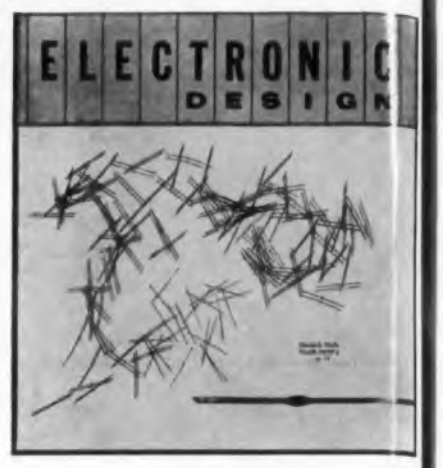
RONIC ESIGN

NOVEMBER 11, 1960

Flyspeck Diode
Stands 20,000 g
... p. 74

HIGHLIGHTS OF THIS ISSUE



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Canadian Electronics Bouncing Back

ELECTRONICS up North is emerging from its lean years headed in a new direction. The industry, though still convalescent, is aggressively pushing its designs on potential customers in the U. S. Three years ago things were different.

Then, in the face of a rising Canadian Gross National Product and record half-billion electronic sales the year before, sales dropped more than 15 per cent. Protectionist "buy Canadian" talk increased and uncertainty clouded the industry's future. Some companies collapsed, many designers and other engineers drifted to the U. S. and Europe.

The decline was blamed on reduction in defense spending, a sharp rise in importation of parts and products, and a weakening of the consumer electronics market.

Now, Canada's electronics industry is once again confident, expanding and making an impression in design circles. Paralleling this transformation is a tightening of links between the Canadian and U. S. electronics industries.

What has happened? Canadians cite three factors:

- The joint U.S.-Canadian Production Sharing Program, under which Canadian suppliers have easier access than before to U.S. military contracts.
- New emphasis on research and product development—a result of the realization that Canada must be selective in choosing areas of electronic competition.
- An upturn in Canada's consumer electronics market.

Since 1933 and the passage of the "Buy American" act, bids made by Canadians on U.S. military contracts had to be increased by a factor that was equivalent to a tariff. Moreover, end items for

(Continued)

Originality, Novel Layout Win Canadian Design Contest

Two prizes for best Canadian-designed electronic product and component were awarded to two companies exhibiting at the Canadian IRE show in Toronto last month. Criteria for the awards included originality, usefulness, quality of design, human engineering, marketability and other considerations. The contest was judged by men prominent in Canadian electronics, who named as winners Raytheon Canada, Ltd., and Bach-Simpson, Ltd.

This frequency controller-indicator, which combines in a small package a meter and a supervisory system, uses an idea reportedly new to direct-readout freq meters. A motor designed to run synchronously over a wide range of input frequencies and voltages is directly coupled to a small ac generator mounted integrally with it. A signal applied to the motor generates a voltage proportional to the input frequency. Both meter and generator are potted, and the whole design is engineered to keep its characteristics over a continuous operating period of 10 years.

Raytheon's scan converter for bright display of radar-originated information, is built around a scan-converter tube designed by the parent U.S. firm. Intended for continuous duty in air-traffic control, the complete unit was designed for durability, accessibility, and good heat dissipation. Hot parts are mounted on the outside of the chassis on hinged frames. Both the front and back of the cabinet are hinged. Small parts are mounted on horizontal strips on each swinging frame so that all components and parts are completely accessible. Cable entry is through bottom and top of cabinet.

NEWS

the U.S. military had to have a U.S. parts content of at least 50 per cent in general.

These restrictions, though they did not apply to equipment unavailable in the U.S., were inconsistent with the official policies of the American and Canadian Governments to establish cooperation in defense production. Though the U.S. military services interpreted the "buy American" restrictions liberally, preference was clearly given in competitive procurement to U.S. suppliers.

This year, however, the Defense Production Sharing Program was instituted by agreement between the two countries. Under the program, military electronics equipment supplied by Canada to U.S. contractors and military services is, in effect, exempt from provisions of the "Buy American" act.

