	C′	50	5	100	66.7	>1.5		25
Radio Corp. of America	4402	CdS	0.33-0.74	0.58	0.29	<0.58			P	0.049	A		10	12	12	>1		25
	4403	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	C		10	50(ac)	78(ac)			25
	4404	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	C		10	50(ac)	40(ac)			25
	4413	CdS	0.33-0.74	0.58	0.29	<0.58			P	0.049	A		10	12	12	>1		25
	4423	CdS	0.33-0.74	0.58	0.49	<0.55			P	0.196	A		10	50(ac)	40(ac)			25
	4425	CdS	0.33-0.74	0.58	0.49	<0.55			P	0.196	A		10	12	80	>0.15		25
	4448	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	C		10	50(ac)	40(ac)			25
	4450	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	C		10	50(ac)	40(ac)			25
	4451	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	C		10	50(ac)	40(ac)			25
	4453	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	C		10	50(ac)	40(ac)			25
	7163	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	C		10	50(ac)	40(ac)			25
	7412	CdS	0.33-0.74	0.58	0.29	<1.35			P	0.049	A		10	12	1	>12		25
	SQ2500	CdS	0.33-0.74	0.58	0.49	<0.55			P	0.196	A		10	12	6	>2		25
	SQ2502	CdS	0.33-0.74	0.58	<1.275	1.13			P	0.785	C		10	50(ac)	40(ac)			25
	SQ2503	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	C		10	50(ac)	40(ac)			25
	SQ2508	CdS	0.33-0.74	0.58	0.37	0.18			P	0.049	C		10	12	1	>12		25
	SQ2519	CdS	0.33-0.74	0.58	0.37	0.18			P	0.049	C		10	12	12	>1		25
	SQ2520	CdS	0.33-0.74	0.58	0.6	0.26			P	0.196	C		10	12	80	>0.15		25
	SQ2521	CdS	0.33-0.74	0.58	0.6	0.26			P	0.196	C		10	50(ac)	40(ac)			25
	SQ2523	CdS	0.33-0.74	0.58	0.49	<0.55			P	0.196	A		10	12	80	>0.15		25
	SQ2524	CdS	0.33-0.74	0.58	0.49	<0.55			P	0.196	A		10	12	80	>0.15		25
	SQ2525	CdS	0.33-0.74	0.58	0.6	0.26			P	0.196	C		10	12	6	>2		25
	SQ2526	CdS	0.33-0.74	0.58	0.6	0.26			P	0.196	C		10	12	80	>0.15		25
	SQ2527	CdS	0.33-0.74	0.58	0.6	0.26			P	0.196	C		10	12	80	>0.15		25
	SQ2528	CdS	0.33-0.74	0.58	0.29	<0.58			P	0.049	A		10	12	0.1	>120		25
	SQ2529	CdS	0.33-0.74	0.58	0.37	0.18			P	0.049	C		10	12	0.1	>120		25
	SQ2531	CdS	0.33-0.74	0.58	0.37	0.18			P	0.049	Z		10	12	0.1	>120		25
	SQ2531V1	CdS	0.33-0.74	0.58	0.37	0.18			P	0.049	Z		10	12	1	>12		25
	SQ2531V2	CdS	0.33-0.74	0.58	0.37	0.18			P	0.049	Z		10	12	1	>12		25
	SQ2531V3	CdS	0.33-0.74	0.58	0.37	0.18			P	0.049	Z		10	12	12	>1		25
	SQ2531V4	CdS	0.33-0.74	0.58	0.37	0.18			P	0.049	Z		10	12	12	>1		25
	SQ2531V5	CdS	0.33-0.74	0.58	0.37	0.18			P	0.049	Z		10	12	15	>0.8		25
	SQ2531V6	CdS	0.33-0.74	0.58	0.37	0.18			P	0.049	Z		10	12	15	>0.8		25
	SQ2532	CdS	0.33-0.74	0.58	0.6	0.21			P	0.196	Z		10	12	6	>2		25
	SQ2532V1	CdS	0.33-0.74	0.58	0.6	0.21			P	0.196	Z		10	50(ac)	40(ac)			25
	SQ2532V2	CdS	0.33-0.74	0.58	0.6	0.21			P	0.196	Z		10	12	80	>0.15		25
	SQ2532V3	CdS	0.33-0.74	0.58	0.6	0.21			P	0.196	Z		10	12	80	>0.15		25
	SQ2532V4	CdS	0.33-0.74	0.58	0.6	0.21			P	0.196	Z		10	12	80	>0.15		25
	SQ2533	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	Z		10	50(ac)	40(ac)			25
	SQ2533V1	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	Z		10	50(ac)	40(ac)			25

Light Characteristics		Dark – Light Resistance Ratio	Radiation Source		Sensitivity			Maximum Ratings			Temperature Characteristics			Response Times		Response Time Test Parameters			Notes
Incident Illumination	Light Resistance		Type	Color Temperature	Applied Voltage		Illumination Sensitivity	Power Dissipation at 25 °C.	Ambient Operating Temperature	Voltage Rating	Incident Illumination	Relative Room Temp. Resistance	Temperature	Rise Time (0-63.2%)	Decay Time (100-36.8%)	Supply Voltage	Series Resistance	Incident Illumination	
ft-c	K			°K	v ac rms	v dc	ma/ft-c	mw	°C	v	ft-c	%	°C	m sec	m sec	v	K	ft-c	
1	550		T	2870				100	75	250									o
1	230		T	2870				100	75	250									o
1	100		T	2870				100	75	250									o
1	5.2		T	2870				100	65	80	1	270	60	4.5	3			10	p
1	100		T	2870				100	65	250	1	270	60	4.5	3			10	p
1	1.7		T	2870				200	75	170				28	13			10	q
1	17		T	2870				200	75	420				28	13			10	q
1	>0.85, <2.5		T	2870				200	65	80				4.5	3			10	ff
1	>8.5, <25		T	2870				200	65	400				4.5	3			10	ff
10	15		T	2870				250	55	300	100	190	55						
10	70		T	2870				75	55	300	100	190	55						
10	7.5		T	2870				250	55	125	100	190	55						
10	25		T	2870				75	55	125	100	190	55						
10	10		T	2870				250	71	300	100	146	71	10	0.8				
10	3		T	2870				1000	71	300	100	146	71	10	0.8				ee
10	40		T	2870				75	71	300	100	146	71	10	0.8				
10	5		T	2870				250	71	125	100	146	71	10	0.8				
10	20		T	2870				75	71	125	100	146	71	10	0.8				
10	1.4		T	2870				1000	71	300	100	123	71	~160	~15				ee
10	5		T	2870				1000	71	300	100	123	71	~160	~20				ee
10	5		T	2870				600	71	300	100	123	71						
10	1.4		T	2870				600	71	300	100	123	71						
10	25		T	2870				75	71	300	100	123	71						
10	1.5		T	2870				350	71	125	100	123	71						
1			ESE		50		1.5	250		500									r
1			ESE		50		3	250		500									r
1			ESE		50		6	250		350									r
1			ESE		50		12	250		350									r
50	1.33		T	2800				250		500									r
50	0.67		T	2800				250		500									r
50	0.33		T	2800				250		350									r
1			ESE		50		1.5	500		1000									r
1			ESE		50		3	500		1000									r
1			ESE		50		6	500		700									r
1			ESE		50		12	500		500									r
50	1.33		T	2800				500		1000									r
50	0.67		T	2800				500		1000									r
50	0.33		T	2800				500		700									r
50	0.165		T	2800				500		500									r
10	<7.5		T	2870				50w	60	300				~70	~20			10	mm
1			F		50		>8, <16	750kk	75	250				~70	~20			10	t
1			F		50		>2.5, <5	750kk	75	600				~70	~20			10	t
10	>4.37, <8.57		T	2870		12	>0.14, <0.275	50w	60	110				~70	~20			10	ll
1			F		50		>1.5, <4	200w	60	250				~70	~20			10	ll
1	>0.828, <3.33		T	2870		12	>3.6, <14.5	200w	60	110				~70	~20			10	mm
1			F		50		>1.5, <4	750kk	75	600				~70	~20			10	t
3.5			F		50		>0.572, <1	750kk	75	600				~70	~20			10	t
35			F		50		>0.0572, <0.1	750kk	75	600				~70	~20			10	t
1			F		50		>3, <7	750kk	75	600				~70	~20			10	t
1			F		50		>1, <3	750kk	75	600				~70	~20			10	t
1	>43.7, <185		T	2870		12	>0.065, <0.275	50w	60	200				~70	~20			10	ll
1	>15, <50		T	2870		12	>0.24, <0.8	200w	60	250				~70	~20			10	mm
1			F		50		>2.5, <5	750kk	75	600				~70	~20			10	nn
1			F		50		>0.8, <1.7	750kk	75	600				~70	~20			10	t
1	>43.7, <185		T	2870		12	>0.065, <0.275	50w	60	200				~70	~20			10	t
10	<7.5		T	2870				50w	60	300				~70	~20			10	s
1	>0.828, <3.33		T	2870		12	>3.6, <14.5	200w	60	110				~70	~20			10	s
1			F		50		>1.5, <4	200w	60	250				~70	~20			10	t
1	>4, <12		T	2870		12	>1, <3	200w	60	110				~70	~20			10	mm
1	>2, <6		T	2870		12	>2, <6	200w	60	110				~70	~20			10	mm
1	>15, <50		T	2870		12	>0.24, <0.8	200w	60	250				~70	~20			10	s
1	>4, <12		T	2870		12	>1, <3	200w	60	110				~70	~20			10	s
1	>2, <6		T	2870		12	>2, <6	200w	60	110				~70	~20			10	s
1	>1000, <3000		T	2870		12	>0.004, <0.012	50w	60	300				~70	~20			10	ll
1	>1000, <3000		T	2870		12	>0.004, <0.012	50w	60	300				~70	~20			10	t
1	>1000, <3000		T	2870		12	>0.004, <0.012	50w	60	300				~70	~20			10	t
1	>100, <300		T	2870		12	>0.04, <0.12	50w	60	200				~70	~20			10	t
1	>43.7, <185		T	2870		12	>0.065, <0.275	50w	60	200				~70	~20			10	t
10	>4.37, <8.57		T	2870		12	>0.14, <0.275	50w	60	110				~70	~20			10	t
10	<7.5		T	2870				50w	60	300				~70	~20			10	s
1	>4, <12		T	2870		12	>1, <3	50w	60	110				~70	~20			10	t
1	>2.5, <7.5		T	2870		12	>1.6, <4.8	50w	60	110				~70	~20			10	t
1	>15, <50		T	2870		12	>0.24, <0.8	200w	60	250				~70	~20			10	s
1			F		50		>1.5, <4	200w	60	250				~70	~20			10	t
1	>4, <12		T	2870		12	>1, <3	200w	60	110				~70	~20			10	s
1	>2, <6		T	2870		12	>2, <6	200w	60	110				~70	~20			10	s
1	>0.828, <3.33		T	2870		12	>3.6, <14.5	200w	60	110				~70	~20			10	s
35			F		50		>0.0572, <0.1	750kk	75	600				~70	~20			10	t
3.5			F		50		>0.572, <1	750kk	75	600				~70	~20			10	t

TABLE 1: CHARACTERISTICS OF PHOTOCONDUCTORS (Continued)

Manufacturer	Type Number	Material	Spectral Response		Physical Dimensions						Package Description	Dark Characteristics						Ambient Test Temperature
			Spectral Limits (10% Points)	Sensitivity Peak	Diameter	Depth	Length	Width	Dimensional Coding	Sensitive Area		Previous Light Intensity	Minimum Dark Time	Applied Voltage	Maximum Dark Current	Dark Resistance	Dark Illumination Level	
			micron	micron	in.	in.	in.	in.		sq. in.		ft-c	sec	v	μa	meg	ft-c	°C
Radio Corp. of America (Continued)	SQ2533V2	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	Z		10	50(ac)	40(ac)			25
	SQ2533V3	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	Z		10	50(ac)	40(ac)			25
	SQ2533V4	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	Z		10	50(ac)	40(ac)			25
	SQ2533V5	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	Z		10	50(ac)	40(ac)			25
	SQ2533V6	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	Z		10	50(ac)	40(ac)			25
	SQ2533V7	CdS	0.33-0.74	0.58	1.24	0.285			P	0.785	Z		10	50(ac)	78(ac)			25
Sylvania Electric Products, Inc.	8100	CdS		0.56	<0.5	<0.515			P		A′		10			>0.5		25
	8142	CdS		0.56	<0.5	<0.515			P		A′		10			>0.2		25
	8143	CdS		0.56	<0.5	<0.515			P		A′					>0.9		25
	8318	CdS	0.46-0.755	0.61	<0.25	<0.55			P		A′	2	10			>10		25
	8345	CdS		0.56	<0.5	<0.515			P		A′		10			>0.075		25
	8346	CdS		0.56	<0.5	<0.515			P		A′		10			>0.3		25
	8347	CdS		0.56	<0.5	<0.515			P		A′		10			>1.6		25
	8474	CdS	0.46-0.755	0.61	<0.25	<0.55			P		A′	2	10			>0.15		25
	8475	CdS	0.46-0.755	0.61	<0.25	<0.55			P		A′	2	10			>0.3		25
	8476	CdS	0.46-0.755	0.61	<0.25	<0.55			P		A′	2	10			>0.6		25
	8477	CdS	0.46-0.755	0.61	<0.25	<0.55			P		A′	2	10			>1.2		25
	8478	CdS	0.46-0.755	0.61	<0.25	0.55			P		A′	2	10			2.4		25
	8582	CdS	0.46-0.755	0.61	<0.25	<0.55			P		A′	2	10			>10		25
	SRP-3419A	CdS		0.56	0.845	1.2			P		A′					>10		25
	SRP-3614				1.187	0.625			P				10			>1		25
	SRP-3614A				1.375	0.625			P				10			>1		25
Vactec, Inc.	VT-11L	CdSe	0.62-0.86	0.74		0.05	0.368	0.335	P		H					0.1		25
	VT-111	CdSe	0.62-0.86	0.74		0.05	0.368	0.335	P		H					0.1		25
	VT-112	CdSe	0.62-0.86	0.74		0.05	0.368	0.335	P		H					0.5		25
	VT-113	CdSe	0.62-0.86	0.74		0.05	0.368	0.335	P		H					0.5		25
	VT-114	CdSe	0.62-0.86	0.74		0.05	0.368	0.335	P		H					0.5		25
	VT-211	CdSe	0.62-0.86	0.74	0.21	0.146			P		G′					0.1		25
	VT-212	CdSe	0.62-0.86	0.74	0.21	0.146			P		G′					0.5		25
	VT-213	CdSe	0.62-0.86	0.74	0.21	0.146			P		G′					0.5		25
	VT-214	CdSe	0.62-0.86	0.74	0.21	0.146			P		G′					0.5		25
	VT-31L	CdSe	0.62-0.86	0.74	0.36	0.185			P		D′					0.1		25
	VT-311	CdSe	0.62-0.86	0.74	0.36	0.185			P		D′					0.1		25
	VT-312	CdSe	0.62-0.86	0.74	0.36	0.185			P		D′					0.5		25
	VT-313	CdSe	0.62-0.86	0.74	0.36	0.185			P		D′					0.5		25
	VT-314	CdSe	0.62-0.86	0.74	0.36	0.185			P		D′					0.5		25
	VT-41L	CdSe	0.62-0.86	0.74	0.55	0.34			P		P′					0.1		25
	VT-411	CdSe	0.62-0.86	0.74	0.55	0.34			P		P′					0.1		25
	VT-412	CdSe	0.62-0.86	0.74	0.55	0.34			P		P′					0.5		25
	VT-413	CdSe	0.62-0.86	0.74	0.55	0.34			P		P′					0.5		25
	VT-414	CdSe	0.62-0.86	0.74	0.55	0.34			P		P′					0.5		25
	VT-51L	CdSe	0.62-0.86	0.74	0.55	0.205			P		P′					0.1		25
	VT-511	CdSe	0.62-0.86	0.74	0.55	0.205			P		P′					0.1		25
	VT-512	CdSe	0.62-0.86	0.74	0.55	0.205			P		P′					0.5		25
	VT-513	CdSe	0.62-0.86	0.74	0.55	0.205			P		P′					0.5		25
	VT-514	CdSe	0.62-0.86	0.74	0.55	0.205			P		P′					0.5		25
	VT-61L	CdSe	0.62-0.86	0.74	1.26	0.265			P		C′					0.1		25
	VT-611	CdSe	0.62-0.86	0.74	1.26	0.265			P		C′					0.1		25
	VT-612	CdSe	0.62-0.86	0.74	1.26	0.265			P		C′					0.5		25
	VT-10L	CdS	0.45-0.76	0.55		0.05	0.368	0.335	P		H					0.1		25
	VT-101	CdS	0.45-0.76	0.55		0.05	0.368	0.335	P		H					0.1		25
	VT-102	CdS	0.45-0.76	0.55		0.05	0.368	0.335	P		H					0.5		25
	VT-103	CdS	0.45-0.76	0.55		0.05	0.368	0.335	P		H					0.5		25
	VT-104	CdS	0.45-0.76	0.55		0.05	0.368	0.335	P		H					0.5		25
	VT-201	CdS	0.45-0.76	0.55	0.21	0.146			P		G′					0.1		25
	VT-202	CdS	0.45-0.76	0.55	0.21	0.146			P		G′					0.5		25
	VT-203	CdS	0.45-0.76	0.55	0.21	0.146			P		G′					0.5		25
	VT-204	CdS	0.45-0.76	0.55	0.21	0.146			P		G′					0.5		25
	VT-30L	CdS	0.45-0.76	0.55	0.36	0.185			P		D′					0.1		25
	VT-301	CdS	0.45-0.76	0.55	0.36	0.185			P		D′					0.1		25
	VT-302	CdS	0.45-0.76	0.55	0.36	0.185			P		D′					0.5		25
	VT-303	CdS	0.45-0.76	0.55	0.36	0.185			P		D′					0.5		25
	VT-304	CdS	0.45-0.76	0.55	0.36	0.185			P		D′					0.5		25
	VT-40L	CdS	0.45-0.76	0.55	0.55	0.34			P		P′					0.1		25
	VT-401	CdS	0.45-0.76	0.55	0.55	0.34			P		P′					0.1		25
	VT-402	CdS	0.45-0.76	0.55	0.55	0.34			P		P′					0.5		25
	VT-403	CdS	0.45-0.76	0.55	0.55	0.34			P		P′					0.5		25
	VT-404	CdS	0.45-0.76	0.55	0.55	0.34			P		P′					0.5		25
	VT-50L	CdS	0.45-0.76	0.55	0.55	0.205			P		P′					0.1		25
	VT-501	CdS	0.45-0.76	0.55	0.55	0.205			P		P′					0.1		25
	VT-502	CdS	0.45-0.76	0.55	0.55	0.205			P		P′					0.5		25
	VT-503	CdS	0.45-0.76	0.55	0.55	0.205			P		P′					0.5		25
	VT-504	CdS	0.45-0.76	0.55	0.55	0.205			P		P′					0.5		25
	VT-60L	CdS	0.45-0.76	0.55	1.26	0.265			P		C′					0.1		25
	VT-601	CdS	0.45-0.76	0.55	1.26	0.265			P		C′					0.1		25
	VT-602	CdS	0.45-0.76	0.55	1.26	0.265			P		C′					0.5		25

Light Characteristics		Dark – Light Resistance Ratio	Radiation Source		Sensitivity			Maximum Ratings			Temperature Characteristics			Response Times		Response Time Test Parameters			Notes
Incident Illumination	Light Resistance		Type	Color Temperature	Applied Voltage		Illumination Sensitivity	Power Dissipation at 25 °C.	Ambient Operating Temperature	Voltage Rating	Incident Illumination	Relative Room Temp. Resistance	Temperature	Rise Time (0-63.2%)	Decay Time (100-36.8%)	Supply Voltage	Series Resistance	Incident Illumination	
ft–c	K			°K	v ac rms	v dc	ma/ft–c	mw	°C	v	ft–c	%	°C	m sec	m sec	v	K	ft–c	
1			F		50		0.8, 1.7	750kk	75	600				70	20			10	†
1			F		50		1, 3	750kk	75	600				70	20			10	†
1			F		50		1.5, 4	750kk	75	600				70	20			10	†
1			F		50		2.5, 5	750kk	75	600				70	20			10	†
1			F		50		3, 7	750kk	75	600				70	20			10	†
1			F		50		8, 16	750kk	75	250				70	20			10	†
2	5		T	2870				300	70	400									x
2	1.5		T	2870				300	70	400									x
2	9		T	2870				300	70	400									x
2	40		T	2870				50	70	300									x
2	0.75		T	2870				300	70	400									x
2	3		T	2870				300	70	400									x
2	16		T	2870				300	70	400									x
2	1.5		T	2870				50	70	150									x
2	3		T	2870				50	70	200									x
2	6		T	2870				50	70	300									x
2	12		T	2870				50	70	300									x
2	24		T	2870				50	70	300									x
2	100		T	2870				50	70	300									x
2	1000–2000							50											
	2.5[ii]							300	70										ii
	5.5[ii]							300	70										ii
2	0.7		T	2850				200		70	0.01	67	65	6	5			10	u
2	2.3		T	2850				200		70	0.01	67	65	6	5			10	u
2	22		T	2850				200		300	0.01	67	65	6	5			10	u
2	60		T	2850				200		300	0.01	67	65	6	5			10	u
2	148		T	2850				200		300	0.01	67	65	6	5			10	u
2	2.3		T	2850				50		70	0.01	67	65	6	5			10	v
2	7.8		T	2850				50		70	0.01	67	65	6	5			10	v
2	22		T	2850				50		200	0.01	67	65	6	5			10	v
2	140		T	2850				50		300	0.01	67	65	6	5			10	v
2	0.9		T	2850				100		70	0.01	67	65	6	5			10	v
2	4.2		T	2850				100		70	0.01	67	65	6	5			10	v
2	22		T	2850				100		300	0.01	67	65	6	5			10	v
2	55		T	2850				100		300	0.01	67	65	6	5			10	v
2	140		T	2850				100		300	0.01	67	65	6	5			10	v
2	0.7		T	2850				350		70	0.01	67	65	6	5			10	v
2	2.3		T	2850				350		70	0.01	67	65	6	5			10	v
2	22		T	2850				350		300	0.01	67	65	6	5			10	v
2	60		T	2850				350		300	0.01	67	65	6	5			10	v
2	148		T	2850				350		300	0.01	67	65	6	5			10	v
2	0.7		T	2850				350		70	0.01	67	65	6	5			10	v
2	2.3		T	2850				350		70	0.01	67	65	6	5			10	v
2	22		T	2850				350		300	0.01	67	65	6	5			10	v
2	60		T	2850				350		300	0.01	67	65	6	5			10	v
2	148		T	2850				350		300	0.01	67	65	6	5			10	v
2	0.7		T	2850				1000		300	0.01	67	65	6	5			10	v
2	2.3		T	2850				1000		300	0.01	67	65	6	5			10	v
2	22		T	2850				1000		300	0.01	67	65	6	5			10	v
2	1.6		T	2850				200		70	0.01	142	65	29	15			10	u
2	3		T	2850				200		70	0.01	142	65	29	15			10	u
2	16		T	2850				200		300	0.01	142	65	29	15			10	u
2	66		T	2850				200		300	0.01	142	65	29	15			10	u
2	136		T	2850				200		300	0.01	142	65	29	15			10	u
2	4.3		T	2850				50		70	0.01	142	65	29	15			10	v
2	8		T	2850				50		70	0.01	142	65	29	15			10	v
2	22		T	2850				50		200	0.01	142	65	29	15			10	v
2	110		T	2850				50		300	0.01	142	65	29	15			10	v
2	1.8		T	2850				100		70	0.01	142	65	29	15			10	v
2	3		T	2850				100		70	0.01	142	65	29	15			10	v
2	16		T	2850				100		300	0.01	142	65	29	15			10	v
2	70		T	2850				100		300	0.01	142	65	29	15			10	v
2	144		T	2850				100		300	0.01	142	65	29	15			10	v
2	1.3		T	2850				350		70	0.01	142	65	29	15			10	v
2	2.6		T	2850				350		70	0.01	142	65	29	15			10	v
2	16		T	2850				350		300	0.01	142	65	29	15			10	v
2	66		T	2850				350		300	0.01	142	65	29	15			10	v
2	144		T	2850				350		300	0.01	142	65	29	15			10	v
2	1.3		T	2850				350		70	0.01	142	65	29	15			10	v
2	2.6		T	2850				350		70	0.01	142	65	29	15			10	v
2	16		T	2850				350		300	0.01	142	65	29	15			10	v
2	66		T	2850				350		300	0.01	142	65	29	15			10	v
2	144		T	2850				350		300	0.01	142	65	29	15			10	v
2	1.3		T	2850				1000		300	0.01	142	65	29	15			10	v
2	3		T	2850				1000		300	0.01	142	65	29	15			10	v
2	15		T	2850				1000		300	0.01	142	65	29	15			10	v

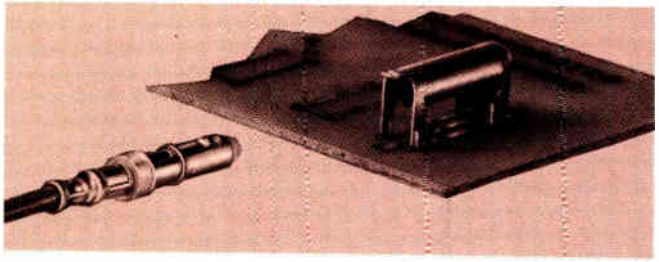


Fig. 1. Miniature coaxial socket for printed circuit boards, may be mounted near components or at edge of board (AMP Inc.).