Canadian suppliers receive preference over all other foreign sources and are often treated as American suppliers. Duty-free privileges can be obtained in subcontract work, and the Canadian electronics industry has been invited to tell its story to the U.S. military services.

The first results of the program are becoming apparent. Canadian Aviation Electronics, Ltd., has earned a fire-control subcontract from Hughes Engineering, and other successes have been made in radar, communications and data processing.

Canada is banking heavily on the Production Sharing Program. The Minister of Defense Production told Canada's Parliament that the Canadian electronic industry is "now in a transition period, which is likely to persist for two or three years, during which Canadian defense electronic production must be reoriented, in a very large measure, to serve a North American rather than a Canadian market."

Because production sharing is linked to R & D, the Canadians are hopeful of eventually receiving either significant research contracts or complete responsibility for a phase of the North American defense effort, or both.

To get its share, Canada's electronic industry has:

- Formed a Defense Production Sharing Committee in the Canadian Electronics Industries Association to help Canadians do business in the U.S.
- Started to set up American subsidiaries to relieve U.S. customers of customs and other paperwork. Both Sinclair Radio Labs and Welwyn Resistor have established two-man offices in the U.S. to handle this chore.
- Undertaken to exhibit in American shows.

In addition Government help is available to companies seeking American markets for their products or services.

The director of the Canadian IRE, A.P.H. Barclay, wrote recently, "In Canada we cannot hope to spread ourselves across the whole electronic horizon but must narrow our sights to particular fields of endeavor."

This sums up the Canadian position: that in a country of some 16 million people, R & D for export rather than mass production for home consumption should be the electronic industry's goal.

Canada's Deputy Minister of Defense Production, D. A. Golden, says: "Canadian industry will be able to share in . . . production programs only if its engineering capacity can be maintained and technical competence advanced through the performance of appropriate development tasks."

Therefore, the Canadian Government underwrites a good deal of electronic research—on the assumption that production sharing presupposes development sharing.

To keep military R & D efforts efficient, an Electronic Component Research and Development Committee advises the Government's Defense Research Board on the development of components to meet or anticipate defense requirements.

Another reason for confidence in Canada's electronics industry, at least for the near future, is the opening of the replacement market for TV sets. Saturation of the TV-set market was an important factor in the sagging sales of the last two years.

More help will be given by the establishment of second TV channels in major cities now served only by the Canadian Broadcasting Company network.

U.S.-Canadian Industries Moving Closer

Most of the exhibitors at last month's Canadian IRE show were either American companies or Canadian subsidiaries and affiliates of American companies. Many of the U. S. concerns wanting sizable business with Canada have set up over-the-border units to get it.

Some Canadian subsidiaries are merely marketing or production facilities for their U.S. parents. But others have strong R & D departments that are contributing substantially to the company record.

Two engineers from Canadian Westinghouse contributed the paper judged best at last year's National Electronic Conference. Raytheon Canada designed a scan converter around the parent company's scan converter tube and won the best-designed-product prize at this year's Canadian IRE show. Northern Electric, the Bell System's Canadian affiliate, is doing advanced research in a wide range of fields.

With close company tie-ins, with many Canadian engineers working in this country, and with the new Production Sharing Program, the gap between the U.S. and Canadian electronics industries is narrowing. ■ ■

NEWS

22 Stereo Broadcasting Systems Vie for FCC Nod

How Proposed Stereo Systems Compare

FM Stereo Systems With FM Subcarriers

System	Main Channel			Subcarrier			
	Signal	Bandwidth KC	% Mod.	Signal	Bandwidth KC	Freq. KC	Swing KC
Calbest	L+R	15	70	—R	3.5	27	±5
Crosby	L+R	15	50	L—R	15	40	±25
EMI	L+R	15	>90	$\frac{L^1}{L^1+R^1}$	0.1	22	±0.5
Halstead	2L—R	15	70	2R—L	15	41	±7

FM Stereo Systems With AM Subcarriers

GE	L+R	15	50	L—R	15	31.5	d.s.b.
Zenith	L+R	15	90	L—R	15	39	d.s.b. s.c.

Notes: d.s.b.—double sideband s.c.—suppressed carrier

TV Sound Stereo Systems

EMI	L+R	15	90	$\frac{L^1}{L^1+R^1}$	0.1	22	A
GE	L+R	15	100	L—R	15	31.5	B
Motorola	L+R	12	85	L—R	0.3-4	23.6	C
Philco	L+R	7	95	L—R	0.5-7	15.75	D

Notes: A—Same as FM system. B—Same as FM system but suppressed carrier. C—±5 KC swing FM. D—Lower side band suppressed carrier.

AM Stereo Systems

System	L+R Information	L—R Information	
		Bandwidth KC	How Obtained
CBS	Normal AM	?	Phase Mod.
Philco	Normal AM	0.3-?	Phase Mod.
GE	Normal AM	0.3-4	±4 KC FM
RCA	Normal AM	?	±0.5 KC FM
Westinghouse	Normal AM	0.3-3	±3 KC FM
EMI	Normal AM	0.1	±0.2 KC FM
Kahn	(L on one sideband, R on the other)	?	?

THE NAGGING question of multiplex adapter availability was raised again at the recent New York High Fidelity Music Show. With stereo playback equipment dominating the attention of the 46,000 visitors, major manufacturers of tuners and complete packages were besieged with requests for stereo broadcast adapters. But, as in previous years, spokesmen were again compelled to stall the public, because Federal Communications Commission evaluation of proposed systems has not been completed.

No less than 22 stereophonic systems are being evaluated by the National Stereophonic Radio Committee (NSRC) in its effort to help the FCC set up standards for the broadcasting and manufacturing industry.

Though systems are proposed for each broadcast service—fm, am and television—highest priority is being given to fm. The FCC has asked the industry for its recommendations on fm by Dec. 11. NSRC is giving its highest priority to the evaluations of Panel 1 on System Specifications, under the chairmanship of C. J. Hirsch.

AM-FM Systems Outlined

In a recent report, Mr. Hirsch described the 22 proposed systems and progress toward agreement on which might be the best to offer for the FCC's consideration.

For fm, systems are proposed by Calbest, Crosby, Halstead, Electrical and Musical Industries, Ltd. (EMI); General Electric, Philco, Zenith, Volpe, Svorec, Neeley and Lippincott. For am, schemes have been submittted by GE, Kahn, EMI, Philco, Westinghouse, the Columbia Broadcasting System and Radio Corporation of America. For TV, systems have been offered by GE, EMI, Motorola and Philco.

The fm systems are divided into two groups: those with fm subcarrier (EMI, Calbest, Crosby and Halstead) and with am subcarrier (GE, Zenith, Volpe, Svorec, Neely and Lippincott). Philco had an am subcarrier system but withdrew it, stating that its advantages were not

great enough to justify prolongation of debate.

At the time of Mr. Hirsch's report, only the fm-am group had offered preliminary findings. NSRC was still awaiting reports from the fm-fm, the am broadcasting and the TV groups. Another committee is completing a theoretical comparison of fm-fm and fm-am systems.

Preliminary Findings Noted

Mr. Hirsch reported the results of the preliminary findings on fm-am systems as follows:

"The GE system provides the least expensive stereo performance, because the receiver does not need to reconstruct the subcarrier.

"Philco and Zenith, because they need not reserve modulation range for the subcarrier, which is nearly suppressed, allow fuller modulation (almost 100 per cent) for L + R channels and therefore are expected to provide superior monophonic and stereophonic reproduction."

"There appears to be little to choose between Philco and Zenith in performance. The same can be said for the time-multiplex systems, since after modification, they will resemble the Zenith approach very closely. However, as stated above, the receivers are more complicated than the GE stereo receiver.

"The Receiver Panel (No. 4) of NSRC will be asked to evaluate the relative complexity of the fm-am receivers. If a system gives greater performance but results in costlier receivers, the facts will be presented to the FCC for decision."