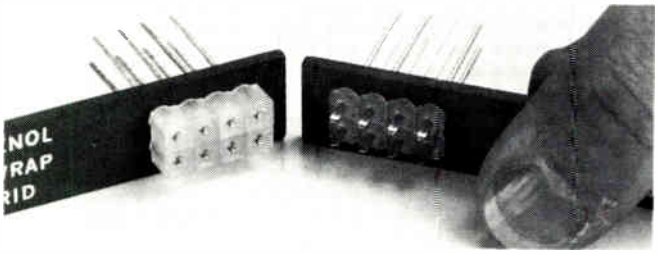


Fig. 2. Male and female connectors for patchboard use. Contacts are inserted into nylon bushings that are snapped into punched holes in a base plate (Amphenol).

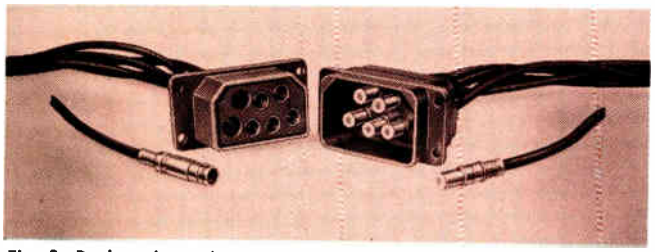


Fig. 3. Rack and panel mounting plug and receptacle assembly containing removable coaxial connectors (Burndy).

STATE-OF-THE-ART FEATURE

1965 Connector Specifications Guide

Part 4 - Plugs & Jacks

Fourth and Last
of a Series of Reports
Industry's Most Complete

ELECTRONIC CONNECTOR SURVEY

See Previous Issues for Parts 1, 2 and 3:

PART 1: PRINTED CIRCUIT CONNECTORS (January, 1965)

PART 2: COAXIAL AND SHIELDED CABLE CONNECTORS (February, 1965)

PART 3: MULTIPIN CONNECTORS (April, 1965)

THIS PARTICULAR SURVEY ON PLUGS AND JACKS, cord and cable assemblies, binding posts, audio connectors, clips and terminals, not only covers a wide assortment of connectors, but at once spotlights the newest as well as the oldest names in the manufacture of radio, communications, control, instrumentation, power and test equipment.

Many of us may reject the thought of changes being made in familiar connectors, such as the recessed male receptacles found in projectors, record changers, motors, and other portable cord set devices, for example, but changes there are, nevertheless, and they are being made for reasons of economy, smaller size, better performance and longer life.

Through the development of new materials and processes, the connector industry seems to come up with many more new designs than it retains of the old.

Advances in Plugs and Jacks

Many of the plugs and jacks featured in this survey are telephone types featuring a design known as "long frame telephone jack" that originated several decades ago with Bell Telephone Systems and Western Electric Company, and which is still supplied by many manufacturers, some to military spec (Kings).

Some jack manufacturers, however, have recently initiated patchfield designs that depart from the ¼-inch diameter size standards of the long frame and short frame series. Size reductions in the new "Bantam" plug and jack designs, for example, make it possible to mount these miniature equivalents on 5/16-inch centers as compared to the old standard ⅝-inch center to center spacing, doubling the number of jacks in a given area (ADC Products).

Carrying miniaturization of the plug and jack field still further, there are new color coded subminiature tip jacks and tip plugs (only .080 inch diameter to be exact) for use in printed circuits or for other limited space applications. Though extremely compact, they are rated at 5 amps and 1500 volts, with contact resistance less than two milliohms (E. F. Johnson).

In general, jack manufacturers try to use metals which not only exceed mil spec requirements but retain the performance over long periods of time. Palladium, an element of the Platinum group, though harder and more fusible, is one of the metals used as leaf springs in new telephone jacks (Switchcraft). Palladium is highly resistant to surface contamination and may be used in both wet and dry circuits with high reliability. Average contact resistance using the metal is .005 ohms.

A press-fitted test jack .250-inch diameter is also available for miniaturized applications. Insulation is high temperature glass-filled diallyl phthalate with

voltage breakdown of 3 Kv (Electronic Molding Corp.).

Economies are introduced in new recessed 125-volt AC connectors, and one-piece phono plugs that will fit any standard phono socket. The phono plugs can be crimped up to 1,000 per hour (Cinch).

Versatile Binding Posts

New binding posts feature polystyrene insulation for low dielectric constant, low dissipation factor and minimum moisture effects. Some types have contoured holes to provide firm grip without shearing wire. Sizes are for AWG #40 to #10. Bases are keyed for anti-rotation for any panel thickness to 5/16-inch (General Radio).

Also featured are new waterproof types, miniatures ranging in size downward to .310 inches diameter, and universal types that accept a standard banana plug inserted into the top (Eby) (General Radio). One style with the banana plug jack also has a built-in fuse holder (Superior). Another style, a miniature, accepts a midget banana plug (.094" hole) is rated for 15 amps, 100 volts (James Millen).

Several firms offer new spring type binding posts that are convenient for quick interconnection of insulated wire or cable. No stripping is necessary; the insulated cable is simply inserted into the post and spring action causes sharp teeth to pierce the insulation and make electrical contact with the wire.

Trends in Cable Assemblies

Indications are that more and more manufacturers are specifying custom cable design and assembly services, and that applications are now numerous in military, aircraft and space industries (Burndy).

Molded cable assemblies are custom made and tested to manufacturers' specifications. Connectors and cables are integrally molded into one piece of any length from inches to hundreds of feet long, with any variety of connectors molded at any point (Alden Products). Smaller size, superior strain relief and better shielding from foreign matter are some advantages claimed for molded cable assemblies over soldered or screw-connected assemblies (Switchcraft).

Fabrication facilities for custom cable assembly and design often include "white rooms" with dust-free controlled environments for the ultimate in contamination free assemblies (Amphenol).

Power cordset developments include a new grounded series switching plug and cord for use with foot switches, timers and photo cells, and a heavy duty cable with a nine-pronged plug molded directly to the cord for use with vending machines (Miller).

Terminals and Terminations

Several manufacturers specialize in a galaxie of solder and solderless terminations designated variously according to their shapes, as spades, rings, tongues, hooks, tags, splices, pigtails. These are available in bulk or in strip form, insulated or non-insulated, for manual assembly or for automatic lead terminating machinery.

One type of PVC (75°C Vinyl) insulated strip crimp terminal is available for insulation diameters from .056 to .250 inches (Kent), as well as a vinyl insulated two piece crimp tag (Penn-Union). Both are color coded for ease of selection. Featured also is an automatic method of welding electric wires to strip terminals as well as automatic splicing of wires (Electric Terminal).

The crimp splice, a hollow bare copper sleeve usually serrated on the inside for best contact and grip, is available insulated or non-insulated and for either butt or parallel splicing of wires. A solid seamless splice of one-piece barrel construction is nylon insulated and handles temperatures from —60°F to 250°F (Electric Terminal). The "push-on" tab, another member of the splice family consist of mating splice connectors (Jackson).

The pigtail is a copper sleeve similar to the splice except that it is crimped closed at one end and flared at the other for easy insertion of wires. Insulated pig-

Fig. 4. Snap-locking plugs and receptacles can be used singly or stacked together to form a multipin single connector (Elco).

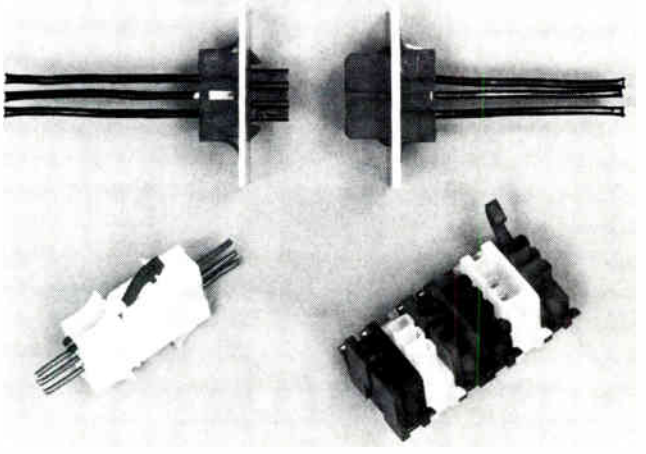


Fig. 5. Nylon insulated butt and parallel splices with solid, seamless, one-piece barrel construction (ETC Inc.).

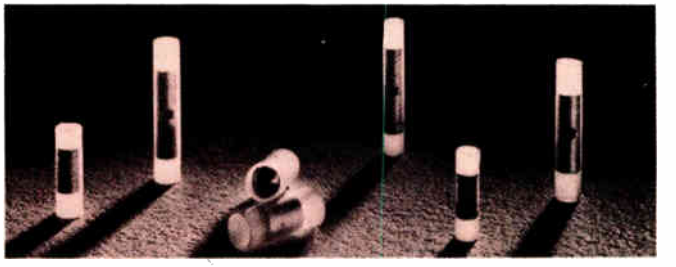
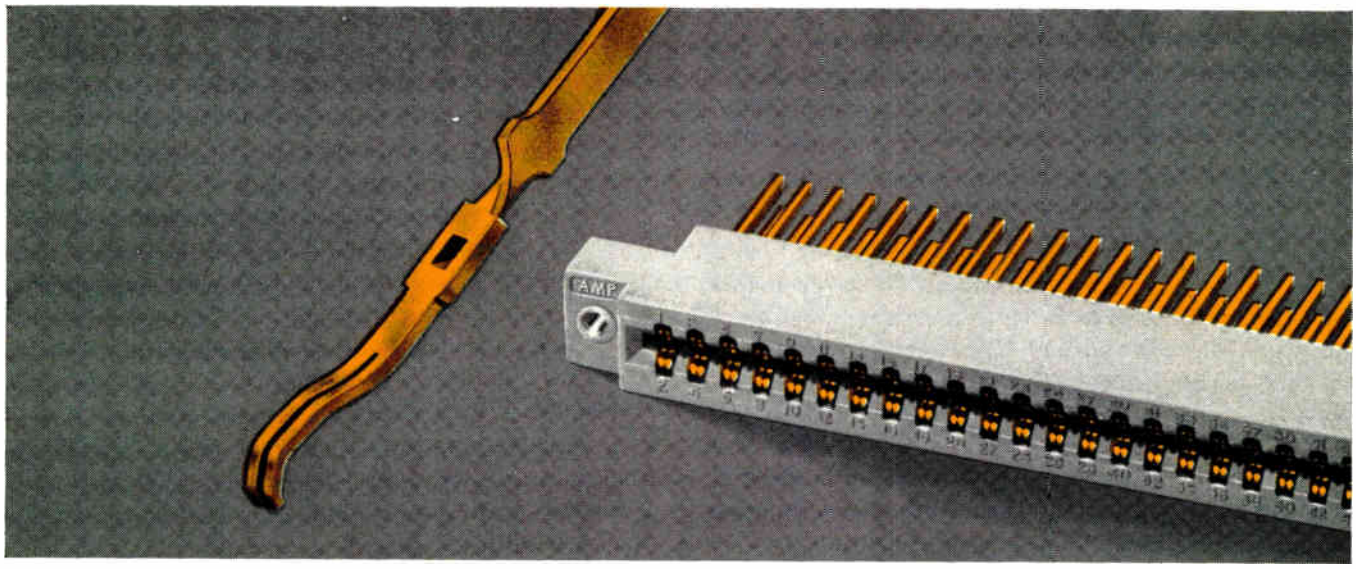
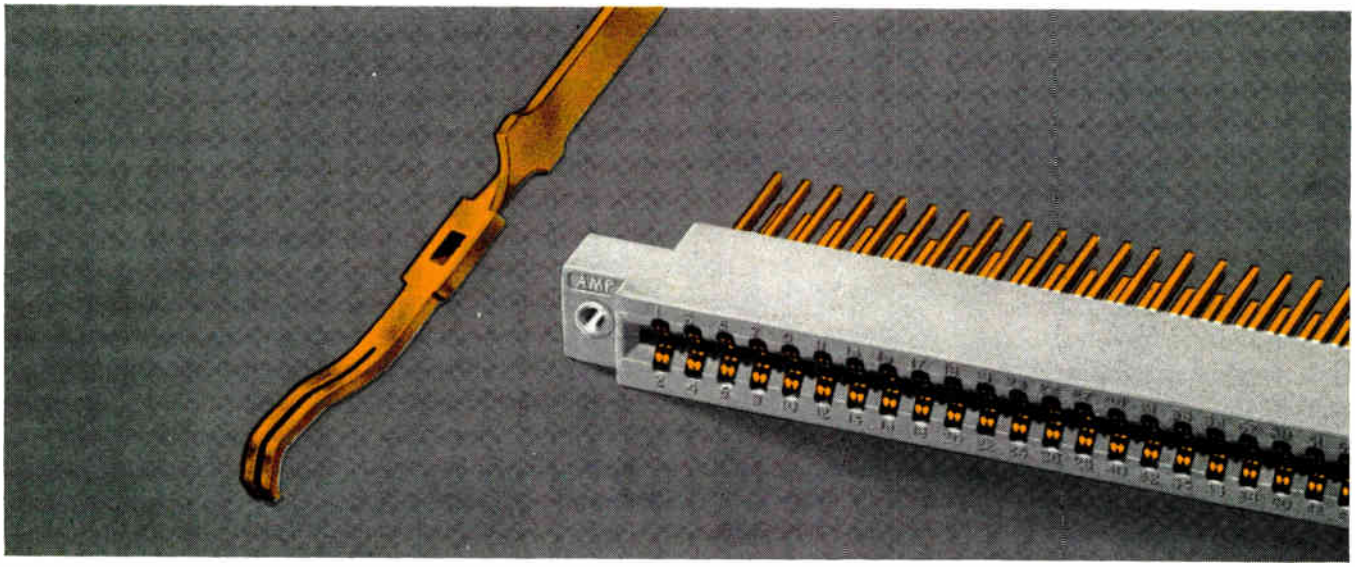


Fig. 6. Completely enclosed molded phone jack designed for high density electronic packaging (Switchcraft).



Pardon our redundance, but you asked for it!



We're referring to the contacts in our new TERMI-TWIST★ Printed Circuit Connector. In addition to all their other advantages, they're bifurcated for redundancy.

Now, with TERMI-TWIST contacts, you may use automated point-to-point wiring techniques and have the benefits of AMP's gold-over-nickel plating—plus contact redundancy. Yet, they're designed for cost savings from the front bifurcated contact through the center twist locking section right back to the rear post which accommodates AMP's new TERMI-POINT★ clip wiring devices.

For reliability, the phosphor-bronze contacts are plated with gold over nickel, including a .000030" gold plating on the critical contact areas. Thanks to their 90° twist and square shoulder design, the contacts are positively aligned and firmly locked in the housing. Contact removal, however, is easily accomplished with ordinary long nose pliers.

These low-cost TERMI-TWIST Connectors are available in either diallyl phthalate or phenolic housings in sizes which include 15, 22, 31, or 43 contact positions, with contacts loaded on one or both sides. They are designed with a contact density of .156" for convenient replacement of existing panel mounted connectors.

Take a look at these TERMI-TWIST Connector features:

- Economy—low initial and per-line cost
- Wiring compatibility—use TERMI-POINT clips; or solder, weld, or wrap
- Flexibility—accepts printed circuit boards from .054" to .071" thick
- Quality—meets mechanical and electrical requirements of MIL-C-21097
- Reliability—Gold-over-nickel plating and high contact force
- Versatility—optional automatic machine or hand tooling

If you've been asking around for an economical and reliable board edge connector that's compatible with automated application, don't overlook this TERMI-TWIST Connector. Write for complete details today.

★Trademark of AMP Incorporated

AMP INCORPORATED
Harrisburg, Pennsylvania

INDUSTRIAL SALES DIVISION

A-MP★ products and engineering assistance available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • Mexico • Spain • West Germany

PLUGS and JACKS (Continued)

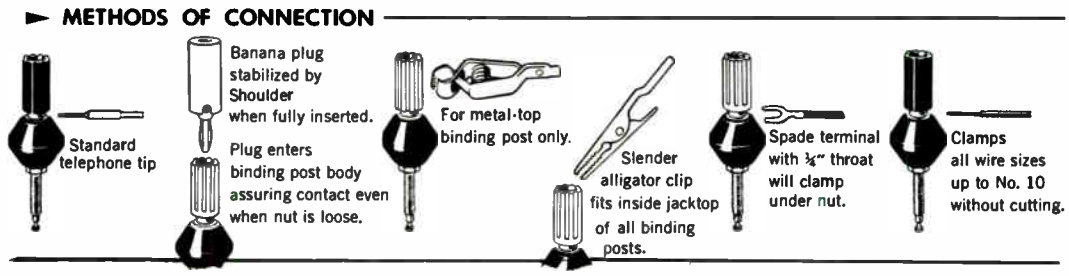


Fig. 10. Versatile new binding post offers several methods of connection (General Radio).

tails are usually nylon or vinyl covered (Hollingsworth).

Terminal boards in strip form are available with tinned terminals riveted to them ready for soldering or wire wrapping (Keystone). There are terminal strips of laminated phenolic with plated terminals that hold the wire lead in position after insertion and before production soldering (Cinch). A solid taper pin is available than can be applied at high speed. The taper pin is held by a plastic carry strip designed to release the pin when it's crimped (Kent).

Press-in feedthrough and standoff terminals with molded diallyl phthalate dielectric, though miniature size, safely pass high voltages through chassis and panel. Additional creepage length to compensate for smaller size is achieved by elimination of the usual threaded metal housing (Winchester) (Electronic Molding Corp.).

Miniature ceramic terminal strips utilize separable terminals, that is, the terminals can be spaced at desired distances from each other on a common strip. Voltage rating is 1400 volts DC (Miller).

Added to the terminals is an array of clips, bands, cable retainers and other metal specialties (C. Sjoberg).

Terminals and connectors made specifically for the manufacturers of appliances and electrical fixtures are also featured. A new connector uses self-mating terminals requiring less pressure to connect and capable of carrying up to 25 amps (Packard Electric). A snap action connector makes possible the stacking of any combination of plugs and receptacles to form a single connector for cable to cable, cable to panel or panel to panel applications in appliances (Elco). Another snap action connector that can be panel mounted or free hanging has identical shells of polycarbonate resin and features ratings of up to 600 volts between poles and 9½ amps per circuit (Kent). Some of the smallest Underwriter Laboratories' approved convenience outlets for TV, radios, radio clocks, machines, lamps, instruments, mount on 1⅛-inch centers and take less than one inch behind the mounting panel (Alden Products). A new power connector incorporates the safety of a self-deflecting blade to provide automatic ground connection when plugged into 2 or 3-hole receptacles (APM-Hexseal).

Manufacturers of connectors serving commercial and industrial power applications are listed with their products such as the compression mated or bolted taps and lugs, and two- or three pole caps (Penn Union) and outlets meeting latest revisions in N. E. C. requirements for modern, heavy duty equipment, appliances and portable tools (Leviton). Included are power cords to 100 feet length, power plugs and receptacles handling up to 200 amps (Pyle-National).

Extreme Environment "Specials"

Connections at temperatures to 500° F are provided by polarized connectors with prongs and inserts made of thermocouple alloy and bodies of glass-filled phenolic (West Instrument). Also available are color coded plugs and jacks with up to 12 poles to connect thermocouples to extension wire and the extension wire to instruments (Honeywell).

In the atomic industry, remote handling operations are being simplified by hinged self aligning connectors that open and close like a book. Featured is a ball and socket contact pin assembly providing a mobile joint to give the self-aligning capability (Cole Electric).

New explosion proof connectors permit the safe making and breaking of electrical circuits in hazardous locations without use of allied supporting devices and as interlocking mechanisms or complicated procedural control involving purging or pressurization (Pyle National).

Fig. 7. Laminated phenolic terminal strip and miniature sockets with terminals that grip the wire in position before production soldering (Cinch).

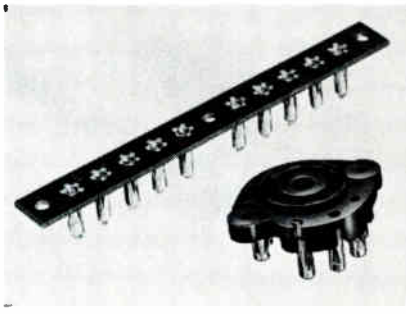


Fig. 8. One piece molded transistor socket permitting complete isolation of a base terminal (Hugh H. Eby Co.).

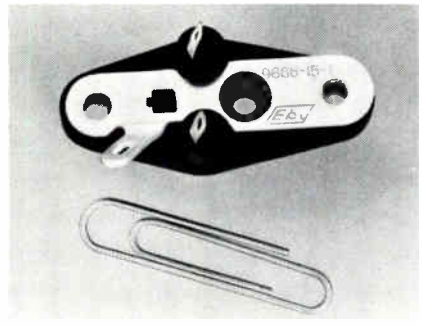


Fig. 9. Explosion proof connectors incorporate arc quenching contact inserts, a snap action coupling device and safe breaking of 200 amp loads (Pyle-National).

Manufacturers of Plugs, Jacks, Cable Assemblies and Terminals

	PLUGS & JACKS														CORD & CABLE ASSEMBLIES								BINDING POSTS, TERMINALS									
	TIP PLUGS & TIP JACKS	TELEPHONE PLUGS & JACKS	MULTI-PIN PLUGS & JACKS	OCTAL PLUGS & SOCKETS	PIGGYBACK CONNECTORS	RIGHT ANGLE CONNECTORS	PRINTED CIRCUIT CONNECTORS	THERMOCOUPLE CONNECTORS	TWIN LEAD PLUGS & JACKS	JUNCTIONS	SOLDER TYPES	SOLDERLESS	MINIATURE	SUBMINIATURE	PATCH PANELS & CORDS	POWER PLUGS & RECEPTACLES	POWER CORDS	WIRE & CABLE SETS	HARNESSES	HIGH VOLTAGE CABLES	SUBMINIATURE	TOOLS	PINS, PLUGS & SOCKETS	STANDOFFS	BINDING POSTS	RING TERMINALS	SPADE TERMINALS	FLAG TERMINALS	SPLICES	MALE & FEMALE BLADES	PIGTAILS	EYELETS	CLIPS	TOOLS
ACCURATE ELECTRONICS, CORP., P.O. Box 935G, Elyria, O.	X	X	X	X	X	X	X			X	X	X	X	X	X	X		X					X	X	X	X	X	X	X	X			
ACI Div. of KENT CORP., 206 Center, Princeton, N. J.							X					X						X	*X														
ADC PRODUCTS, INC., 6325 Cambridge St., Minneapolis, Minn.		X	X								X	X	X		X																	
ADEC, INC., 86 Frelinghuysen Ave., Newark 14, N. J.			X																													
ADVAC PRODS., INC., 174 Richmond Ave., Stamford, Conn.								X																X								
AIRBORN, INC., P.O. Box 20232, Dallas, Tex.			X		X		X	X			X	X	X	X									X									
ALDEN PRODUCTS CO., 117 N. Main Street, Brockton, Mass.	X			X	X		X		X	X	X		X	X	X	X	X	X	X	X			X								X	X	X
AMP, INC., Harrisburg, Pa.			X		X	X	X		X	X		X	X	X	X							X	X			X	X	X	X	X	X	X	X
AMPHENOL CONNECTOR DIV., 1830 S. 54th St., Chicago, Ill.	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	[1]X	[1]X		X		X				X				X
ANDREW CORP., Box 807, Chicago, Ill.															X																		
APM-HEXSEAL CORP., 41 Honeck St., Englewood, N. J.																X																	
ASSOCIATED ENGINEERING CORP., 65 Kent St., Brookline, Mass.															X			X															
ASTROLAB, INC., 35 Commerce St., Springfield, N. J.							X						X	X																			
ATLAS CONNECTOR CORP., 9722 Alpaca St., S. El Monte, Calif.											X	X	X	X																			
AUTOMATION DIV., KENT CORP., 206 Center, Princeton, N. J.			X																				X			X	X	X	X	X			X
AVA ELECTRONICS & MACHINE CORP., 1 Maple St., E. Rutherford, N. J.															[2]X				[2]X		X												
BARNES DEVELOPMENT CO., 213 W. Baltimore Ave., Lansdowne, Pa.				X											X																		
BEAUCHAINE & SONS, INC., Laconia, N. H.			X								X											X										
BENDIX, Scintilla Div., Sidney, N.Y.			X		X	X	X	X			X	X	X			X		X	X	X	X		X										
BILL JACK INDUSTRIES, 143 S. Cedros Ave., Solana Beach, Calif.			X			X	X			X	X	X		X							X							X				
BIRNBACH RADIO CO., INC., 435 Hudson St., New York 14, N.Y.	X	X	X			X	X				X	X	X	X	X	X	X	X		X	X		X	X	X	X	X	X	X		X		
BURNDY CORP., Norwalk, Conn.				X		X	X								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CAMBLOCK DIV., Waltham Prec. Instrument Co., Waltham 54, Mass.																								X	X								
CAMBRIDGE THERMIONIC CORP., 445 Concord Ave., Cambridge, Mass.					X	X	X				X	X	X		X								X	X	X	X	X	X			X	X	
CAROL CABLE CO., 249 Roosevelt Ave., Pawtucket, R.I.																	X	X		X						X	X	X			X	X	
CICOIL CORP., 13833 Saticoy St., Van Nuys, Calif.																			X		X												
CINCH MFG., CO., 1026 S. Homan St., Chicago, Ill. 60624			X	X		X	X				X	X	X	X		X									X							
COLE ELECTRIC CO., 8439 Stellar Dr., Culver City, Calif.			[3]X					[3]X		[3]X		[3]X				[3]X	[3]X						[3]X						[3]X				
CONNECTORS, INC., 128 Broad St., Stamford, Conn.						X				X	X							X															
CONTINENTAL CONNECTOR CORP., 34-63 56th St., Woodside, N.Y.			X			X	X				X	X	X	X																			X

*Complete Circuit Assemblies, Flat, Encapsulated

[1]Made by Cable Div., 6235 S. Harlem Ave., Chicago, Ill.

[2]RF, Coaxial

[3]Ball and Socket

Manufacturers of Plugs, Jacks, Cable Assemblies and Terminals (Continued)

	PLUGS & JACKS														CORD & CABLE ASSEMBLIES								BINDING POSTS, TERMINALS										
	TIP PLUGS & TIP JACKS	TELEPHONE PLUGS & JACKS	MULTI-PIN PLUGS & JACKS	OCTAL PLUGS & SOCKETS	PIGGYBACK CONNECTORS	RIGHT ANGLE CONNECTORS	PRINTED CIRCUIT CONNECTORS	THERMOCOUPLE CONNECTORS	TWIN LEAD PLUGS & JACKS	JUNCTIONS	SOLDER TYPES	SOLDERLESS	MINIATURE	SUBMINIATURE	PATCH PANELS & CORDS	POWER PLUGS & RECEPTACLES	POWER CORDS	WIRE & CABLE SETS	HARNESSES	HIGH VOLTAGE CABLES	SUBMINIATURE	TOOLS	PINS, PLUGS & SOCKETS	STANDOFFS	BINDING POSTS	RING TERMINALS	SPADE TERMINALS	FLAG TERMINALS	SPLICES	MALE & FEMALE BLADES	PIGTAILS	EYELETS	CLIPS	TOOLS
DAGE ELECTRIC CO., INC., Hurricane Rd., Franklin, Ind.						X		X			X	X	X	X										X							X	
DANTE ELECTRIC MFG., CO., Marne Park, Bantam, Conn.											X	X															*X				X	
D-CEMCO, INC., 1024 W. 9th St., P.O. Box 8, Upland, Calif.											X	X		X	X								X	X		X	X	X	X	X	X	X
DIGITAL SENSORS, INC., 4127 Figueroa St., Los Angeles, Calif.																			[1]X				[1]X										
DONMAR PRODS., INC., P.O. Box 8396, Denver, Colo.	X														X										X		X					X	
EAGLE ELECTRIC MFG., CO., 23-10 Bridge Plaza, S. L.I.C., N.Y.						X						X				X	X															
HUGH H. EBY CO., 4701 Germantown Ave., Philadelphia, Pa.*	X		X	X			X				X	X	X	X		X		X					X	X	X								
ELCO CORP., Willow Grove, Pa.			X	X		X	X				X	X	X	X		X	X				X	X		X	X								X
ELECTRIC TERMINAL CORP., Drawer E. Pilgrim Sta., Warwick, R. I.																							X			X	X	X	X	X		X	X
ELECTRONIC CONNECTORS, INC., Kew Gardens, N. Y.	X		X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X		X		X	X	X	X			X		X	X	
ELECTRONIC FITTINGS CORP., 29 Sugar Hollow Rd., Danbury, Conn.	X		X		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
ELECTRONIC MOLDING CORP., 40 Church St., Pawtucket, R.I.	X												X	X									X	X	X						X		X
ERCONA CORP., 432 Park Ave., New York 16, N. Y.		X	X	X	X	X	X				X	X	X	X									X	X	X								
ETC, INC., 990 E. 67th St., Cleveland, O.																										X	X	X	X	X	X		X
EQUIPMENT & SERVICE CO., 7118 Envoy Court, Dallas, Tex.																X																	
GARLOCK INC., 8 Fellowship Rd., Cherry Hill, N. J.	X			X		X	X												[2]X					X									
GC ELECTRONICS CO., 400 S. Wyman St., Rockford, Ill.	X	X				X			X		X	X	X									X	X	X	X		X	X					X
GENERAL RADIO CO., West Concord, Mass.	X		X		X	X					X	X			X								X		X						X		X
HOLLINGSWORTH CO., Phoenixville, Pa.																										X	X	X	X	X			X
HOLUB INDUSTRIES, INC., Sycamore, Ill.																																X	X
HONEYWELL, Philadelphia Div., Wayne & Windrim Aves., Philadelphia, Pa.								X																									
HUGHES CONNECTING DEVICES, P.O. Box H, Newport Beach, Calif.						X	X			X		X	X	X	X	X			X	X	X	X	X										X
HYDRO MOLDING CO., INC., 100 Sharron Ave., Plattsburgh, N. Y.							X																X							X		
ISOLATION PRODS., INC., 2286 Mora Dr., Mountain View, Calif.						[3]X																		[3]X									
ITT CANNON ELECTRIC, Div. Int'l. Tel. & Tel. Corp., 3208 Humboldt, L.A., Calif.		X				X	X	X		X	X	X	X	X	X	X		X	X		X	X										
J. A. JACKSON CORP., 430 Canter Ave., Mamaroneck, N. Y.																										X	X	X	X	X			X
JAVEX ELECTRONICS, 9509 Oak Glen Rd., Cherry Valley, Calif.	X		X	X		X			X		X	X	X			X									X								
JETTRON PRODS., INC., 57 Rte. 10, Hanover, N.J.																		X	X	X													
E. F. JOHNSON CO., Waseca, Minn.	X						X						X										X		X				X				
JOY MFG. CO., 338 S. Broadway, New Philadelphia, O.																X	X	X	X														

*Also Coaxial terminations.

[1]For flat, multiconductor interconnecting cable.

[2]Complete circuit assemblies, flat encapsulated

[3]High voltage, ion pump connectors

Manufacturers of Plugs, Jacks, Cable Assemblies and Terminals (Continued)

	PLUGS & JACKS														CORD & CABLE ASSEMBLIES								BINDING POSTS, TERMINALS											
	TIP PLUGS & TIP JACKS	TELEPHONE PLUGS & JACKS	MULTI-PIN PLUGS & JACKS	OCTAL PLUGS & SOCKETS	PIGGYBACK CONNECTORS	RIGHT ANGLE CONNECTORS	PRINTED CIRCUIT CONNECTORS	THERMOCOUPLE CONNECTORS	TWIN LEAD PLUGS & JACKS	JUNCTIONS	SOLDER TYPES	SOLDERLESS	MINIATURE	SUBMINIATURE	PATCH PANELS & CORDS	POWER PLUGS & RECEPTACLES	POWER CORDS	WIRE & CABLE SETS	HARNESSES	HIGH VOLTAGE CABLES	SUBMINIATURE	TOOLS	PINS, PLUGS & SOCKETS	STANDOFFS	BINDING POSTS	RING TERMINALS	SPADE TERMINALS	FLAG TERMINALS	SPLICES	MALE & FEMALE BLADES	PIGTAILS	EYELETS	CLIPS	TOOLS
KEYSTONE ELECTRONICS CORP., 49 Bleecker St., N. Y.	X	X		X			X				X	X	X										X	X								X	X	X
KINGS ELECTRONICS CO., INC., 40 Marbledale Rd., Tuckahoe, N. Y.		X				X			X			X	X		X							X			X									
KOLTON ELECTRIC MFG., CO., 123 New Jersey Railroad Ave., Newark, N. J.																								X	X	X	X						X	
LAB-TRONICS, INC., 3656 N. Lincoln Ave., Chicago, Ill. 60613	X	X	X	X	X	X					X	X	X		X	X	X	X	X	X	X		X		X									
LEVITON MFG. CO., 236 Greenpoint Ave., Brooklyn, N.Y.																X	X																	
LIVINGSTON ELECTRONICS CORP., 320 Runnymede Rd., Essex Falls, N. J.				X																														
MALCO MFG., CO., 4023 W. Lake St., Chicago 24, Ill.						X	X								X	X							X			X	X	X	X	X				X
MATRIX SCIENCE CORP., 3311 Winona Ave., Burbank, Calif.			X			X			X	X	X	X		X	X	X	X		X	X	X													
METHODE ELECTRONICS, INC., 7447 W. Wilson Ave., Chicago 31, Ill.	X	X	X	X		X	X		X		X	X	X	X	X	X					X		X											
MIDLAND INT'L. CORP., 1519 Atlantic St., N. Kansas City, Mo.	X	X							X		X	X			X							X	X		X									
JAMES MILLEN MFG., CO., INC., 150 Exchange St., Malden 48, Mass.	X		X	X	X	X			X		X	X	X										X	X	X								X	
MILLER ELECTRIC CO., 150 Hamlet Ave., Woonsocket, R.I.		X	X		X						X	X				X	X	X																
MINNESOTA MINING & MFG. CO., 2501 Hudson Rd., St. Paul, Minn.			X				X					X						X	X															
FRANK MORSE CO., 354 Congress St., Boston, Mass.																X										X	X	X						
MOSLEY ELECTRONICS, INC., 4610 N. Lindbergh Blvd., Bridgeton, Mo.			X						X		X	X																						
MULTICON, INC., Graybill, Ind.			X									X	X																					
NATIONAL CONNECTOR CORP., Science-Industry Center, Minneapolis 28, Minn.			X			X	X				X	X	X	X									X				X			X				X
NATIONAL TEL-TRONICS CORP., 52 St. Casmir Ave., Yonkers, N.Y.	X	X	X				X				X	X	X										X		X									
NEWAL, INC., 80 Pickett District Rd., New Milford, Conn.															X	X						X	X	X	X									
NUGENT ELECTRONICS CO., INC., 802 E. 8th St., New Albany, Ind.	X		X		X	X	X				X	X	X	X									X	X					X					
NU-LINE INDUSTRIES, INC., 1015 S. 6th St., Minneapolis, Minn.																		X	X	X														
OMNI SPECTRA INC., 8844 Puritan Ave., Detroit, Mich.						X	X				X	X	X	X							X													
PACIFIC ELECTRICORD CO., 747 W. Redondo Beach Blvd., Gardena, Calif.																X	X	X																
PACKARD ELECTRIC DIV., General Motors, P.O. Box 431, Warren, O.																		X	X							X	X			X		X	X	
PATTON-MacGUYER CO., 17 Virginia Ave., Providence, R.I.											X	X														X	X	X	X	X				X
PENN-UNION ELECTRIC CORP., P.O. Box 209, Erie, Pa.																									X	X	X	X	X	X	X			X
PERMONITE MFG. CO., 910 Jackson Blvd., Chicago 7, Ill.			X								X	X				X			X	X			X		X		X							
PHYSICAL SCIENCES CORP., 314 E. Live Oak Ave., Arcadia, Calif.						X		X					X	X																				
PYLE-NATIONAL CO., 1334 N. Kostner Ave., Chicago, Ill.			X			X		X			X	X	X			X	X	X	X	X		X												
PYLON CO., INC., Attleboro, Mass.																																	X	X

Manufacturers of Plugs, Jacks, Cable Assemblies and Terminals (Continued)

	PLUGS & JACKS													CORD & CABLE ASSEMBLIES								BINDING POSTS, TERMINALS										
	TIP PLUGS & TIP JACKS	TELEPHONE PLUGS & JACKS	MULTI-PIN PLUGS & JACKS	OCTAL PLUGS & SOCKETS	PIGGYBACK CONNECTORS	RIGHT ANGLE CONNECTORS	PRINTED CIRCUIT CONNECTORS	THERMOCOUPLE CONNECTORS	TWIN LEAD PLUGS & JACKS	JUNCTIONS	SOLDER TYPES	SOLDERLESS	MINIATURE	SUBMINIATURE	PATCH PANELS & CORDS	POWER PLUGS & RECEPTACLES	POWER CORDS	WIRE & CABLE SETS	HARNESSES	HIGH VOLTAGE CABLES	SUBMINIATURE	TOOLS	PINS, PLUGS & SOCKETS	STANDOFFS	BINDING POSTS	RING TERMINALS	SPADE TERMINALS	FLAG TERMINALS	SPLICES	MALE & FEMALE BLADES	PIGTAILS	EYELETS	CLIPS	TOOL
PYRO ELECTRIC, INC., Muskin Rd., Walkerton, Ind.								X																								
PYROMETER CO. OF AMERICA, INC., Penndel, Pa.								X											*X													
RAYTHEON CO., Components Div. Ind. Components Oper., 465 Center, Quincy, Mass.	X					X	X				X		X	X											X							
ROYAL INDUSTRIES, 1702 Wayne Street, Toledo 9, Ohio										X						X	X	X														
RYE SOUND CORPORATION, 145 Library Lane, Mamaroneck, N. Y.	X	X	X			X			X		X	X	X			X		X	X				X		X		X			X		X	
SEALECTRO CORP., 225 Hoyt St., Mamaroneck, N. Y.	X		X			X	X				X		X	X	X			X	X		X		X	X			X						
C. SJOBERG & SON, 415 Station Ave., Cranston, R.I.																							X			X	X	X	X	X	X	X	X
SPECIALTY SOCKET CO., 305 Ft. Lee Rd., Leonia, N.J.																							X	X									
STANDARD CONNECTOR CORP., 57 State St., North Haven, Conn.			X													X																
STATHAM INSTRUMENTS, INC., 2211 Statham Blvd., Oxnard, Calif.			X					X		X	X	X																				
SUPERIOR ELECTRIC CO., 383 Middle St., Bristol, Conn.																X									X								
SWITCHCRAFT, INC., 5555 N. Elston Ave., Chicago, Ill.		X	X			X					X	X	X	X	X																	
TECHNICAL MATERIEL CORP., 700 Fenimore Rd., Mamaroneck, N.Y.						X	X				X	X	X	X	X	X			X				X										
TELEPHONE DYNAMICS CORP., 32 Sunrise Hwy., Baldwin, L.I.		X	X			X	X				X		X																			
TELERAD MFG. CORP., Lionel-Anton Div., Hoffman Pl., Hillside, N.J.		X					X				X	X	X	X			X	X	X		X												
THERMO ELECTRIC CO., INC., 109 5th St., Saddlebrook, N.J.								X					X																				
THOMAS & BETTS CO., 36 Butler St., Elizabeth, N.J.																			[1]X				X			X	X	X	X	X	X		X
TOWER MFG. CORP., 158 Pine St., Providence, R.I.			X			X				X	X	X				X							X										
TRIPLE A SPECIALTY CO., 5750 W. 51st St., Chicago, Ill.																										X	X	X	X	X		X	X
TROMPETER ELECTRONICS, INC., 7238 Eton Ave., Canoga Park, Calif.									X	X			X		X																		
TRU-CONNECTOR CORP., 245 Lynnfield St., Peabody, Mass.						X			X		X				X	X			X	X													
UCINITE CO., Div. United Carr Fastener Corp., Newtonville 60, Mass.		X	X										X	X	X																		
U.S. COMPONENTS, INC., 1320 Zerega Ave., Bronx, N.Y.	X					X	X				X	X	X	X		X						X	X								X		X
VACUUM CERAMICS, INC., 15 W. Main St., Cary, Ill.			X	X				X					X	X									X										
VERITRON WEST, INC., 20245 Sunburst St., Chatsworth, Calif.			X	X				X															X	X	X	X	X	X			X		
VIKING INDUSTRIES, INC., 21343 Roscoe Blvd., Canoga Park, Calif.			X			X	X				X	X	X	X	X	X			X														
WALDOM ELECTRONICS, INC., 4625 W. 53rd St., Chicago 32, Ill.	X										X											X	X			X	X	X	X	X			X
WEST INSTRUMENT CORP., 3860 N. River Rd., Schiller Park, Ill.								X																									
WINCHESTER ELECTRONICS DIVISION, Litton Industries, Main St., Oakville, Conn.						X	X	X			X	X	X	X		X						X	X	X	X								
ZORAN, INC., 4853 N. Ravenswood Ave., Chicago, Ill.		X																X	X						X								

*Thermocouple

[1]Ty-Rap ties and systems for cable harnesses

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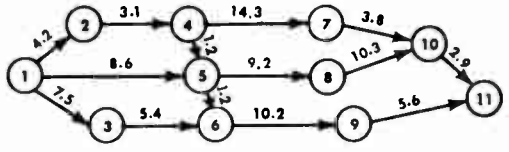
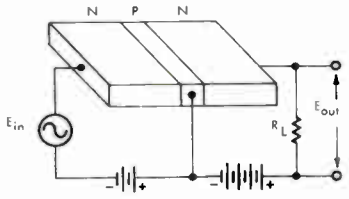
PERT



12. Examine the network you have just constructed.
   (a) Identify the critical path by giving the sequence of events along the path: _____.
   (b) Give the T_E which you calculated for the ending event of the network _____ weeks
   (c) It is now reported that activity 6-9 cannot be completed in less than 11.8 weeks. Will it still be possible to meet T_L? ☐ yes ☐ no
   (d) If the changes mentioned in (c) above would make it impossible to plan completion of the project by the time the allotted span has run out, what can he do to replan so that he does meet the schedule?