Factors being considered by the committee with the final decision up to the FCC are: compatibility, signal-to-noise (monophonic and stereo), stereo effect, receiver and transmitter complexity, utilization of spectrum space, and effect of propagation (multipath).

The systems specification panel has been suffering delays, Mr. Hirsch said, because adequate test facilities could not be found by Panel 6 (Subjective Aspect). This was resolved by the offer of facilities by Bell Labs.

Thus another year may pass before final system approval is decided by the FCC. Until then major manufacturers are reluctant to invest in the development and production of adapter units. Monophonic broadcast reception will still prevail for the coming year. ■ ■

Electronics Education to Benefit from Ford Foundation Grants

Two of the most unusual applications of the $19.5 million recently granted by the Ford Foundation to 10 schools to modernize the teaching

of engineering will directly affect education in electronics.

Case Institute of Technology will use its $1 million to create centers in engineering design and systems research and Massachusetts Institute of Technology will introduce new curricula to meet the requirements of tomorrow's engineering.

Believing that "the greatest emphasis in engineering education should be placed upon the close relationships and inter-disciplinary character of modern engineering and science," Case will set up an engineering design laboratory that will specialize in authentic design problems. Among projects being considered are those for computer-controlled machine tools, electronically controlled devices for the handicapped, and instruments for unusual environments.

The laboratory will be headed by Dr. J. B. Reswick, who defines engineering design as "the creative experience which begins with an original concept or idea, utilizes science and engineering, and ends with the construction and evaluation of a device or system which meets a human need."

The lab will specialize in "authentic design problems" and will cut across many of the existing boundaries between the special fields in engineering and science, according to Case.

Work at the systems research center will also cross different fields. The center is said to be the first academically based center in systems engineering. It will use the talents of the entire Case faculty.

Systems under study for early work at the center include a complex automatic computer for industrial control and a large-scale communication system.

MIT will use its $9.275-million grant to support a program of development and innovation in its engineering school. Seven professorships in newly emerging fields will be created, new labs to demonstrate fundamental concepts will be developed, and steps will be taken to help students financially through fellowships and loans.

A major program will be the creation of "new syntheses of courses to couple the basic science with the newly emerging fields of engineering and to introduce students to the 'hard-headed' purposefulness of engineering."

The awards were announced during a meeting of the American Institute of Consulting Engineers by Dr. H. T. Heald, president of the Ford Foundation, who asserted that engineering education had fallen behind engineering developments.

Also of significance to electronics is the use to be made of Ford Foundation funds by the University of Michigan. A major share of its grant, $900,000, will be used by the university to support an experimental program leading to the widespread use of computers in engineering education.

Details of Perceptron Recognition Research Reported

THE FIRST actual pattern-recognition perceptron is nearing completion at the Cornell Aeronautical Laboratories in Buffalo, N.Y., reported Dr. A. E. Murray at the National Electronic Conference last month.

Dr. Murray, who is active in the Navy-sponsored program, delivered a paper describing for the first time many details of the perceptron project.

Perceptron is the class name for a family of pattern recognition machines that operate on principles believed used in the human brain. So far, all except one perceptron exist only as simulations on an IBM 704. The first actual Mark I perceptron is now being completed and is expected to discriminate reliably between such patterns as E's and X's, squares and diamonds, and E's and F's.

The Mark I consists of 400 sensing transducers randomly connected to 512 electro-mechanical memory units called the association system. These units are randomly connected to response, or display, units. The response units are connected, also in random, through feedback circuits to the memory system.