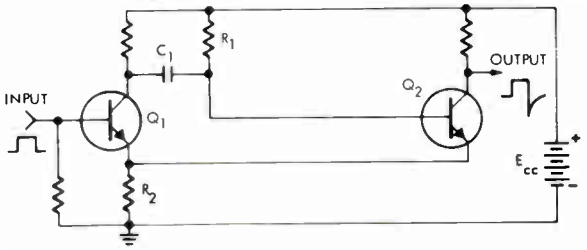
INTRODUCTION TO TRANSISTORS



29.
   (a) The NPN transistor circuit illustrated above operates as a(n) _____.
   (b) With reference to the circuit shown above, MATCH the items below on the left with those on the right by placing one letter in each blank:

A. base-collector junction	1.___high impedance
B. emitter-base junction	2.___input impedance
	3.___low impedance
	4.___output impedance

BASIC TRANSISTOR CIRCUITS



27.
   (a) The schematic diagram above shows an emitter-coupled one-shot _____.
   (b) In the stable state Q_1 is ☐ on ☐ off and Q_2 is ☐ on ☐ off.
   (c) The positive pulse turns on Q_1 which in turn: ☐ cuts off Q_2 ☐ turns on Q_2.
   (d) When C_1 discharges, Q_2 is: ☐ cut off ☐ turned on.
   (e) When Q_2 conducts, drawing current through R_2, Q_1 becomes _____ biased.

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Time (hrs.)	11.3	10.5	9.4	13.3	19.0	13.8	11.3	9.5
Age (yrs.)	36	22	44	48	52	47	47	50
Score (%)	94	97	97	94	92	87	80	79

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Salary Desired to Change Jobs in present area _____

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Company	Div. or Dept.	Title	Dates

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MICROELECTRONIC DEVELOPMENTS . . .

The first commercial computer in the information sciences to use monolithic integrated circuits (SDS 92), according to Scientific Data Systems, has been delivered to Beckman Instruments. SDS engineers say that one 3/8-inch circuit replaces about 40 second generation components.

Computer Test Corp., Cherry Hill, N.J., announces development of the SSE-1100 Memory Exerciser. The firm reports that it is the industry's first commercially available automatic test system using off-the-shelf integrated circuits to do all the logic, timing and error checking for the entire system.

"The electronic industry's first line of diode-transistor-logic (DTL) integrate circuits for commercial EDP use" has been introduced by Molecular Electronics Division of Westinghouse Electric Corp. At the same time, Raytheon becomes second source for certain molecular integrated circuits now made only by Westinghouse.

5-NSEC INTEGRATED CIRCUITS FOR HIGH-SPEED COMPUTERS

A new line of monolithic emitter-coupled logic (ECL) gates featuring high speed, moderate power dissipation, excellent logic flexibility, and the multi-function approach to system economy has been introduced by Texas Instruments Inc.

The unsaturated logic gates were specifically designed for large, high-speed, ground-based computer systems, report TI engineers. They have a propagation delay of 5 nsec.

The integrated-circuit line initially includes two gates: SN7000 and SN7001. The SN7001 is a dual OR/NOR gate including two output resistors which may be connected to any of the four outputs. The SN7000 differs in having an additional pair of output resistors internally connected. Both units contain a 3-input and 2-input gate in the same double-epitaxial silicon bar.

NEW LABORATORIES

Three laboratory units for advanced development of communications techniques in microwaves, high frequency, and weapons systems have been established, reports Sylvania Electric Products Inc.

BUSS: The Complete Line of Fuses and . . . .

NEW TECH DATA

Application Notes

This package of 7 sweep generator application notes will aid in the selection of the best sweep technique for a particular testing problem. Each note gives a step-by-step procedure and shows oscillograms. In addition, a sheet is included which defines such marketing techniques as birdy markers, absorption markers, sideband markers, etc. Telonic Industries, Beech Grove, Ind.

Circle 244 on Inquiry Card

Digital Voltmeter

This bulletin describes a 5-digit digital voltmeter. It measures, averages, or mathematically integrates voltages from ±1μv to ±1kv. Comprehensive details are given on the operating principle and applications of integrating dvms. Non-Linear Systems, Inc., P. O. Box 728, Del Mar, Calif.

Circle 245 on Inquiry Card

Instrument Catalog

Precision voltmeters, transfer standards and accessories, precision and high voltage power supplies, voltage dividers, galvanometers, calibrators, microvolt potentiometers, and related accessories are described in this 16-page brochure. It contains photos and operating specs. John Fluke Mfg. Co., Inc., P. O. Box 7328, Seattle, Wash.

Circle 246 on Inquiry Card

Semiconductor Guide

This semiconductor replacement guide describes the SK series transistors and silicon rectifiers. Thirteen of the transistors described can replace 2700 types of transistors currently being used in the entertainment industry. Included in the description is a chart listing 2700 transistor types and their replacements. Radio Corp. of America, Electronic Components and Devices, Harrison, N. J.

Circle 247 on Inquiry Card

Circuit Cooler

Data is available on a line of forced air cooling equipment for electronic uses. The Model 6EB300 is packaged centrifugal blower designed for cooling and pressurization of tightly packed rows of card-mounted solid-state component circuits in electronic enclosures. It delivers just the right quantity, pressure, and distribution of air required for the purpose. McLean Engineering Laboratories, P. O. Box 228, Princeton, N. J.

Circle 248 on Inquiry Card

Shielding Analogies

A common language that will aid personnel working in RFI to communicate with others outside the field is given "Some Useful Analogies for RF Shielding and Gasketing." This paper offers some analogies or word pictures that should help solve this problem. Technical Wire Products Inc., 129 Dermody St., Cranford, N. J.

Circle 249 on Inquiry Card

Relay Bulletin

Bulletin 6042H171 describes a new 50a., 3PDT relay. Particularly applicable as a power transfer device, it meets or exceeds the requirements of Mil-R-6106E. A pancake-type magnet makes it almost 50% lighter than previous designs. The semi-balanced armature enhances vibration (10G's @ 35 cps; 8G's @ 1500 cps) and impact shock (50G's) resistance. Cutler-Hammer Inc., 436 N. 12th St., Milwaukee, Wisc.

Circle 250 on Inquiry Card

Inductive Devices

This 20 page, 3 color catalog provides data on an entire line of inductive devices. It provides descriptions, application notes, and general features of each. Detailed specs., product and facility photographs, graphs, and engineering drawings are also included. Vanguard Electronics Co., 930 W. Hyde Park Blvd., Inglewood, Calif.

Circle 251 on Inquiry Card

Band-Pass Filters

Data is available on a group of low-priced, coaxial, fixed-tuned, band-pass filters. The filters have a construction of 2 to 5 sections with 3db bandwidths of 2, 5, 10 or 20% of center freq. Center Freqs. range from 100 to 3200mc. Sectionalized construction permits the user to specify a filter custom-made to meet his own center freq. requirements and still pay off-the-shelf prices. RLC Electronics Inc., Port Chester, N. Y.

Circle 252 on Inquiry Card

NEW TECH DATA

Magnetic Shields

Data Sheet 177 illustrates and describes various photomultiplier magnetic shields. The units can be shorter in length and yet give better protection from magnetic fields than shields previously variable. Magnetic Shield Div., Perfection Mica Co., 1322 No. Elston Ave., Chicago, Ill.

Circle 253 on Inquiry Card

Amplifier Chart

This chart lists the operating characteristics of a line of solid-state operational amplifiers. The units described meet the requirements in measurement, computing, control, data processing, and testing applications. Philbrick Researches Inc., Allied Drive at Rt. 128, Dedham, Mass.

Circle 254 on Inquiry Card

Switches/Resistors

This 32-page catalog contains data on a line of switches, resistors, and potentiometers. Each unit is accompanied by application data, photos, and operating ranges. Included is an off-the-shelf list of military potentiometers. Clarostat Mfg. Co., Dover, N. H.

Circle 255 on Inquiry Card

Toroid Data

Bulletin 301 contains specs. for toroidal ferrite cores with initial permeabilities higher than 5000. Included in this bulletin are detailed electrical, magnetic and mechanical specs. as well as curves for loss factor vs. freq., permeability vs. freq., and permeability vs. temp. Ferroxcube Corp., Saugerties, N.Y.

Circle 256 on Inquiry Card

Tool Catalog

This 16-page catalog describes precision tools especially selected for instrument manufacture and repair. The first section of the catalog is devoted to precision soldering tools. The second section features a complete line of tools for electronics. Included are instrument pliers, needle files, precision tweezers, tiny knives, knife sets, etc. Telvac Instrument Co., 18531 Ventura Blvd., Tarzana, Calif.

Circle 257 on Inquiry Card

Impedance Measurements

"Impedance Measurements from 20MC to 2GC with a New Standing Wave Detector" presents theory and operation of the PRD 219 Standing Wave Detector for coaxial systems. The unit eliminates heavy coaxial slotted sections, has interchangeable calibrated susceptances, a universal output jack, and is lightweight and portable. PRD Electronics, Inc., subs. of Harris-Intertype Corp., 1200 Prospect Ave., Westbury, L. I., N. Y.

Circle 258 on Inquiry Card

Metal Selector Chart

This clad metal selector chart should be of interest to those who seek diverse engineering properties beyond today's metal and alloys. The chart covers capabilities in the cladding or bonding of dissimilar metals for use in the production of precision parts for industry. Electronic Metals and Alloys, Inc., 84 Dunham St., Attleboro, Mass.

Circle 259 on Inquiry Card

Coaxial Terminations

Data is available on 2 small 20w. coaxial terminations for the 0-10GC range. The 374 NM weighs less than 5½ oz., and 374 NF weighs less than 4½ oz. Both types are 2½ in. long by 1½ in. dia. (max.). VSWR is 1.05 in the 0-4GC range, and 1.25 in the 4-10GC range. Narda Microwave Corp., Plainview, L. I., N. Y.

Circle 260 on Inquiry Card

Variable Delay Lines

Data is available on a family of electrically-variable delay lines for use in precision trimming applications. The units use high Q silicon voltage-variable capacitors and ultrastable miniature inductors coupled with advanced network design techniques. The resulting units feature wide delay swings, broad bandwidths and dynamic range, and high reliability. LFE Electronics, div. of Laboratory for Electronics, Boston, Mass. 02115.

Circle 261 on Inquiry Card

NEW TECH DATA

Logic Design Aid

The 32-page technical booklet is for digital logic systems designers. Entitled, "Short Cuts to Successful Logic Systems" the brochure contains much of the basic data needed for successful use of welded logic modules. The contents include a discussion of NAND/NOR logic concepts; a glossary of logic systems terminology; basic equations; circuits and module operating parameters; mechanical specs. for modules; and accepted test procedures. Also included is a module selector chart designed to speed and simplify system spec. Magnetic Systems Corp., 2000 Calumet St., Clearwater, Fla.

Circle 233 on Inquiry Card

Zener Diodes

Data is available on a new line of economically priced, high-reliability 50w. zener diodes. Called the 50T Series, the line consists of 35 voltage ratings from 6.8 to 200v. They have large junctions and lower impedance in the avalanche region for increased reliability. The zeners are in hermetically sealed stud-mounting cases which are 0.425 in. dia. The large ¼-28 stud and 9.16 in. hex base effectively conduct heat away from the junction to the heat sink. Sarkes Tarzian Inc., 415 N. College Ave., Bloomington, Ind.

Circle 234 on Inquiry Card

Integrated Circuits

This 18-page design/application manual, "Integrated Logic," describes the Series L integrated logic modules. The manual includes general data on the characteristics of the Series L line, specs. and block diagram for each modular type, applications data and prices. It is intended as a guide to the efficient use of integrated logic modules in solid state digital systems. Digital Products, Box 1351, 335 W. 7th St., San Pedro, Calif.

Circle 235 on Inquiry Card

Instrument Article

The use of function modules to build industrial control systems is described in reprints of an article described in Bulletin 603. The article is entitled, "A Building Block Approach to Industrial Instrumentation Systems." Available from Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

Circle 236 on Inquiry Card

Circuit Modules

Data is available on a new family of digital, integrated circuit modules. Called the "F" series, the new line coupled with the existing Abacus "I" series makes available monolithic integrated circuit modules with a choice of flat packs with 36 pin connectors or TO-5 cans with 52 connectors. A few of the circuits available are NAND/NOR gates, flip-flops, lamp and relay drivers, clock sources, etc. Modules operate at speeds up to 5MC with drive capability of 8 unit loads and 40pf. Whittaker Corp., 9229 Sunset Blvd., Los Angeles, Calif.

Circle 237 on Inquiry Card

NEW TECH DATA

S-Band Signal Source

Data is available on an all solid-state crystal-controlled signal generator for testing and determining performance characteristics of S-band equipment. Model 4510 generator is for the 2.0-to-2.4GC band. It has the phase and freq. stability necessary for testing precision communication and tracking receiving systems. The continuously variable output level is calibrated from 0 to —140dbm. The output freq. is continuously tunable over a range of ±200KC and can be phase modulated and freq. modulated, either separately or simultaneously. ITT Federal Laboratories, 15151 Bledsoe St., San Fernando, Calif.

Circle 238 on Inquiry Card

Digital Printer

This brochure describes the Model 410A high-speed digital printer. The 410A can print more than 10 lines/sec., yet is competitive in price with instruments limited to 3-to-5 lines/sec. It offers 8-digit column printing with up to 4 additional columns optional. Computer Measurements Co., 12970 Bradley Ave., San Fernando, Calif.

Circle 239 on Inquiry Card

Power Supply Catalog

This 16-page dc plug-in power supply catalog contains line drawings, specs. and prices. Both single output and dual output models are described in detail. Acopian Corp., Easton, Pa.

Circle 240 on Inquiry Card

Facilities Brochure

A 2-color, 10-page folder, "Available, A Backlog of Experience," depicts experience and facilities for performing engineering and production work in the areas of guidance, automatic controls, data display systems, communications and instrumentation and automatic test equipment. LTV Military Electronics Div., Ling-Temco-Vought, Inc., P. O. Box 6118, Dallas, Tex.

Circle 241 on Inquiry Card

Relay Bulletin

GEA-6628C, 22 pages, describes an entire line of sealed relays. The 9 product types, including some recently introduced, are discussed in detail with features, description, uses, ratings, specs. and pricing information listed for each type. Dimensional drawings and mounting forms are shown. General Electric Co., Schenectady 5, N. Y.

Circle 242 on Inquiry Card

Spacer Resin

Exact and unchanging gap spacing in "U" core sections on fly-back transformers, inductors and other magnetic devices can now be achieved with Posi-Gap spacer resin. The resin dries at room temp. and is filled with precision sized glass beads. Spacing is controlled by the bead size. Complete details available from 3M Co., 2501 Hudson Rd., St. Paul, Minn.

Circle 243 on Inquiry Card

NEW TECH DATA

Engineering Kit

Data is available on an engineering kit which contains 10MC DTL integrated circuits. This kit included flip-flops, 2 and 4 input NAND gates, gate extenders, line drivers, 1 shots, a clock source and interface circuitry. Also included are connectors, a mounting panel and a convenience walnut storage container. Microsystems Components, 5353 Topanga Canyon Blvd., Woodland Hills, Calif.

Circle 262 on Inquiry Card

Trigger Diode

The ST Trigger Diode is a symmetrical 3-layer avalanche unit used in activating SCRs and bi-switches. Its unique characteristic is a symmetrical switching mode which fires whenever the breakover voltage is exceeded in either direction. The average power dissipation at 50°C is 1w. with a peak current capability of 1a. for 20μsec. Details available from P. R. Mallory & Co, Inc., 3029 E. Washington St., Indianapolis, Ind.

Circle 263 on Inquiry Card

Terminals Bulletin

Bulletin 320-465 describes glass-to-metal hermetic seals and terminals. Complete dimensional and electrical data are given for single and multiple lead terminals and terminal headers, graded seals, strain-relief terminals and seals, diode housings and compression seals. Latronics Corp., Latrobe, Pa.

Circle 264 on Inquiry Card

Pulse Generators Catalog

This 3-color condensed catalog contains major specs., general descriptions, and prices for 25 standard pulse generators, digital data generators, and plug-in output units. Domestic and foreign representatives and service centers are also listed. Datapulse, div. of Datapulse Inc., 509 Hindry Ave., Inglewood, Calif.

Circle 265 on Inquiry Card

Welding Equipment

Catalog 107, 20 pages, describes a complete line of precision stored-energy welding equipment. Illustrated are power supplies, welding heads and handpieces, modular weld stations, electrodes, and accessories. It also contains electrode selection data and customer services information. Weldmatic Div. / Unitek, 950 Royal Oaks Dr., Monrovia, Calif.

Circle 266 on Inquiry Card

FM Devices

Data is available on a complete family of FM telemetry components, including 3 basic types of sub-carrier voltage controlled oscillators. Included in the line are a high-level, differential input VCO; a low level differential input VCO; a high-level single-ended VCO; a wide-band summing amplifier, and a line of component mounting assemblies. All standard IRIG channels and deviations are available. Hughes Electronic Products Div., P. O. Box H, Newport Beach, Calif.

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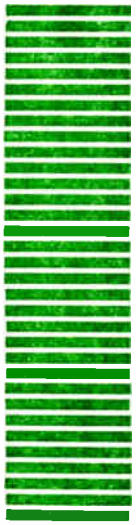

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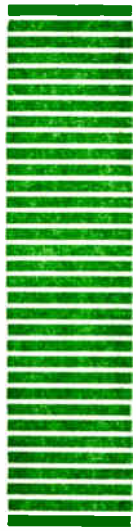

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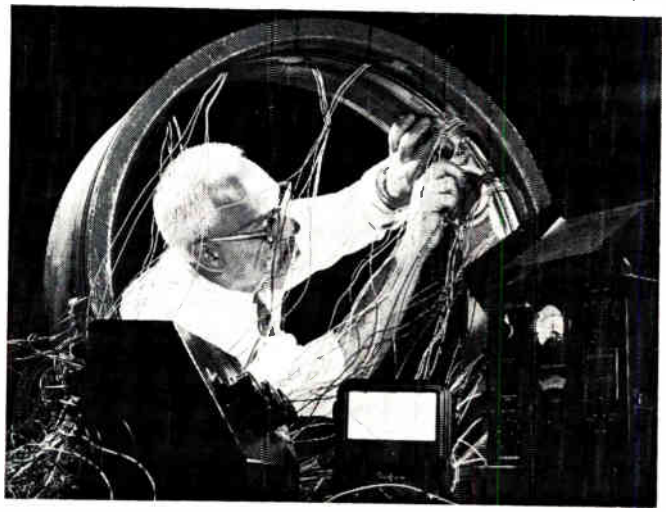
By electrically measuring built-in stresses that develop during fabrication, engineers at Goodyear are attempting to determine the longevity of steel rims before actual load tests. The old way of testing after rim assembly was too costly.



A two-week course in electromagnetic measurements and standards will be conducted Aug. 9-20 at the Boulder Labs of the National Bureau of Standards. The course, which is offered in cooperation with the Univ. of Colo., will consist of about 40 lectures.

The problems of testing integrated circuits may have been greatly reduced by a digitally controlled power system developed by Rowan Controller Co., Eatontown, N.J. The programmable unit, Model 620, is capable of 2½ billion combinations of voltage and current in steps of 1 μa or 10 μv. The output current range is programmable from 1 μa to 500 ma in 1 μa steps. Output voltage range is 0 to 50v in 10mv increments. Regulation is 0.3%.

All types of circuits, printed-circuit boards and I/C micrologic packages, can be tested on the Sequential Component Automatic Test System (SCAT). The tester performs differential DC and AC voltage measurements from 100v to 1mv, and current measurements from 100ma to 10pa. SCAT, a product of Continental Device Corp., Hawthorne, Calif., also makes pulse measurements to 10GC in the same socket used for DC tests.

Direct reading of the metallic element concentration in a solution or suspension without manual calculation is provided a digital concentration readout. The readout, made by Perkin-Elmer, Norwalk, Conn., is intended for their Model 303 Atomic Absorption Spectrophotometer. In operation the operator need only test a sample solution and adjust the accessory to read 1000. Subsequent unknowns will then read out in parts per million without calculation.

Measuring distances to 10,000 ft to within ±½ foot is easily accomplished by the Model 5210 Ranging Unit by Eldorado Electronics, Concord, Calif. The unit is an operational time interval counter which measures and visually indicates distance based on the radar foot (2.035 nsec.). Operating range is 1 ft. to 10,000 ft.

A series of scientific bulletins designed to inform the researcher of the latest developments in application and measurement of radioactivity and related investigations are contained in a publication called The Nucleus®. These bulletins are available free from Nuclear-Chicago, 359 Howard St., Des Plaines, Ill.

It is now possible to check the characteristics of thin-films while they are being deposited. An x-ray diffractometer attachment permits comprehensive in situ x-ray diffraction analysis of thin films. The unit provides both quantitative and qualitative measurements. It permits accurate x-ray intensity measurements at very specific angles of incidence with respect to the film being examined. The attachment is a product of Materials Research Corp., Orangeburg, N.Y.

Interferometer precision is extended when used with mirror rotator. Mirror can be rotated in either direction at speeds from 0.1 to 3 arc-seconds/sec. Applications include measurement of refractive index differences and gradients, diffusion, ion transport, and large molecular weights. For more information write: Kollmorgen Corp., 347 King St., Northampton, Mass.

An Area Monitor, which uses a pulse rate electrometer, provides drift-free ionization chamber detectors for accurate monitoring of pulsed and continuous radiation. The system, Model RMI-110, was developed by Tracerlab/West, Richmond, Calif., for monitoring accelerators, reactors and other nuclear facilities.

An instrument that detects leaks as small as 0.1 cu in./hr. has been built by Beckman Instruments Inc., Fullerton, Calif. Called the Infrared Leak Detector, it works on a gas-sensing principle. A gas not found in the atmosphere is inserted in the system to be checked. Then a probe collects a continuous sample of the atmosphere surrounding the tested system. If a leak is detected, an audio signal occurs and a readout instrument indicates the severity of the leak.

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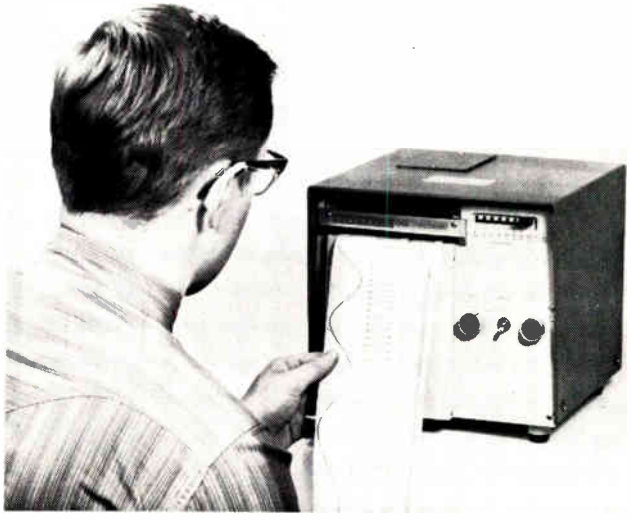
Laboratories working on a limited budget, and who need a direct writing oscillograph get a real break with the Honeywell Model 1706 Visicorder. It records up to 6 channels of h-f data. Dynamic data such as strain, pressure, vibration, and acceleration can be recorded simultaneously at 8 paper speeds.



EMC sets certain requirements for spectrum analyzers, field intensity meters, signal generators and coupling devices. These are discussed in terms of dynamic range, calibration accuracy, spurious effects and the like.

Electromagnetic Compatibility

THE INCREASING USE OF THE ELECTROMAGNETIC SPECTRUM and increased complexity of electronic equipments requires serious consideration of the interference problem. Electromagnetic compatibility (EMC) aspects of equipment and systems engineering usually involve the measurement and evaluation of specialized equipment characteristics in order to establish interaction relationships.

The data requirements for EMC analyses are often similar to the empirical information needed for general equipment and system analysis, or ECM analysis. However, two unique compatibility analysis requirements often result in selected measurements which are peculiar to EMC evaluation.

First of all, information is required over a wide range of system parameters and variables, and often includes ranges considered beyond the control of normal equipment and system design. For example, far out-of-band transmitter emission or receiver response characteristics may be measured to evaluate the significance of coupling via such spurious frequency paths. Similarly, receiver system performance over a wide variety of signal input levels may be of concern.

Secondly, data are often necessary over a wide range of system spectral relationships, more numerous and specialized than those generally involved in ECM studies. For example, it is important to evaluate particular receivers against many classes of modulation the system was not designed to accept, or to establish the effects of a range of response bandwidth against particular potential interference modulations.

EMC data requirements are dictated by the type of compatibility problem to be evaluated, and the objectives of the analysis. Problems may encompass a variety of internal equipment, intra-system, and inter-system arrangements, for the purpose of specification compliance, performance evaluation, frequency assignment, site selection, frequency allocation, or other reasons.

The Compatibility Standard

The "bible" for compatibility measurements is currently MIL-STD-449(B)[1]. This standard describes measurement procedures and instrumentation requirements for the equipment parameters listed in Table 1. The "C" version of the standard has recently been prepared by the Dept. of Defense, and will soon be available for distribution.

The new version of the standard will differ from earlier versions in the following areas:

Three additional tests have been added. These include the measurement of receiver impulse response, audio selectivity, and FM discriminator bandwidth.

Tests of emission spectrum characteristics and spurious emission have been consolidated with more emphasis on the performance of narrow band, non-radiated measurements. Broadband calibration of spectrum analyzers has been added.

The CW desensitization and the adjacent signal interference tests have been combined, and the basic test approach has been redefined.

Test limits have been added for many equipment parameters. For example, a low frequency limit based on waveguide cutoff has been incorporated. Limits on receiver and transmitter intermodulation have also been included.

Table 1: Categories of Measured Data (MIL-STD-449B and C)

TRANSMITTER	RECEIVER		ANTENNA
fundamental power output	sensitivity	CW desensitization	
emission spectrum	selectivity	dynamic range	
spurious emissions	spurious responses	oscillator radiation	horizontal and vertical
modulation characteristics	overall susceptibility	MIL-STD-449C only	polarization patterns
intermodulation	intermodulation	impulse response	
modular bandwidth	adjacent signal interference	audio selectivity	
carrier frequency stability	pulse desensitization	FM discriminator bandwidth	

By H. M. SACHS,

Deputy Director of Technical Operations,
Electromagnetic Compatibility Analysis Center,
U. S. Navy Marine Engineering Laboratory, Annapolis, Md.

Measurements

A supplement to the standard will contain detailed data collection formats.

A major distinction is made in the standard between closed-system (non-radiated) tests and open-field (radiated) tests for both transmitter and receiver parameters.

Closed System (Non-radiated) Measurements

A considerable percentage of EMC equipment characteristics data is procured by directly coupling instrumentation to the unit under test. All communication transmitter and receiver data are obtained in this way, and more and more radar emission measurements are being performed in this manner.

The basic procedure for measuring non-radiating transmitter characteristics is shown in Fig. 1. Energy is coupled to the measuring equipment through a signal sampling device, which may be a voltage divider, power attenuator, probe, directional coupler, or similar unit, depending on the equipment type and frequency range of interest. Under conditions when energy can propagate between the transmitter and the antenna or dummy load in a variety of modes, the sampling device must couple to all of the modes involved.

Calibration is by the signal substitution method. The frequency-selective voltmeter for closed-system tests is generally a spectrum analyzer, although wide-band data from a field-intensity meter may sometimes be required.

Similarly, Fig. 2a indicates the closed system receiver measurement procedure for single signal tests; and Fig. 2b illustrates the two-signal receiver test procedure.

A limitation exists in performing non-radiating compatibility measurements, since data is collected within

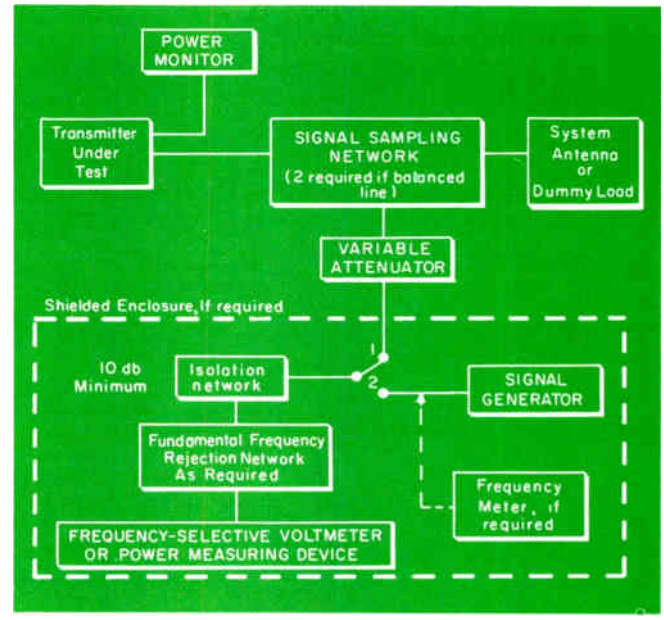


Fig. 1: Typical closed-system (non-radiated) measurement setup.

the system and does not directly represent either the energy radiating from the transmitter antenna, or the radiated energy to which the receiver is susceptible. A complete picture of the radiated emission or susceptibility characteristic of the system can only be obtained after the insertion losses and mismatch losses of the system transmission line components and antenna are taken into account.

Another limitation to in-guide measurements is that it is difficult to obtain valid information under conditions when multiple-mode propagation can exist. Various types of transmission lines, but particularly microwave waveguide systems, can support different types of electric and magnetic field distributions within the guide, as defined by the guide dimensions and material. For example, for rectangular, air-filled waveguide with broadwall dimension twice the narrow wall dimension, the first or dominant mode will propagate above frequency $f_{(1,0)} = \frac{c}{2a}$, where c is the velocity of light, and a is the broadwall dimension in corresponding units. Other propagation modes will be supported above cutoff

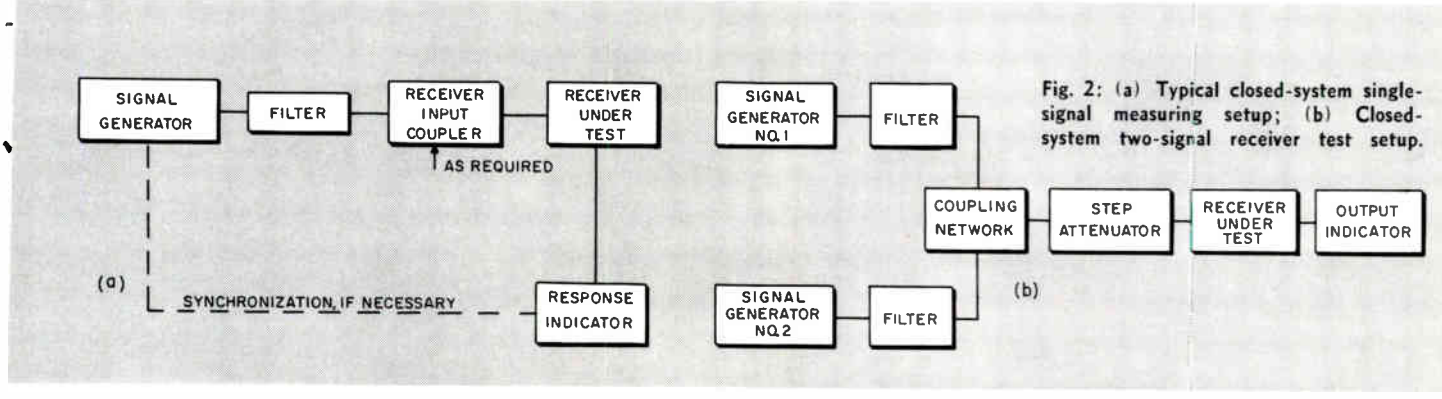


Fig. 2: (a) Typical closed-system single-signal measuring setup; (b) Closed-system two-signal receiver test setup.

frequencies corresponding to $f_{(m,n)} = \frac{c}{2a}[m^2 + 4n^2]^{1/2}$, where m and n denote the order of the particular mode. This relationship is shown in Fig. 3, up to the sixth harmonic of the system tuned frequency.

FOR AIR FILLED RECTANGULAR WAVEGUIDE WITH 2:1 RATIO OF INSIDE DIMENSIONS

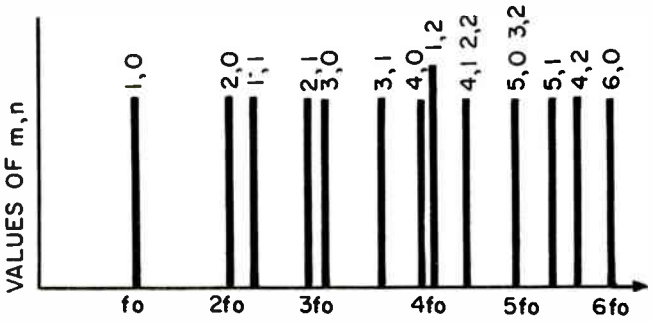
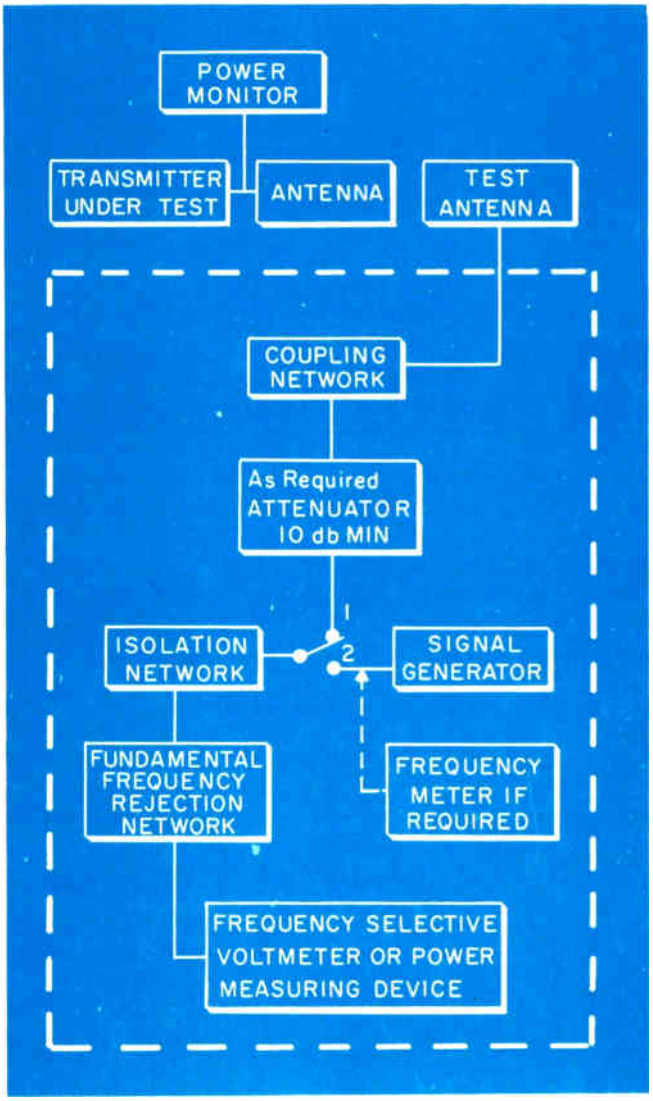


Fig. 3: Frequencies above which various TE_{mn} and TM_{mn} modes can propagate.

Fig. 4: Typical open-field (radiated) measurement block diagram.



Multimode couplers have been and are being investigated and developed,[2] but no such device has been generally accepted to date. For compatibility analysis purposes, a satisfactory multimode coupling device must either (1) couple to each significant mode separately, or (2) couple to the total energy in the guide, independent of mode.

Open-field (Radiated) Measurement

Radiated compatibility measurements are now used in monitoring transmitter emission characteristics in that part of the spectrum where multiple-modes may propagate in the system guide. In this respect, the major concern is with radar systems. Practical problems associated with the availability of suitable high power signal generators have resulted in the suspension of radiated receiver susceptibility testing.

The basic approach for radiated emission measurements is shown in Fig. 4. The major difference here as compared with Fig. 1 is a calibrated test antenna system capable of being moved in space so that a position of maximum received energy can be located. The requirement for radiated radar measurements is a physical separation between the system and test antennas of at least $\frac{D^2}{\lambda}$ (where D is the maximum aperture dimension of the larger antenna, and λ is the wave length at the fundamental frequency). The resultant peaks due to direct and reflected energy will generally occur a few feet apart, with the lowest peak several feet off the ground.

Radiated measurements may become relatively time-consuming, since antenna reorientation in azimuth and elevation, and test antenna height adjustment for every measurement frequency change is necessary to maximize the received signal. Sighting effects must also be considered in the interpretation of the data. The dynamic range of radiated measurements can generally be expected to be somewhat less than in-guide measurements, since typical propagation loss values are higher than losses in typical signal sampling devices.

Instrumentation Requirements

It is desirable to have spectrum analyzer and field-intensity meter spurious responses well below the instrument sensitivity levels (perhaps 80-100 db down). Unless this can be assured, it becomes necessary to identify whether or not a received signal is due to a transmitter spurious emission or to an instrument spurious response. This can generally be accomplished by the judicious use of high-pass or bandpass filters, but their applications are not amenable to automatic data collection.

It must be recognized that, particularly in the case of spectrum analyzers, emission measurements may have to be made in the vicinity of spectral energy of considerable relative power. Under these circumstances, analyzer overload can be expected, with the resultant effect of degrading its amplitude calibration. The overload

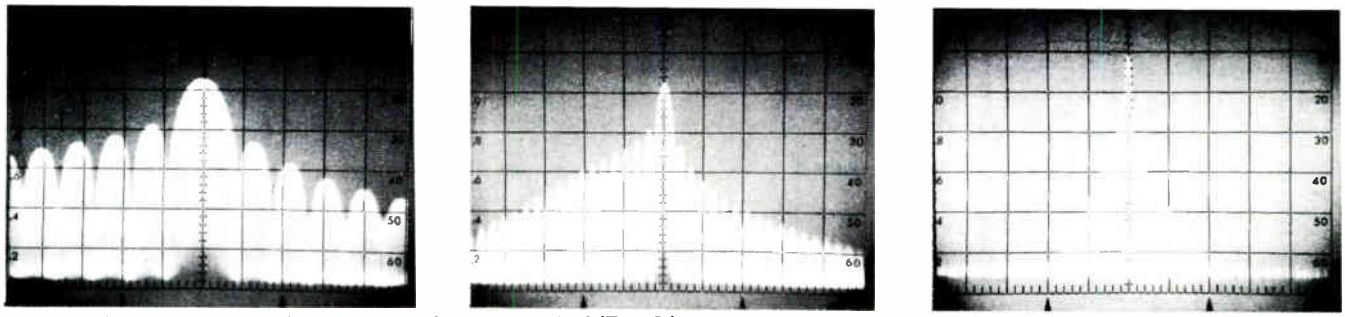


Fig. 5: Pulse spectrum with dispersion (a) of approximately 1/T MC/cm; (b) approximately 4/T MC/cm; (c) approximately 10/T MC/cm.

characteristics of these receivers should be determined by noting the change in observed spectral waveshapes as attenuation is removed ahead of the analyzer. Normal instrumentation operation should be restricted to measurements below the established overload level, taking into account the fact that notch or other filter types may be employed to keep input spectral energy below the overload level.

As noted in MIL-STD-449 ( ), the CW sensitivity of the measurement receiver is a function of its tuned frequency. Minimum sensitivity levels for both closed-system and open-field measurements are the same, varying from −90 dbm below 300 MC to −50 dbm above 10,000 MC. These levels are intended to provide a reasonably wide dynamic range of measurement, although it is hoped that sensitivity levels at higher frequencies might be improved at some future date. For example, the goal of pulse spectrum measurements is to obtain a description of transmitter emission characteristics for power density levels exceeding −50 dbm using a relatively broadband instrument, and correspondingly better with a narrow band device.

A minimum spectrum analyzer pulse display range of 60 db is desirable. The display should be linear with respect to the logarithm of power. A variable dispersion range from about $\frac{1}{T}$ MC/cm. (where T is the pulse width in μsec) to perhaps $\frac{10}{T}$ MC/cm. seems satisfactory, the particular dispersion used being a function of the immediate structure of the spectrum being analyzed. The total spectrum to be investigated (which typically will be from 0.9 dominant mode waveguide cutoff to that frequency at which multiple-mode propagation can begin) is assembled from successive analyzer photographs of this type. Spectrum analyzer displays are shown in Fig. 5, for dispersion ranges of about $\frac{1}{T}$, $\frac{4}{T}$ and $\frac{10}{T}$ MC/CM. Note a dynamic range of about 55 db in the latter figure.

The resolution bandwidth of the spectrum analyzer must be known and recorded. The sweep rate must be chosen so that the sensitivity of the instrument is maintained.

It is very important that, concurrent with the measurement of pulse emission spectral characteristics, the time waveform characteristics of the signal under investigation be determined. This can best be accomplished by the closed-system test setup shown in Fig. 6. Primary concern here is a matched, wideband (at lease 30 MC) detection system to eliminate pulse distortion and adequately portray pulse rise and decay time.

Care must be taken to assure that harmonics of signal generators employed for receiver susceptibility measurements are attenuated sufficiently to prevent false receiver responses. This can be accomplished using low-pass or band-pass filters after the generator. Insertion loss of the filter at the tuned frequency of the signal generator must be known and taken into account in the data reduction process. The level of harmonic rejection is required such that receiver responses are due only to the generator fundamental.

Some pulse signal generators of the master oscillator-power amplifier type generate a CW output during the interval between pulses. This residual CW energy should be below the receiver sensitivity during pulse desensitization tests, and at least 30 db below the peak value of the pulse for other tests.

Accuracy in knowing the signal generator frequency (or accuracy with respect to the frequency to which the receiver under test is tuned) as high as 1 part in 10^6 is required for certain tests. In particular, the measurement of receiver selectivity, and of spurious response frequencies dictates this level of accuracy.

It is important that ancillary devices such as attenuators, couplers, transitions, and the like be calibrated across the entire measurement frequency range, and not only across the tuning range of the equipment under test. Insertion loss shall be known within 1 db at each measurement frequency. As indicated earlier, a coupler designed for operation under multiple-mode conditions must be able to identify the total forward power in a transmission system, independent of mode.

Measurement Techniques

A few of the measurement problems related to compatibility analysis will next be discussed. These may

be considered typical of the difficulties that arise in trying to assess out-of-band system performance characteristics.

In order to obtain a selectivity curve of a pulsed system indicative of its CW selectivity, a pulse signal wide enough to provide a narrow energy spectrum in comparison with the receiver bandwidth, but narrow enough to avoid erroneous bias buildup in the receiver's gain control circuits, is used. The recommended pulse width for a particular receiver test is defined as that width which, if either increased or decreased by a factor of two, would not appreciably change the receiver selectivity measurement. A rule of thumb for preliminary testing is a pulse width of ten times the nominal system pulse width.

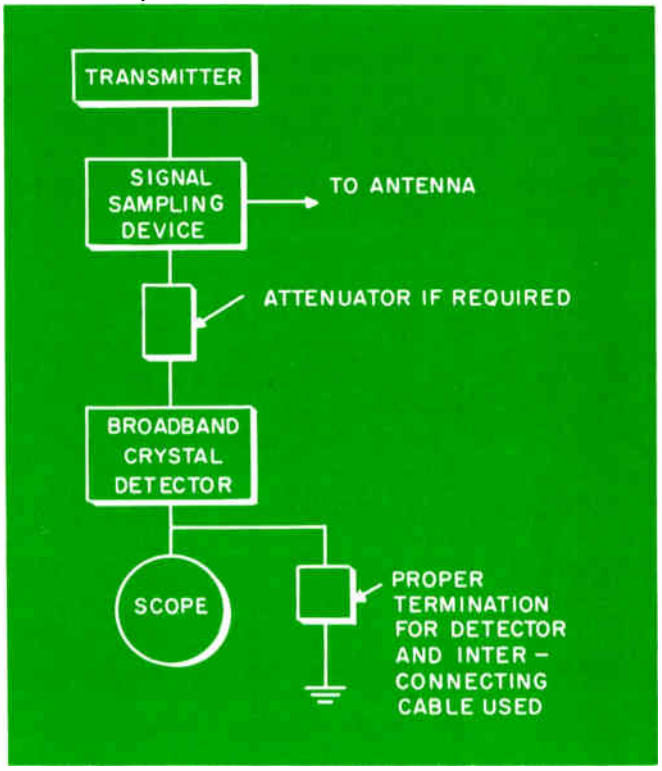


Fig. 6: Pulsed closed-system test setup for measurement of modulation characteristics.

Using this wide pulse, selectivity data is obtained based on a midpulse minimum visible signal (MPMVS) criteria. The MPMVS threshold is identical to the more conventional minimum visible signal criteria, except that only the center section of the pulse is considered in establishing the threshold. In this way, pulse leading and trailing edge transients that would influence the threshold are disregarded.

It is important that the establishment of MPMVS criteria be maintained throughout the selectivity test. This becomes difficult to do when making measurements 30 and 40 db below the receiver sensitivity level and lower, and the tendency is to establish the threshold from the leading and trailing pulse transients.

When performing receiver spurious response measurements under conditions of high level pulse input signal injection, an overloading of the receiving system may occur. This can result in what appears to be a great number of high order spurious responses, and in some cases, a general spurious background level. This phenomenon may become apparent at signal levels of −25 to −10 dbm or higher for typical receivers. One method of determing this level may be to disable the first local oscillator and, with the first mixer biased at its normal operating level, to establish that level of input signal where the effect occurs.