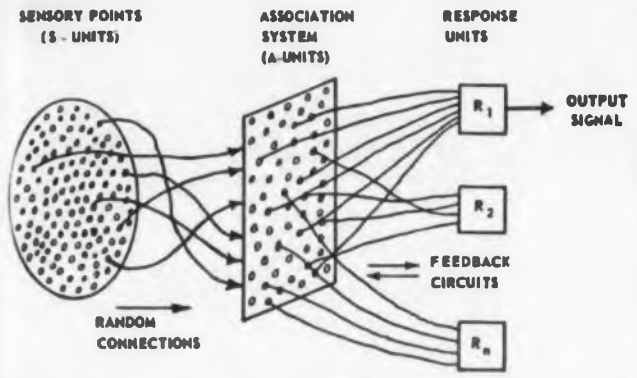
In operation, a portion of an image is picked up by a transducer and passed to some of the memory elements, all of which are unbiased and equally likely to switch one way as another. The signal goes on to the display, from where its effect is fed back to strengthen or inhibit the memory cells so they will provide a memory trace that will dominate future responses.

The perceptron design is potentially versatile. Input can be radar, optical, audio or other stimuli. Output can be any type of readout or display. But, Mr. Murray told ELECTRONIC DESIGN, it is more difficult to force the machine to learn to do useful work than it is to permit it to learn spontaneously.

This is because Perceptron networks have no special relation-detectors and will be incapable of certain kinds of useful behavior. They are at their best when working with relatively noncoherent patterns. For coherent-pattern recognition, additional logic for coherence-sensing, edge and corner detection, inside-outside, before-after, under-over, and other topological relationships, is expected to give improved performance, and will be researched later. Except for work now under way in transform generalization and time relationships, effort has been confined to machines that sense only non-analytic attributes. But simulated perceptrons have been taught to generalize and discriminate coherent patterns and, in special circumstances, to spontaneously form "rational" or useful classifications for a collection of coherent stimuli.

One simulated perceptron recognized shapes regardless of position or orientation, and in favorable (but not rigged) circumstances a perceptron modified its own transmission characteristics to reflect population characteristics met in its signal environment. In some experiments a perceptron was presented with a succession of horizontal and vertical bars in various vertical and horizontal positions. This machine had only two possible responses, each of which eventually and spontaneously come to be associated with just one bar class.

All perceptrons may be classed as multi-



Schematic of perceptron organization shows the three types of units that work together to recognize patterns. Sensory units can be photocells, filters, or any transducer. Output cells can feed any type of readout or display.

port signal transmission networks with transmission characteristics that can be arranged to change automatically or can be changed from the outside to adapt the machine to applications related to complex signal recognition and/or classification. Two of the interesting features are:

- The adaptation is operational. It is on-the-job training, with the adaptation occurring as a result of practicing the tasks to which it will be trained. Neither the original internal circuit details nor the details of the adaptive changes need to be known or specified in order to construct or train a machine for useful or desirable behavior.
- The loss or malfunction of a few components is not likely to affect noticeably the reliability of operation.

Perception Structure

In all perceptrons to date, there have been at least three distinguishable sets or layers of functional units. In a signal flow graph for the network, each unit is a node of the network diagram and the nodes are connected by branches. Nodal units of different layers have different connection constraints and different dynamic properties. Three-layer devices, have, in the first layer, S-units (sensory cells); in the second layer, A-units (association cells); and in the third layer, R-units (response or output cells). So far, except for S-units, non-linear elements have yielded the best results; linear A-units have been only briefly considered.

In a practical machine, S-units either are or contain the input terminals for the network. They may include transducers, each sampling some small part of a complex input pattern and converting this information into a signal transmitted to several A-units. In a moderate-size machine of 400 or 500 or more A-units, connections from S-units to A-units may be random—one feasible construction scheme being to begin the wiring at the A-unit level, taking n_o leads from each

A-unit and connecting them, in random fashion, to the S-units. If the task is pursued in this manner, the number of output leads from each S-unit will be a random variable.

Because of the plurality of outputs from each S-unit and the scrambled wiring between the S-units and the A-unit layer, each A-unit receives connections from several S-units, over which flows a rather unique, small sampling of any activity among the S-units. The uniqueness is enhanced by the provision for some S-units, or at least some S→A branches, to inhibit the A-units they drive.

If the net sum of the signals received by an A-unit is sufficient to turn it "on", it will put out a signal to whatever R-units it has connections. Finally, the states of the R-units, as determined by the signals received from active A-units, either may be read by an observer as an identification or classification label or may be used to direct or otherwise control an external device.