For spurious response measurements at pulse signal input levels below −25 dbm, it is almost always possible to identify the mechanism of response generation using the standard spurious response equation. This equation is a function of the number of receiver conversion stages. For a single conversion receiver,

$$f_{sp} = \frac{p f_{lo} + f_{if}}{q}$$

where p is an integer or zero denoting the harmonic order of the local oscillator; q is an integer (not zero) denoting the harmonic order of the mixer input signal; and f_{lo} and f_{if} denote the local oscillator and intermediate frequencies, respectively. However, this is not the case for high input power tests, and no identification should be attempted.

During the course of conducting two-signal tests such as for receiver or transmitter intermodulation, it is important to identify whether or not a particular effect is actually the phenomenon of interest, or is due to the individual signals comprising the test, or is caused by some effect within the test equipment. One convenient check is to alternately turn off each of the signals associated with the test. If the response remains when only one generator is on, it is not an intermodulation product.

With transmitter intermodulation, it is possible to further isolate the cause of the response by switching a step attenuator in and out and noting the signal level under both conditions. Transmitter intermodulation product levels will vary linearly with the change in attenuation. Intermodulation products formed in the frequency-selective voltmeter will vary in a non-linear manner.

With receiver intermodulation, a similar differentiation can be made. First, increase both signal generator output levels simultaneously by 3 db and note the receiver output level. Then insert 3 db of additional attenuation ahead of the receiver under test. Receiver intermodulation products will vary non-linearly with the amount of inserted attenuation, while signal generator intermodulation products should vary by the amount of the attenuation.

References

1. MIL-STD-449(B), Military *Standard Radio Frequency Spectrum Characteristics, Measurement of,* 29 July, 1963.
2. Goldberg, J., et al, *Final Report on New Methods for Measuring Spurious Emissions,* RADC-TDR-63-80, Contract AF 30(602)-2511, Feb., 1963.

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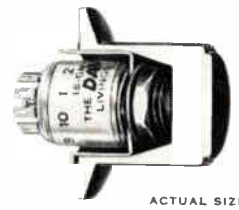

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The Series K was developed for instrument and commercial applications where the same size, quality and electrical specs as the Series G were needed . . . at a . lower cost.

Although the Series K (without knob) costs only $4.85 to $3.85 each (depending upon quantity), it is a completely enclosed unit offering long life, low contact resistance, high dielectric strength, wide operating temperature range, positive detent action and resistance to corrosion, shock and vibration. Both the Series G and K come in single deck, shorting and non-shorting . . . in various combinations up to 4 poles and 10 positions.

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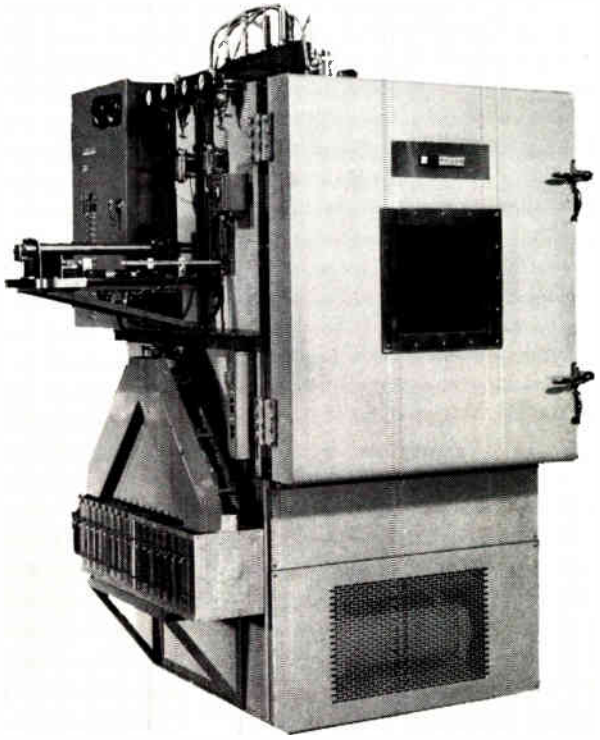
WHAT'S NEW

TEST CHAMBER SPEEDS IC TESTING



Test chamber automatically feeds and unloads 1500 devices/hr.

THE ENVIRONMENTAL CHECK IS THE MOST TIME-CONSUMING phase of IC testing. This is due to the limited speed at which the test chamber can handle circuits. If more devices can be processed/hr., production is increased and cost is decreased. The Multiple Track Automatic Environmental Test Chamber produced by Philco Corp., Lansdale, Pa., can test approximately 1500 devices/hr. This is about three times faster than existing techniques.

The test chamber automatically transfers and feeds to a test head the microelectronic devices pre-loaded into carriers. Test head selection is made by actuating a switch. This enables the operator to select a test head without opening the chamber door. An 18 track mechanism within the environmental chamber accepts device-loaded carriers through a load port. A magazine containing 16 carriers is fed through this port to a track located in line with the port. Each index of the mechanism presents an empty track to the load position. Fifteen indexes are required to move a specific track from the load position to the test location. The indexing rate is controlled by an adjustable timer, and is set to assure sufficient soak time regardless of the operating speed of the associated tester.

At the test location, a carrier is transferred to a turret which indexes into the TO-5 or flat pack test head. The positioning of the test head provides a

signal to the associated circuit tester which initiates the testing sequence. At the end of its test cycle, the tester provides a signal to the environmental chamber. This initiates the sequence for ejecting the testing device and transferring a new device into the test position. When the track at the test station is emptied, the mechanism indexes and presents the next track to the test station.

A unit may be ejected into a sorting bin array or returned into the same type magazine as was used for loading. The magazine reloading feature provides device serialization when data acquisition is performed on the associated tester.

AUDIO WAVE ANALYZER

FRONT-END PROTECTION FROM OFF-FREQUENCY SIGNALS, and full capability for frequency control and electronic scanning are typical features of the Model EWA-88 audio-wave analyzers. Frequency range is 20 CPS to 50KC. The instrument handles inputs as high as 1kv.

The instrument, a product of Fairchild Electro-Metrics, Amsterdam, N. Y., incorporates built-in electronic scanning and remote voltage tuning. It also has a wideband operating mode, permitting front-end attenuation selection to provide positive protection against signal overload. Overload protection is further enhanced by a low-pass filter at the input to attenuate all signals above 50KC.

Internal sweep rate for electronic scanning is automatically adjusted for the selected i-f bandwidths: 10 KC/min. in the 50 cycle position, and 1KC/min. in the 5 cycle position. The unit generates an X-output proportional to frequency, and a Y-output proportional to signal level, for connection to an oscilloscope or graphic recorder.

Overall dynamic range of the analyzer is approx. 200db with 40db spread on the front panel meter. It includes AFC and 5 special outputs, including restored and tracking.

Instrument features high amplitude and frequency accuracies, and very simple amplitude and freq. calibration procedures.

FIFTY-WATT R-F TRANSISTOR

WHAT IS REPORTED TO BE THE WORLD'S MOST POWERFUL R-F TRANSISTOR, capable of developing 50w. r-f power output at 150mc has been developed by ITT Semiconductor, Palo Alto, Calif.

Designated the 3TE220, the device is a silicon-planer epitaxial interdigitated power transistor with stabilization resistances for long-term stability. The device has the emitter electrically connected to the case to permit high-gain performance. Lower feedback between the input and output of the transistor is also made possible by this feature.

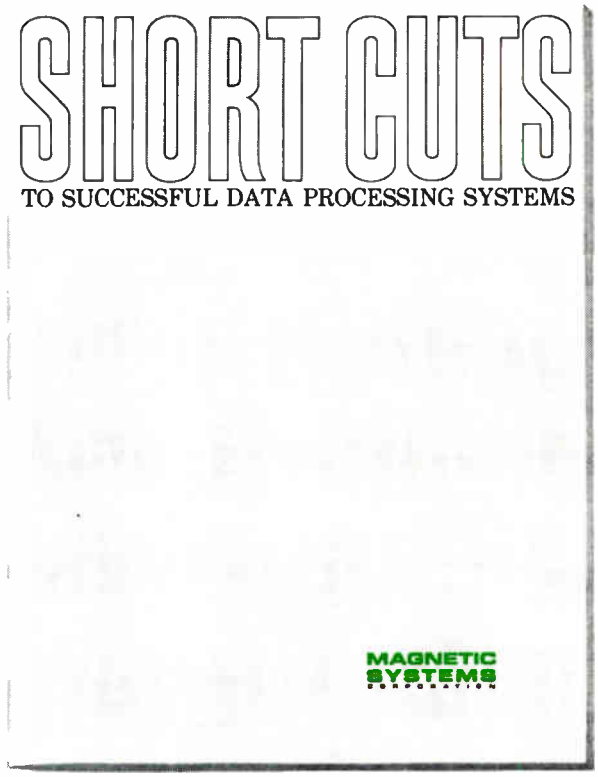
The high-power unit replaces multiples of lower power devices.

It is designed for output use in high-gain Class B and C r-f amplifiers.

The 3TE220 develops 30w. @ 28v., and provides 7db gain in a 40v. circuit. It permits max. collector current of 2.5a. Packaged in a JEDEC TO-3 configuration, the device can be used singly to replace multiples of lower-power devices.

BUSINESS DATA DISPLAY

A TV-like display unit that reports current business data instantaneously in business offices has been introduced by GE Computer Dept. Datanet-760 keyboard display terminal can picture in seconds business data stored in a GE computer system, according to engineers.



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NEW TECH DATA

Switch Catalog

Catalog TG-171 lists in detail the specs. of 21 different solid-state switching devices, with SPST and SPDT and DPDT configurations. Switches operate at any freq. from dc to 8gc with bandwidths of individual models covering typically an octave or greater. The catalog lists all dimensional characteristics and gives specs. Sanders Associates, Inc., 95 Canal St., Nashua, N. H.

Circle 268 on Inquiry Card

Cable Bulletins

Seven technical bulletins, ranging from 3 to 17 pages in length, are available which give operating characteristics of a line of coaxial cable and some of their applications. Topics discussed include: choosing the proper coaxial cable for microwave applications; the effect of radiation on coax; variations of electrical length of coax with temp.; etc. Phelps Dodge Electronic Products, North Haven, Conn.

Circle 269 on Inquiry Card

Intensity Analyzer

This data sheet describes the MF/HF-2T precision field intensity analyzer which measures RFI from 0.15mc to 32mc. The instrument determines the source and analyzes the characteristics of radio interference; field intensity measurements for communications site selection; antenna pattern determinations; etc. Stoddard Electro Systems, 2045 W. Rosecrans Ave., Gardena, Calif.

Circle 270 on Inquiry Card

Transistor Insulators

Data is available on more than 20 mounting insulators for TO-5, TO-8 and TO-18 transistors. Styles available include converters for TO-5 and TO-18 packaged multi-lead microcircuits. These insulators assist in the mounting of transistors on PC boards and provide clearances to allow formation of solder fillets under the transistor. The Robinson Co., 3636-5 W. 139th St., Hawthorne, Calif.

Circle 271 on Inquiry Card

Low-Pass Filter

The LLP-15 is a 15 cycle, low-pass filter for uses requiring an l-f cut-off. It has a loss of less than 3db at 15 cycles and attenuation of more than 40db at 30 cycles and higher. Source and load impedance is 100KΩ. The unit is encased in a hermetically sealed standard Mil FA case. United Transformer Corp., 150 Varick St., New York, N. Y.

Circle 272 on Inquiry Card

Relays Bulletin

Series 640, 900, 240 and 625 general purpose relays are described in bulletin B1. It provides complete descriptions and data on each relay, dimensions and full electrical and mechanical specs. Guardian Electric Mfg. Co., 1550 W. Carroll Ave., Chicago, Ill.

Circle 273 on Inquiry Card

Microwave Limiters, Filters

This short-form catalog gives specs. for microwave YIG bandpass filters—L thru K-bands, tunable bandreject filters, sweeping current supplies. Physical Electronics Laboratories, 1185 O'Brien Dr., Menlo Park, Calif.

Circle 274 on Inquiry Card

Ceramic Magnets

This brochure on ceramic magnets describes several grades of both isotropic (non-oriented) and anisotropic (oriented) units. Methods of manufacturing, design and specifying are covered thoroughly. D. M. Steward Mfg. Co., Chattanooga, Tenn.

Circle 275 on Inquiry Card

Relays Bulletin

Bulletin B2 describes series 1200, 1210, 1220, 1210N and 1200/1200 general purpose relays. It provides data on each relay, as well as dimensions and specs. Guardian Electric Mfg. Co., 1550 W. Carroll Ave., Chicago 7, Ill.

Circle 276 on Inquiry Card

Instrument Cases

This data sheet describes ruggedized Formica cases for quality precision instruments and other diversified uses. Light in weight, durable, moisture and dust resistant, these cases have passed the U.S. Navy shipboard requirement tests. W. A. Miller Co., Oquossoc, Me.

Circle 277 on Inquiry Card

EDITOR'S NOTEBOOK

VEST POCKET RADIO may give London sinisters a rum show, and the bobbies an easier time of it. The Home Office announces it will equip some 300 of its constabulary with Cossor type CC2/8H Pocket Radio-telephones. The VHF radio has almost total concealment. The small mike and earpiece are external. It has high output and low battery wear.

CARBON ELEMENT, in a telephone transmitter, that cancels background noise and provides better voice signal has been introduced by Roanwell Corp. for use in high noise-level areas. Called C-505 Confidencer, the noise-canceling transmitter cancels an average of 18db of noise. It has a range of 300 to 3500cps and is for use in all standard handsets. According to Roanwell, the device can eliminate acoustical feedback in P.A. systems.

STOCK TRANSACTIONS may next be carried out on an automated trading floor at the American Stock Exchange in New York. According to the plan to be implemented early next year, there will be electronic keyboards at each trading post. Transactions will be reported directly to stock tickers so the odd lots and the round lots can be traded faster and the translux will display transactions within seconds. The program also includes a computer system for stock clearing and market surveillance. Supplier is to be The Bunker-Ramo Corp.

NABBED BY EDP may become a criminal cry in the future for yeggs in the Flint, Mich., area. The city will install an NCR 315 this summer, first to handle payroll, taxes, and water-billing. Then the system will be phased in to check out suspicious persons at HQ while the cop on the beat holds the person in question at the corner phone.

DATA TRANSMISSION will triple capacity of communications facilities used to guard against train derailments caused when heat slows or "locks" wheels of moving cars. Developed by Lenkurt Electric Co., Inc., subsidiary of GT&E, the data system increases capacity by dividing each communications channel into three separate channels. It will also transmit heat data.

STEREO IN ORBIT literally became reality when Carl R. Rollert, of Collins Radio Co., sent a stereophonic signal to Relay II, an active repeater satellite, and heard it back on Earth again after a round-trip of more than 11,000 miles into outer space. Mr. Rollert's effort marked the first time stereo signals have been bounced from orbit.

ELECTRONIC DEVICES protect the rare religious volume collection in the most modern book repository of its kind in the world at the National Cathedral in Washington D. C. A motion detection system—a field of inaudible sound—is sensitive enough to detect movements at one inch per second or as fast as 20 feet per second. Antenna wires concealed in the exhibit cases set up a field. If the field is broken the alarm sounds.

LEGISLATIVE SCORECARD is being provided by EDP to help Florida state legislators keep track of more than 3,000 bills considered during each session. Daily computer-produced reports from a high speed RCA 301 system provide the solons with a readily accessible review of all floor and committee actions the day before, a history of all bills in the legislative hopper, and a reference index of all bills by subject and number.

Midgets and specials for electronic assemblies

A cutter that cuts clean and holds the crimped end . . .

One that cuts and crimps wiring on a printed circuit for efficient dip soldering . . .

A trimming plier, flush cutting . . .

A needle nose plier that reaches deep into miniature assemblies . . .

These and dozens of other pliers are available from stock in the complete Klein line. In fact, here you will find pliers exactly designed for any electronic system where clean cutting accuracy, crimping and bending are necessary in extremely confined space.

The Klein line of specially designed electronic pliers offers a plier exactly designed for each specific job—saving time, speeding assemblies, assuring a better product. For complete information write for the Klein catalog on electronic pliers.

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INTERNATIONAL NEWS

Gateshead—Portable, low-cost analogue computer (Analogue tutor Mk2) designed to introduce students to analogue computation is being produced in Britain by System Computers Ltd.

Farnborough — Solartron recently presented a course on advanced computer technology at its computer center for customers and prospective clients from principal European Aircraft firms in Germany, Italy, Sweden, Holland, France and Belgium.

Berlin—A speech recognition device developed by Heinz Kusch of Telefunken so far can recognize the numbers 1, 2, 9, 0, indicated by luminous figures, whether spoken by man or woman. Numbers can also be printed out.

Dusseldorf—International Congress and Exhibition for Instrumentation and Automation (INTERKAMA 1965) set for October 13-19, will deal with automation engineering and will cover instrumentation in pneumatics, hydraulics and electronics.

Paris—A new simulator computer that will aid in evaluating flight characteristics and design of "Concorde," Anglo-French supersonic transport aircraft, has been announced by Le Material Telephonique, ITT subsidiary.

Hong Kong—Cable & Wireless Ltd. is installing a Marconi Self-Tuning h-f communications equipment in its transmitting station at Cape D'Aguilar for Stage I of South East Asia Commonwealth Telephone Cable.

Johannesburg—Netherlands Bank of South Africa is the first organization in the region to install an NCR 315 System. It is being used to process accounts at the bank's main office and eight branches.

Kanagawa, Japan—Hitachi Ltd. has ordered an Automatic Memory Tester (Type 1524) from Digital Equipment Corp. to be used in development and production of data and program storage units.

Taipei, Taiwan—Republic of China has inaugurated a multi-million dollar microwave radio network built by Collins Radio Co. System includes stations around Taiwan perimeter and links to the Pescadores. One off-shore length is about 104 miles long.

ELECTRONIC INDUSTRIES

NEW PRODUCTS

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

CIRCUIT BOARD CONNECTOR

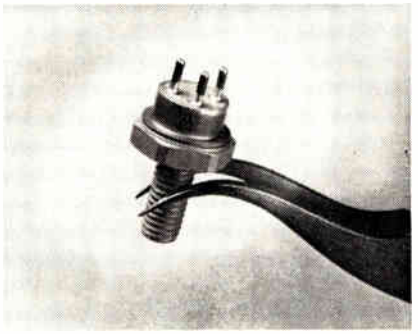
Designed to interconnect 3 circuit boards where space is at a premium.

The receptacle, 74-111, of this micro-miniature connector is divided into a 2 contact section. Any or all of the contacts may be used, depending on the design application. Plug board 74-109 has 2 contacts, and plug board 74-110 has 6 contacts in which any or all may be used. Contact rating is 0.5a. at 1000v. RMS. Dimensions of components: 74-109 is 0.200 x 1.475 x 3/32 in.; 74-110 is 0.410 x 1.475 x 3/32; and the 74-111 receptacle is 0.830 x 1.900 x 0.163. Amphenol Microelectronics, 2801 S. 25th Ave., Broadview, Ill.

Circle 287 on Inquiry Card

AMPLIFIER TRANSISTOR

Delivers 15w. output at 100MC with 7db typical power gain.

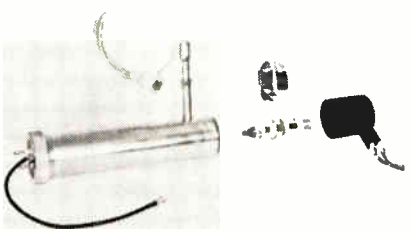


The 2N3818 VHF, NPN silicon power amplifier transistor is designed for Class C amplification from 25v. supplies. Uses include drivers for high-power varactor multiplier chains, and a single sideband amplifier for freqs. through the 74MC band. It is rated at 2a. continuous collector current and 80v. minimum pulse-breakdown voltage. Transistor is packaged in the TO-60 can and uses an interdigitated-type geometry. Motorola Semiconductor Products Inc., P.O. Box 955, Phoenix, Ariz.

Circle 289 on Inquiry Card

POWER SOURCES

R-F sources cover the freq. range from 1 to 11GC. Power output above 30mw.

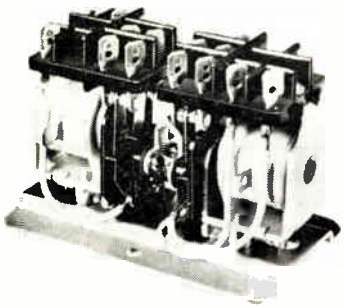


The Velocitron® r-f sources feature r-f shielding on the klystron base leads to prevent radiation and non-contacting low-noise tuning short. They do not require forced-air cooling and have a rugged mechanical structure. Cavity life is practically unlimited. The sources can be used as highly stable local oscillators, bench oscillators, or signal generators or sources with CW, FM, and pulse modulation capability. Polarad Electronics Corp., 34-02 Queens Blvd., Long Island City, N. Y.

Circle 291 on Inquiry Card

DUAL-LATCHER RELAYS

Two relays are mounted on a common base connected by a latching mechanism.

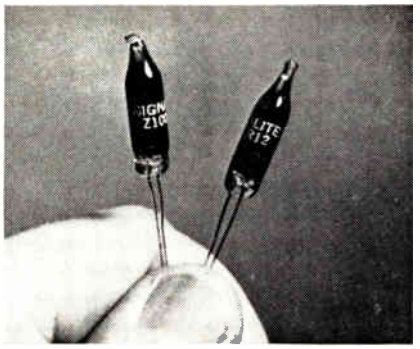


With the 25BL, momentary impulse on the unlatched coil causes the contacts to close and remain latched until the other coil is pulsed. Mechanical life exceeds 20 million operations. Electrical life depends on load characteristics. Pull-in voltages: dc, 75% nominal voltage; ac, 78% of nominal voltage. Designed for heavy duty, 2PDT, 4PDT, or 6PDT switching on ac or dc inputs, it is rated at loads of 5 or 10a. @ 115vac. Weight is 4.5 oz. E. W. Bliss Co., Eagle Signal Div., Davenport, Ia.

Circle 288 on Inquiry Card

REFERENCE TUBE

Maintains its 100v. reference voltage within ±1v., or 1%.

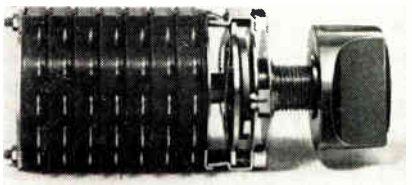


Reference voltage for the Z100R12 is 3ma. It is particularly useful where divisions by 10 or 100 are desired, such as in digital voltmeters. As a voltage regulator it exhibits less than 1v. change in regulating voltage from 0.6 to 12.0ma. Its temp. coefficient is —9mv/°C. The tube has an average ignition voltage of 140vdc. Max. operating current is 14ma. Minimum operating current as a shunt regulator is 0.7ma, and in parallel with a capacitor it is 1.8ma. Signalite Inc., 1933 Heck Ave., Neptune, N. J.

Circle 290 on Inquiry Card

ROTARY SWITCHES

Provide > 50,000 cycle operation for loads to 100vdc, 0.25a.



The series 1 switch line have independently sprung, dual, balanced moving contacts. Improved switching action reduces cross tracking between contact and insulation materials. The stators are keyed and nested for positive deck alignment. Other features include: adjustable stops (with 25 in./lb. stop strength ratings), identified terminals, silver or gold plated current carrying parts, and integral molded in terminals and contacts. Voltage breakdown is 1000v. RMS. Shallcross Mfg. Co., Selma, N. C.

Circle 292 on Inquiry Card

ITT Heat-Shrink Tubing meets tougher new Mil-spec MIL-I-23053A

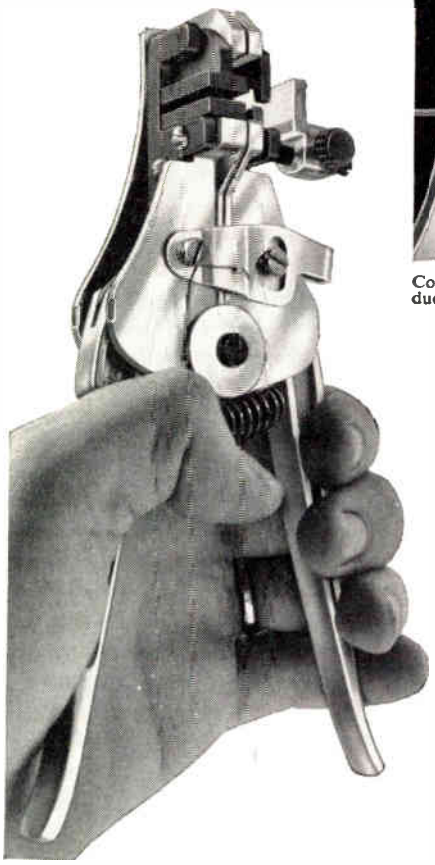
New ITT Heat Shrink Tubing easily fits over coax connector, yet, because it shrinks to 50% of its original size with the application of heat, the tubing forms a tight insulating bond around both the coax and the connector.

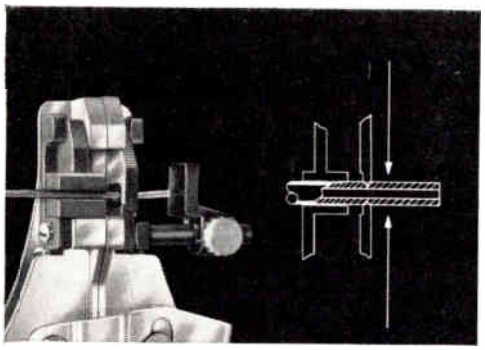
Specify ITT 50% Shrinkable Tubing for Assured Performance... it conforms to revised, and now far more stringent, specification MIL-I-23053A. Ideal for use in military electronics, and for general industrial applications, the tubing shrinks to *half* its original size upon application of heat. ITT tubing is fluorine- and chlorine-free, can't cause corrosion. It's especially suitable for use directly on contacts, even those in the millivolt signal range.

ITT Heat-Shrink Tubing vibration-proofs and weather-proofs electrical connectors, mechanical and hydraulic couplings, and other metallic fittings. It is tight, form-fitting insulation for connections, splices, wire harnesses, cables, and wear points. Available from stock in 14 diameters from 3/64 to 4 inches, clear and in five permanent colors. It retains its flexibility and form stability from –65° to +275°F, and is highly resistant to impact, perforation and abrasion.

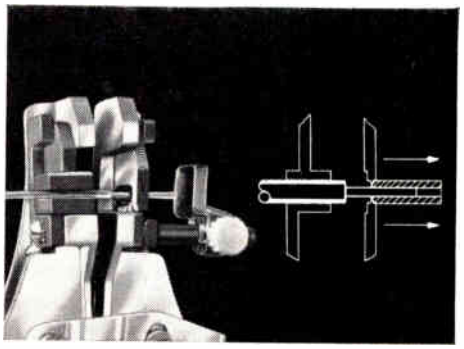
For detailed specifications, technical assistance with applications, or engineering samples, write: Dept. E, ITT Wire and Cable Division, International Telephone and Telegraph Corporation, Clinton, Mass. In Canada, write or call ITT Royal Electric Company (Quebec) Limited, Pointe Claire.

wire and cable division ITT





Collet clamping action compensates for off-center conductor, irregular insulation.



Die severs insulation and strips slug. Never touches conductor, can't nick or scrape.

NO-NICK, NO-SCRAPE WIRE STRIPPING

With Ideal's Custom Stripmaster® you can production strip both stranded and solid conductor wires to aerospace precision specifications. Even under 40-power magnification wires show no nicks, scrapes, or scratches. That's because insulation is removed with dies rather than knife blades. These dies sever insulation with a colleting action that automatically compensates for off-center conductors and insulation irregularities. Special grippers hold the wire without crushing or marking insulation as dies strip the slug without touching the conductor. Each pair of matched dies is individually machined on watchmaker's equipment to precision tolerances.

There are standard Custom Stripmaster models for Type E Teflon, Type EE Teflon, and for general-purpose insulation in wire sizes 10 to 14, 16 to 26, and 26 to 30. Custom Stripmasters with special dies are available for unusual stripping problems.

If you are precision stripping any kind of wire on a production basis, you ought to know about the Ideal Custom Stripmaster. Write today for details.

IDEAL INDUSTRIES, INC.
5127-G Becker Place, Sycamore, Illinois
IN CANADA:
IDI Electric (Canada) Ltd., Ajax, Ontario

Circle 51 on Inquiry Card

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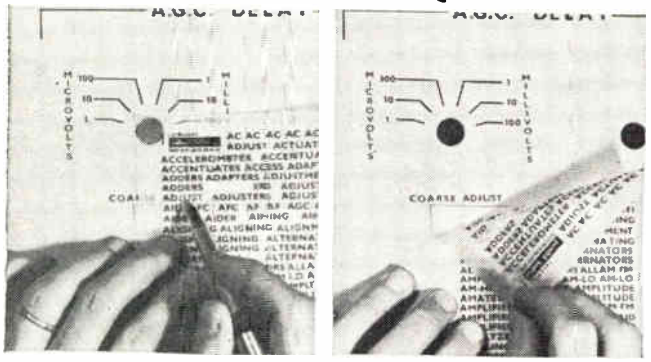
instant lettering® **dry transfer MARKING KITS for ELECTRONIC EQUIPMENT**



"Instant Lettering" marking kits contain all the necessary elements for completely marking electronic equipment, drawings, prototypes, schematics, etc., in a fast easy-to-use form.

Words, letters, numerals, switch patterns, arcs, etc., are printed on a special transparent carrier film. Rubbing over one of these elements with a ballpoint pen releases it from the carrier film and adheres it to your working surface.

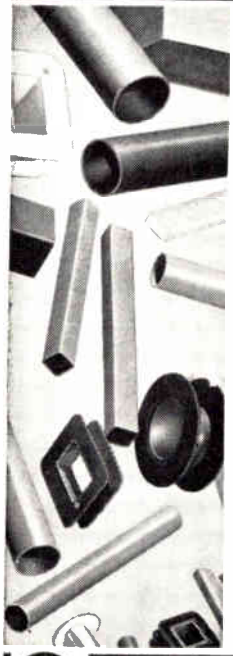
Reproduction quality "Instant Lettering" transfers are clean and sharp, leave no background naze or film, make prototypes look like finished production equipment and give all equipment and drawings a professional look.

WRITE FOR FREE SAMPLE AND COMPLETE DETAILS

THE DATAK CORPORATION
63 71st Street Dept. 625 Guttenberg, N. J.

Circle 64 on Inquiry Card

High Quality Coil Forms For All Electrical Applications



SQUARE AND RECTANGULAR TUBES—Choice of any dielectric material or combinations. Any length, shape or size. Especially recommended for Class A, B and H temperature ranges.

ROUND TUBES—Any decimal size up to 8". Fabricated from dielectric kraft, fish paper, acetate, DuPont Mylar, Johns-Manville Quinterra, fibre glass, other materials or combinations.

RESINITE PHENOLIC IMPREGNATED—Feature the highest resistivity of any resinated product. Furnished in any shape or size—plain, embossed or internally threaded, also in flyback transformer forms.

BOBBINS—Molded or fabricated—to specification in all sizes, shapes and dielectrical materials for all electrical and corrosion requirements, Class A, B and H temperature ranges.

Request catalog and prices. Ask about Precision's complete coil form service.

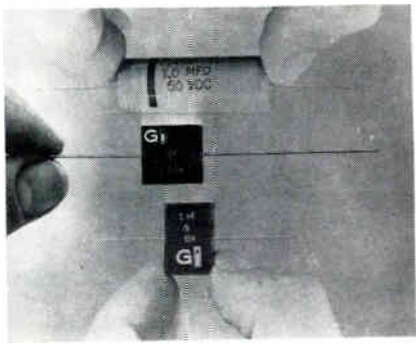
PRECISION PAPER TUBE COMPANY
1049 S. Noel Ave., Wheeling, Ill. 60090 *(Chicago Suburb)*
TELEPHONE 312...537-4250 TWX 312...537-5202

Circle 65 on Inquiry Card

NEW PRODUCTS

CERAMIC CAPACITORS

Working voltage of 100vdc and meet or exceed requirements of Mil-C-11015.



The CN series miniature monolithic ceramic capacitors have a range to 5.0μf. Packaged in transfer-molded plastic cases with non-polar operation, the units can be used over a temp. range of −55°C to +125°C without voltage derating. Capacitance will not change more than ±15% over the temp. range. Gulton Industries, 212 Durham Ave., Metuchen, N.J.

Circle 278 on Inquiry Card

DIFFERENTIAL VCO

Uses crystal referenced circuit to provide stability and linearity.

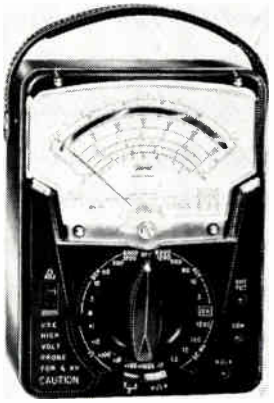
The Model 503-100 low-level differential VCO has an input impedance greater than 100 megohms. It uses no temp. controlled oven. Center freq. and deviation sensitivity are determined by plug-in channel selectors that are available for all standard IRIG and constant bandwidth center freqs. up to 1MC. The unit allows direct FM recording of mv-level transducer signals to be accomplished without intermediate signal conditioning equipment. It is designed for uses involving thermocouples, resistance bridges, potentiometers, and other low-level signal sources, as well as for medium and high-level signal sources. Astrodata Inc., 240 E. Palais Rd., Anaheim, Calif.

Circle 279 on Inquiry Card

NEW PRODUCTS

V-O-M

Offers VTVM sensitivity with all the convenient portability of a V-O-M.



The Model 630-M features 20KΩ/vac sensitivity, one million Ω/vdc sensitivity, and ±3% ac accuracy. Sensitivity is derived from the singular achievement of its basic 0-1 dc μa suspension movement. The unit has no amplifiers, no zero drift, no warm-up, and no power requirements. It makes current measurements from 20na and voltage measurements from 5mv. The Triplett Electrical Instrument Co., Bluffton, Ohio.

Circle 293 on Inquiry Card

AC VOLTMETER

Measures from 100μv to 300v. RMS and −72 to +52db on 12 scale ranges.

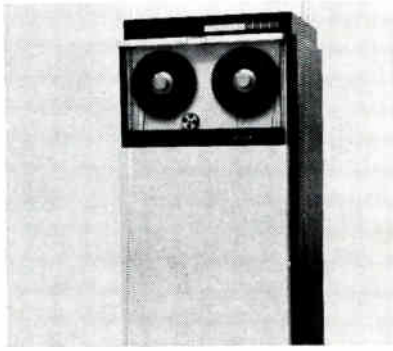
This solid-state ac voltmeter uses a new taut-band indicating principle in the meter movement. This allows the use of a linear scale and results in more accurate readings between scale markings and consistent repeatability without meter tapping. Accuracy is ±2% of full scale, 50 CPS to 300KC. The amplifier output provides 1.4v. p-p, or 0.5v. RMS into 600Ω or more. Input impedance is greater than 10 megohms on 1-300v. range, and 1 megohm on 1-300mv range. Freq. response is flat from 20 cycles to 1MC. For indicating purposes, the instrument is usable from 5 CPS to over 5MC. Motorola Inc., Communications Div., Technical Information Center, 4501 Augusta Blvd., Chicago, Ill.

Circle 294 on Inquiry Card

NEW PRODUCTS

TAPE TRANSPORT

Operates at any speed or combination of speeds between 75 and 150 ips.



The TM-12 uses a single-capstan drive for high reliability. The single-capstan drive system requires less than 1/5 the moving parts of conventional, pinch-roller tape drives, thus needing far less maintenance. Data transfer rate is up to 120,000 characters/sec., suitable for high-speed computers. It has packing density of up to 800 cpi; either 7 or 9-track format is provided. This system can handle various tape formats, both shared and unshared, including IBM-compatible 7-track, IBM 360-compatible and ASC11 9-channel. Ampex Corp., 401 Broadway, Redwood City, Calif.

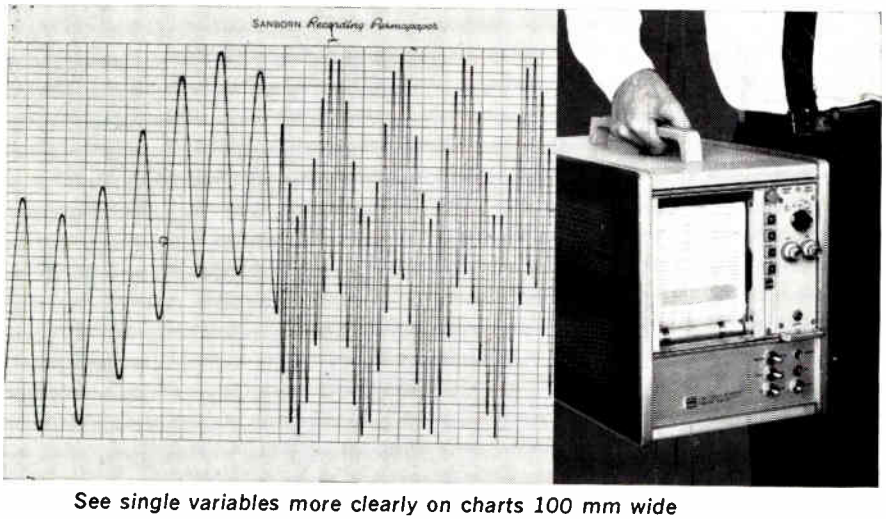
Circle 280 on Inquiry Card

IMPEDANCE METER

Impedance magnitude from 1Ω to 10 megohms and phase angle from 0 to 360°.

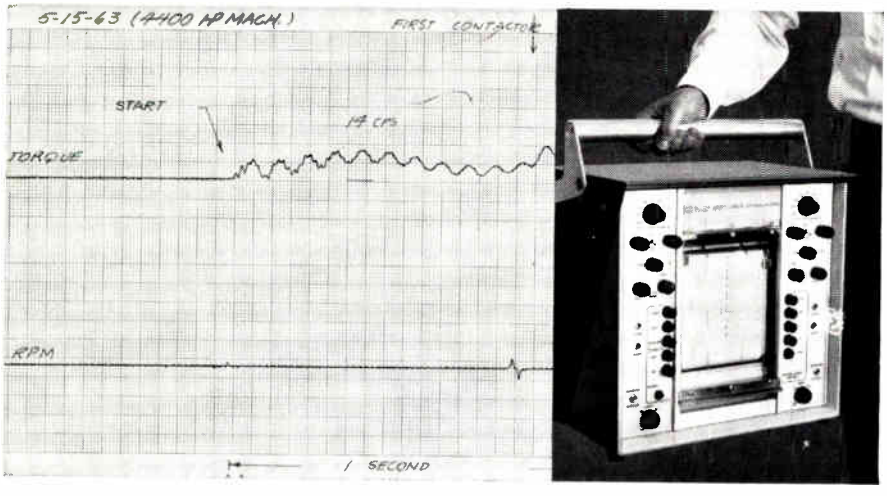
With the Type 4800A Vector Impedance Meter impedance magnitude and phase angle are instantaneously displayed on 2 front panel meters. Analog outputs directly proportional to impedance magnitude, phase angle, and freq. are available so that, by single connection to an X-Y recorder, direct reading plots of vector impedance as a function of freq. may be conveniently obtained. These outputs may also be used to actuate limit switches or operate digital or expanded scale voltmeters for special uses. The meter also functions as a direct reading L-C meter, covering ranges of 1μh to 100Kh and 0.1pf to 10Kμf. Boonton Radio Co., Green Pond Rd., Rockaway, N. J.

Circle 281 on Inquiry Card



See single variables more clearly on charts 100 mm wide

— or record two related variables simultaneously on 50 mm channels



These portable oscillographs will save you valuable lab/field time

For maximum resolution of traces representing extremely small variations in the dc to 30 cps parameter being measured, the Sanborn 7701A single-channel oscillograph combines every time-proven advantage of reliable, heated stylus, rectangular-coordinate recording with the wide adaptability of plug-in signal conditioners of your choice (now 6 Sanborn types to choose from). Chart speeds pushbutton-selected, 0.5 mm/sec to 50 mm/sec; at min. speed, over 30 hours of continuous recording are possible. Basic system, completely portable in 12" x 10" x 18" case, $1,075; interchangeable preamps from $75 to $600.

When two conditions must be measured simultaneously — in the millivolt to 500 volt range, or as low as 10 uv from AC-excited transducers — the 320/321/322 family of portable recorders offers dc-125 cps response, individual-channel Range, Gain, Function, Stylus Heat and Position controls, 0.25 div. max. nonlinearity, four pushbutton chart speeds, low drift and high gain stability. *Model 320* designed for general-purpose dc to 125 cps recording, has 0.5 mv/mm max. sensitivity, floating input; price $1650. *Model 321* carrier-type with built-in oscillator for ac transducer excitation, 10 uv/mm sensitivity; price $1650. *Model 322* for general purpose dc-125 cps recording, 10 mv/mm sensitivity; differential, balanced, high impedance input; price $1395. Each system occupies only one cubic foot, may be used in portable case or rack-mounted.

Call your local Hewlett-Packard/Sanborn field engineering office now for complete specifications or application assistance — or write: Sanborn Division, Hewlett-Packard Company, 175 Wyman Street, Waltham, Mass. 02154

HEWLETT PACKARD hp SANBORN DIVISION

Circle 56 on Inquiry Card

NEW PRODUCTS

TIME INTERVAL COUNTER

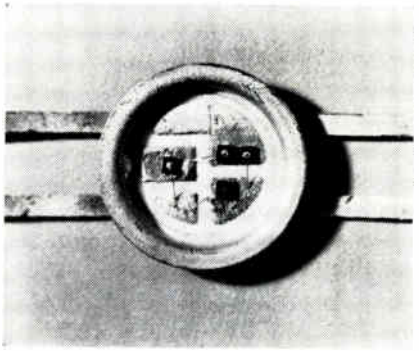
Features 6 ranges. Permits measurements from 10μsec. to 99999 sec.

Model CF-300R interval counter features level gating. It provides a wide range of interval measurements such as pulse length, pulse spacing, and time between electrical events. The unit provides both single line and 2 line gating with separate ± slope and dc level controls. Digital readout is displayed for an interval adjustable from 0.2 to 6 sec., or the display may be held indefinitely until reset. Anadex Instruments Inc., 7833 Haskell Ave., Van Nuys, Calif.

Circle 225 on Inquiry Card

HYBRID CIRCUIT

Consists of 4 diodes with precisely matched dynamic characteristics.



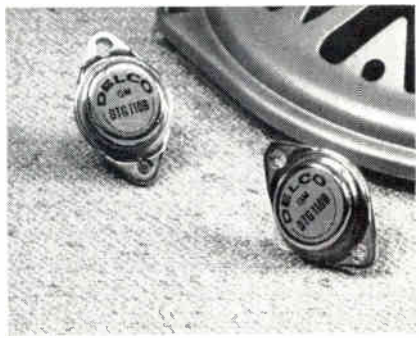
The forward voltage among all 4 diodes is matched to within ±10mv from 0.1ma to 10ma in temps. from −55° to +125°C. Leakage currents are matched to ±20na @ 25°C and ±1μa @ 125°C. Diode offset voltage is matched to ±10 and ±20mv at 10ma of diode current. The stored charge, turn-off time and turn-on time are also closely matched, thereby increasing circuit predictability. The diodes are in a flat pack for easy mounting on PC boards, thin-film microcircuits, or in strip lines. The 50v. diodes have a capacitance of 2pf @ 0v. and a reverse recovery time of 2nsec. Power dissipation at 25°C is 250mw. Steady-state forward current is 115ma. General Electric Co., Schenectady, N. Y.

Circle 226 on Inquiry Card

NEW PRODUCTS

TRANSISTOR

Handles up to 100w. RMS in class AB operation.

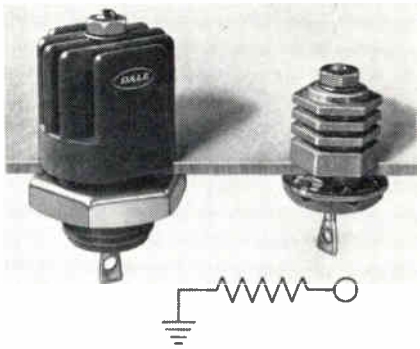


The DTG-11OB has such high power handling capabilities that only 2 instead of 4 are needed to handle up to 100w. RMS power in class AB audio power output applications. It offers low distortion at high power levels. Linear gain (typically 125 at I_c of 5a.) and transconductance characteristics provide for very low amplifier distortion. Delco Radio Div., General Motors Corp., Kokomo, Ind.

Circle 282 on Inquiry Card

WIREWOUND RESISTOR

Panel mount resistor requires only 1 terminal connection.



This resistor uses a finned aluminum housing into which a precision wirewound element is molded. The housing contacts the chassis at a point adjacent to the hottest part of the resistor, thus giving a better heat sink. One major use for the panel mount design is as a drive line resistor in 1μsec. core memory systems using a series termination technique. Resistors are available in 2 models: PH-10-5 rated at 10w. with a max. resistance range of 0.1 to 47.1KΩ; and PH-25-8, rated at 25w. with a max. resistance range of 0.5 to 95KΩ. Both are available in tolerances from 0.05 to 3%. Dale Electronics, Inc., subs. of The Lionel Corp., P. O. Box 488, Columbus, Nebr.

Circle 283 on Inquiry Card

NEW PRODUCTS

DIFFERENTIAL AMPLIFIER

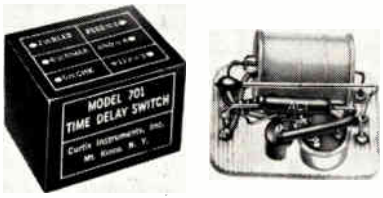
Offers a building block concept with 5 options which provide flexibility.

The 391 Series Low Level DC Differential Amplifier has a single gain between 10 and 1000 and a single bandwidth of 100KC. The 5 options are: 7 switched gains; 5 switched gains with full interpolating vernier; dual output; 8 switched bandwidth; triple output — high level multiplex switch for remote switching of 2nd output. Redcor Corp., 7800 Deering Ave., P. O. Box 1031, Canoga Park, Calif.

Circle 227 on Inquiry Card

TIME DELAY SWITCH

Uses unique principle to provide delays from 30 sec. to 350 hr.



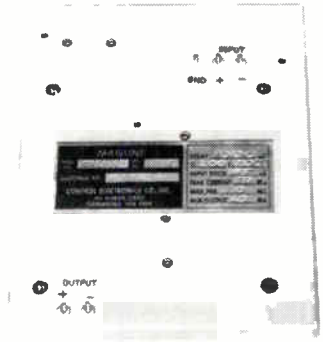
Model 701 uses a unique electro-chemical principle to provide delays. The basic timing element is a microcoulometer consisting of a capillary glass tube filled with 2 columns of mercury separated by an electrolytic gap. Mercury is electro-plated across this gap at a very precise rate determined by the dc current selected for the desired time constant. When the time period ends, the meter impedance rises sharply. This voltage rise is sensed and amplified through a 2-stage, silicon amplifier which drives a reed relay. The unit is entirely resettable although, for continuous symmetrical or asymmetrical cycling, 2 units are required. Running current is less than 10μa with a max. of 2ma at time out. Curtis Instruments, Inc., 351 Lexington Ave., Mt. Kisco, N. Y.

Circle 228 on Inquiry Card

NEW PRODUCTS

DELAY LINE MEMORY

For use in storing digitalized data for short or long intervals of time.

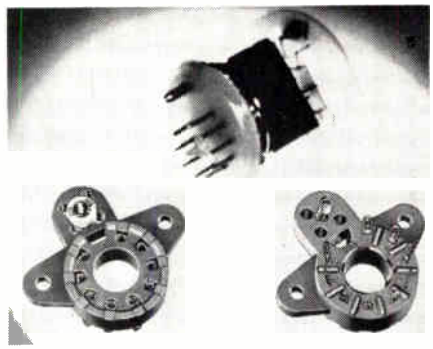


Series FMS 5000 are all-solid-state, self-contained units which provide delays from 50 to 4200μsec./pass-through. Max. pulse repetition rate depends upon the delay of the unit, with 3MC available from the 50μsec. delay unit and 2MC available from the 4200μsec. unit. The memory systems are all "non-return-to-zero" types which accept an input logic signal of 6 ±2vdc (logic level "1") and 0 ±½vdc (logic level "0") to provide an output of 10ma at the same voltage levels as the input logic. Control Electronics Co., Inc., 153 Florida St., Farmingdale, N. Y.

Circle 229 on Inquiry Card

TUBE SOCKET

Transmitter tube socket has low loss at very high frequencies.



Type 444 tube socket has excellent heat, arc resistance and loss factor. These are provided by glass filled alkyd and ceramic insulations. Socket is vented to provide max. cooling of tube base and anode contact area by convection. Voltage breakdown characteristics are enhanced by appropriate barriers between contact positions, and all-molded construction including mounting ears. Type 444 mates with Amperex DX245/8505, DX274/8603 and tubes that have similar magnoval basing with offset anode contact. Connector Corp., 6025 No. Keystone Ave., Chicago, Ill.

Circle 230 on Inquiry Card

NEW PRODUCTS

GOLD PLATER

Deposits a uniform thickness of gold on both sides of PC boards.

The Jet Plater deposits gold uniformly despite differences in surface areas. It eliminates the need for building up too thick a deposit of gold on one surface in order to accomplish the minimum thickness on the other side. It can also be used for the simultaneous plating of equal thickness deposits on internal and external surfaces of special parts where the current required for plating the separate areas varies. The Meaker Co., subs. of Sel-Rex Corp., 75 River Rd., Nutley, N.J.

Circle 295 on Inquiry Card

IC MOUNTING HARDWARE

Developed for the specific problems associated with the support of ICs.

The Series M hardware consists of nylon molded guides, spacers, ejectors and files, horizontal and vertical equipment drawers all for support of miniature mother boards. It includes mountings to attach baby boards to mother boards, and new concepts which permit multiple circuit connections without conventional connectors. Another design allows removing circuit chips for testing without cutting wires or damaging glass insulation. Scanbe Mfg. Corp., 1161 Monterey Pass Rd., Monterey Park, Calif.

Circle 296 on Inquiry Card

Get 'em at Hughes

1N703A 1N497 1N461 2N722 1N270JAN 1N427 1N663
1N128 1N348 1N702 1N625 1N277JAN 1N702 1N625 1N90
1N709 1N627 1N338 1N86 1N140 1N740 1N127 1N276JAN
1N192 1N345 1N598 1N598 1N255 1N626 1N341 1N959A
2N3305 1N283 1N117 1N89 1N349 1N699 1N254 1N128
1N69A 1N276 1N597 1N126A 1N711 1N181A 1N465 1N470
1N95 1N710 1N347 1N706A 1N139 1N332 1N468 1N957
1N712 1N816 1N714 1N908 1N715 1N768 1N837 1N3243
1N344 1N253 1N497 1N96 1N905 1N751 1N771A 1N916B
1N914 1N818 1N726 1N891 1N720 1N915 1N752 1N1990
1N755 1N773 1N914 1N746 1N719 1N904 1N931 1N4371
1N917 1N750 1N958 1N848 1N758 1N812 1N957 1N3053
1N813 1N749 1N879 1N844 1N746 1N840 1N3468 1N4370A
1N742A 1N949 1N772 1N930 1N757 1N706 1N724 1N3244
1N716 1N840 1N781 1N194 1N815 1N769 1N2578 2N1034
1N811 1N777 1N906 1N756 1N954 1N775 1N717 2N1132B
1N810 1N929 1N761 2N1224 1N811 1N748 1N959 2N1035
1N725A 1N954 1N774 1N358 1N3062 1N388 1N2530 1N759
1N3727 1N3287 1N1940 1N2582 1N395 1N90 1N98 1N1986
1N287 1N3872 1N1991 1N3056 2N329A 2N1239 1N3604
1N3052 1N100 1N709A 1N960 1N764 1N713A 1N723 1N770
1N1935 1N1315 1N1410 1N969 1N932 1N762 1N954 1N91
2N1132 2N3306 1N695A 1N3914 1N3914 1N3060 1N3666
1N4321 1N3068 1N4372 1N3055 2N328A 1N3991 1N2571
2N2721 1N1990 1N3205 1N2065 1N1987 1N3592 1N2572
1N933 1N2532 2N1131 1N763 2N3225 ETC ETC ETC . . . .

Over 1,000 types available for off-the-shelf delivery from your nearest Hughes distributor—or direct from Hughes, Newport Beach. We promise prompt delivery.

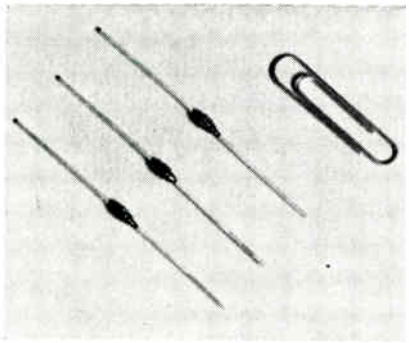
HUGHES

HUGHES AIRCRAFT COMPANY
MICROELECTRONICS DIVISION
NEWPORT BEACH, CALIFORNIA

NEW PRODUCTS

MINIATURE ZENER

Replaces stud zeners. Capable of handling 250w. transients.

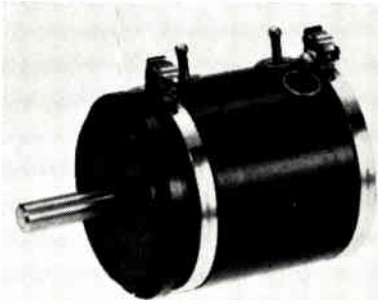


This zener is 0.145 in. in dia. and has a continuous rating of 5w. It can substitute for stud-mounted types many times its size. Voltages available are 6.8 to 400v. It features low dynamic impedances for all voltage ratings combined with extremely sharp knees. These zeners remain completely stable in electrical characteristics, even after overload or exposure to extreme environments. Unitorde Corp., 580 Pleasant St., Watertown, Mass.

Circle 297 on Inquiry Card

POTENTIOMETER

Twenty-turn unit is shorter than many 10-turn units.

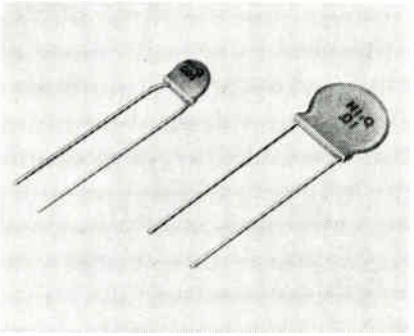


The D20-09 unit is 1.460 in. long. Available in resistances from 1K-200K, standard resolution runs to 0.0003%; absolute linearity of the units is to 0.01%. Total equivalent noise resistance level is 100Ω max. Up to 4 cups can be ganged on the same shaft, each cup after the first adding 1.235 in. to the length. Technology Instrument Corp. of Calif., subs. of Bomar Instrument Corp., 850 Lawrence Dr., Newbury Park, Calif.

Circle 298 on Inquiry Card

DISK CAPACITORS

For manual or automatic insertion in printed-circuit boards.



Flat bottom disk capacitors prevent rock or roll on PC boards because they seat perfectly every time. They eliminate electrode exposure normally encountered with bare bottom disks. The new configuration permits lower circuit board height without kinked leads, as well as complete control of Durez on wire leads. They may be used in applications up to and including 500v. Hi-Q Div., Aerovox Corp., Myrtle Beach, S.C.

Circle 299 on Inquiry Card

NEW PRODUCTS

SWEEP GENERATOR

Provides sweep-generator plug-ins over an extended range of 20 CPS to 1000MC.

The 860-F may be used whenever freq. marking is obtained from a central system, or where marking is obtained from external oscillators. All 860-F plug-ins function as voltage controlled oscillators over its full range. Sweeps include: 0.2 to 60 CPS, log and linear, external input and manual control. The sweep may be varied continuously from 0.2 to 25 CPS, going slowly enough through the pass-band to permit sweep alignment of very high Q circuits. Kay Electric Co., 14 Maple Ave., Pine Brook, N. J.

Circle 300 on Inquiry Card

DECADE COUNTER CIRCUIT

Storage temp.: —55°C to +150°C; operating temp.: 0°C to +75°C.

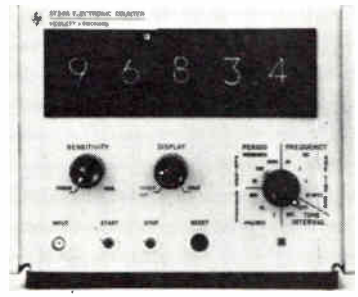
The CμL 958 is a complete decade counter containing interconnected resistors and transistors integrated into a single silicon planar epitaxial chip. The circuit consists of a cascaded set of 4 binary-triggered flip-flops with feedback, so that a count-by-ten circuit is realized. Four inputs are available, with numerical weights of 1, 2, 4 and 8. The CμL 958 can be preset for an arbitrary count by resetting to count 0, returning the reset pin to a low level and grounding the appropriate outputs. Fairchild Semiconductor, div. of Fairchild Camera and Instrument Corp., 313 Fairchild Dr., Mountain View, Calif.

Circle 301 on Inquiry Card

NEW PRODUCTS

MULTI-FUNCTION COUNTER

Compact solid-state 2MC counter makes a wide variety of measurements.

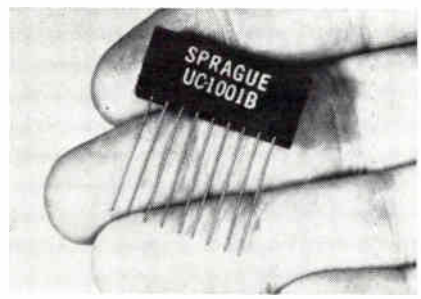


With a built-in crystal time reference, Model 3734A measures freq., makes period observations, calculates the average of multiple periods up to 100K, and measures time intervals. It will indicate the ratio of 2 freqs., or multiples of ratios. The unit totalizes random events over long or short periods by local or remote control. Readout storage provides continuous display of the most recent measurement, even while the instrument is making a new measurement. It makes accurate measurements of signals as low as 100 mv. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif.

Circle 302 on Inquiry Card

MICROCIRCUITS

Packaged in 1 standard case 1.0 x 0.4 x 0.2 in. to facilitate compact packaging.



The UC-1000 family of Ceracircuit® Logic Modules consists initially of 6 circuits: NAND/NOR gate; SCT flip-flop; high fan-out NAND/NOR gate; exclusive OR/half adder; 8-diode gate; and 5-diode gate. They all are 5MC DTL logic, thin-film microcircuits. All logic modules in this series operate from −55°C to +125°C. These DTL units basically consist of thin alumina plates with planar metal-film resistors and film capacitor elements as well as interconnections. On these are mounted glass-encased miniature diodes and epoxy encapsulated miniature transistors. The circuit wafers are then encased in epoxy-filled standard epoxy shells. Sprague Electric Co. 233 Marshall St., No. Adams, Mass.

Circle 303 on Inquiry Card

ELECTRONIC INDUSTRIES

Advertisers — July 1965

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No liability is assumed for errors or omissions.

NEW PRODUCTS

TRANSPONDER DELAY LINE

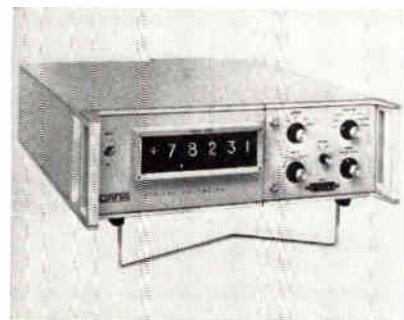
Delay is 21.3μsec., ±0.03μsec. @ 25°C; tapped in equal intervals of 1.45μsec.

The CTC-2665 plug-in type transponder delay line has an impedance of 300Ω (±10%). Accuracy of each tap referred to input is ±30nsec.; figure of merit is 70; temp. excursion: operational —55°C to 125°C; storage, —65°C to 150°C; temp. coefficient of delay: 50 ppm/°C; attenuation is —3db. Columbia Technical Corp., Woodside, N. Y.

Circle 231 on Inquiry Card

FIVE DIGIT DVM

Has 22msec. reading time; 0.005% accuracy and high CMR capabilities.



The Model 5600 has a 0.005% accuracy based on a percentage of reading (from 1 to 999.99v.). The high reading speed is made possible by solid-state switching and a unique direct-coupled input. The common mode rejection is 130db (filtered) and 120db (unfiltered), even when the instrument is connected to a grounded electrical-output device. A fast-setting ac converter provides ac measurements to rated accuracy in 0.4 sec. Data Laboratories, Inc., Irvine, Calif.

Circle 232 on Inquiry Card

CLASSIFIED

No need to scrap reliability for low price ...get both with DALE METAL FILM RESISTORS

LOW NOISE CONSTRUCTION. Maximum for standard resistance range: 0.10 micro-volt per volt over a decade of frequency. Low and intermediate values: below 0.05 micro-volt per volt. Terminating band of low-resistance metal alloy is deposited in same vacuum as metal film element resulting in *oxide-free*, low-noise contact area between film, terminating band and press-fit cap.

CONTROLLED T.C. Ten standard T.C. codes from 0 ± 150 ppm/°C to 0 ± 25 ppm/°C available in operating temperature range of −55°C to +175°C. Close matching between pairs or sets available.

GOOD HF CHARACTERISTICS. Low reactance gives excellent stability at high frequencies. Non-helixed or laterally adjusted units supplied for extremely critical applications above 100 mc.

SPECIAL REQUIREMENTS. Special terminals, special matching, special pre-conditioning, special networks and mountings can be quickly supplied by our Special Film Products Department.

WRITE FOR CATALOG A

DALE ELECTRONICS, INC.

1304 28th Avenue, Columbus, Nebraska

Also Sold by Dale Electronics Canada, Ltd., Toronto, Ontario, Canada

VSMF

MFF Epoxy coated. Meets electrical and environmental requirements of Char. B, C. D. E; MIL-R-10509E, but is dimensionally smaller.

MFH Hermetically sealed in ceramic tube. Meets requirement G; MIL-R-10509E.

MF Transfer molded in epoxy. Meets all requirements of Char. B, C, D, E; MIL-R-10509E.

DALE TYPE	MIL TYPE	125° C RATING	RESISTANCE RANGE	DIMENSIONS (L×D.)
MF 50	RN-50 (Proposed)	1/20 watt	49.9 Ω to 60K Ω	.140x.065
MF-1/10	RN-55	1/10 watt	49.9 Ω to 200K Ω	.250x.093
MF-1/8	RN-60	1/8 watt	30 Ω to 550K Ω	.406x.140
MF-1/4	RN-65	1/4 watt	30 Ω to 1 Megohm	.593x.203
MFS-1/2	RN-70	1/2 watt	49.9 Ω to 2 Megohms	.750x.250
MF-1	RN-75	1 watt	49.9 Ω to 6 Megohms	1.093x.375
MF-2	RN-80	2 watts	100 Ω to 15 Megohms	2.188x.375

Tolerance: ±1% standard; ±.5%, ±.25%, ±.1% available.

ENVIRONMENTAL SPECIFICATIONS*

Dale MF resistors are manufactured to the environmental specifications of MIL-R-10509E. Characteristics D, C or E apply depending on T.C. Code specified at purchase.

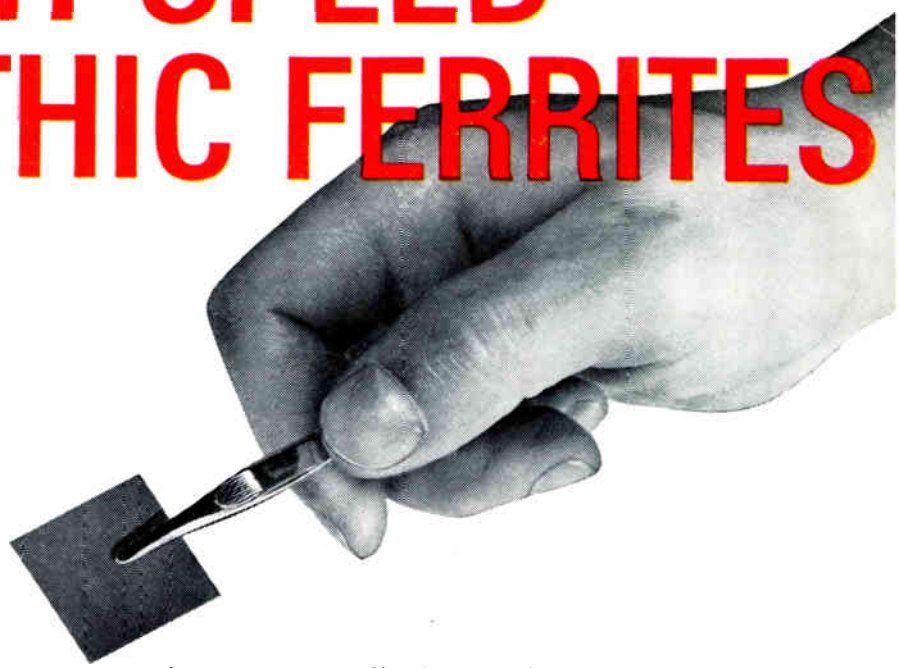
DALE T.C. CODE	Applicable Char. of MIL-R-10509E
T-1 (100 P.P.M./°C)	D
T-2 (50 P.P.M./°C)	C
T-9 (25 P.P.M./°C)	E

*Specifications for MFF and MFH are similar, but vary dimensionally.

Circle 98 on Inquiry Card

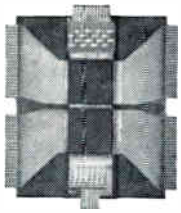
A totally new memory technology from RCA

NEW BATCH-FABRICATED HIGH-SPEED MONOLITHIC FERRITES



Each monolithic array contains 4096 "virtual cores" with an effective diameter of only 5 mils within a single, solid, sintered ferrite wafer only 1 in. by 1 in. by 0.005 in.

RCA monolithic ferrites offer all the proved advantages of ferrite technology plus:



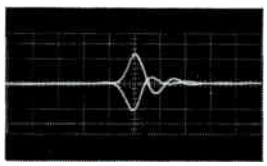
☐ **Potentially much lower cost** than wired core-memory planes because RCA monolithic ferrites can be mass-produced with standard ceramic processing techniques.

☐ **High-density packaging.** Type MF 2100 unit, as shown, is complete with two monolithic memory wafers, and an integral diode matrix assembly. It requires only 3.75" x 4.5" for a memory capacity of 4096 bits in two -"core"- per bit linear-select operation.

☐ **Very high speed.** Full cycle time (read, delay, write), as low as 0.2 usec for 64 x 64 array.

☐ **Low drive current requirement.** Less than present small-core memories: only 400 ma read, 120 ma write for 45 mv output and 35 nsec switching time.

☐ **High output voltage.** Equal to conventional cores. Trace indicates over 50 mv each for differential 1 and 0 output. Compare this with other bulk-fabricated systems having output voltages of only 1 or 2 mv.



. . . . . and no stringing

TYPICAL PERFORMANCE IN 64 x 64 ARRAYS								
READ CURRENT			WRITE CURRENT		DIGITS		TYPICAL OUTPUTS	T_s
I ma	T_d (50%) ns	T_r T_f ns	I ma	T_d (50%) ns	I ma	T_d (50%) ns	1 & 0 mv	nsec
400	110	45	100	120	30	200	35	60
400	80	30	120	100	30	200	45	35
400	60	30	150	30	30	100	30	35

Available now in developmental 4096-bit arrays for testing and evaluation. Call your local RCA Sales Office or write today for information to: RCA Electronic Components & Devices, Memory Products Operation, 64 "A" Street, Needham Heights, Mass. (617) HI 4-7200.

The Most Trusted Name in Electronics

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