Adaptive changes in the system's performance are effected through lasting changes produced in the output levels of A-units by feedback from the R-units, which is integrated and stored in each A-unit as a level-setting value.

An R-unit may or may not have a threshold. Furthermore, since it acts as a signal port for the network proper, the physical character and utilization of its main output signal is at the discretion of the designer—it has nothing to do with the internal behavior of the network. The logical characteristics, however, are important. R-units may be designed to have any number of output states but it will make examples simpler if we consider an R-unit to be a 2-state device. An auxiliary output signal from one or both of its states is fed back to its A-units, modifying their stores values and thereby affecting their future output strength.

Closure of the feedback loop can occur through some external agent such as an operator or trainer or another machine. But if loop closure is internal to the network proper, the perceptron can be capable of self-training.

Stimuli for a perceptron consist of complex signal patterns of any number of dimensions. In a practical machine, such patterns may be optical images projected onto a retinal mosaic of photo-sensitive elements, waveforms fed to an analyzing filter-bank, or some other such projection of a set of physical attributes.

For optical inputs, each S-unit of a perceptron would possess a photo-sensitive element and an amplifier or other impedance matching device for sending driving signals to A-units. Whether the S-units are chosen to be linear or not depends

upon the number of them provided and the gray-scale resolution desired. Because any continuous-tone figure can be closely approximated with a sufficient number of small dots of standard density, any continuous-tone image can be closely characterized by a two-dimensional array of on-off elements. However, for a retina, it is probably cheaper to use a smaller number of S-units and have them linear over some reasonable range.

When a stimulus S_j is projected onto a perceptron retina, a certain set of S-units will be excited. These, in turn will excite a certain set, $A(S_j)$, of A-units but the retinal illumination pattern at the level of the A-units, will be so scrambled that it will lose its original coherence and most other relational characteristics. The combined effect of the outputs from the set, $A(S_j)$, will determine how the relatively small number of R-units will respond.

Feedback operation can be understood more easily by assuming just one binary R-unit, so that the source set for that response unit is therefore the whole population of A-units. Assume also that the feedback from R-unit to A-units is arranged in such a way that A-units may acquire either positive or negative values and, consequently, positive or negative outputs when active. Should the net sum of excitation delivered to the R-unit from the active set $A(S_j)$ be positive, the R-unit will go to the "1" state, otherwise to the "0" state.

Feedback signals from either of these alternative states will add or subtract some small increment, ΔV, from the values of active A-units. thereby affecting their future output levels. Positive feedback from the 1-state will enhance the future effect of those A-units that are presently causing the $R = 1$ response. The same polarity feedback, received by active A-units whose output is unsuccessfully trying to turn on the $R = 0$ response, will decrease their influence toward that response. Hence, a succession of negative experiences may eventually reverse a unit's output polarity. thereby enabling it to receive reinforcements for responding to the same stimuli which once caused decreases in absolute value.

Training a perceptron to a given stimulus environment subjects the population of A-units to a selection and modification process similar in some ways to that which operates in biological evolution. The difference in the two processes stems from the fact that, since A-units neither expire nor have progeny, no genetics or spontaneous mutation are involved. Whatever modification occurs. it takes place within the lifetime of the original set of A-units.

In a perceptron those A-units whose chance connections permit them to be most frequently activated by stimuli of just one class are selected by actual exposure to a stimulus population containing some of this class. Their output polarity is,

at the same time, little by little, adjusted toward the most favored response. Naturally, there are likely to be some A-units whose connections do not fit them for any consistent utility in their signal environment, and they will tend to stay at a relatively low output effectiveness. A mutation process designed to operate on the connections of relatively low-valued A-units could be incorporated and might be beneficial.

Future Plans

Dr. Murray reports that simulation experiments will begin soon with a new and more versatile program, especially on cross-connected A-systems. At about the same time, direct experimentation will begin on the Mark I perceptron.

Multi-layered A-systems are now being studied to discover practical ways for, and advantages of, increasing the logical depth. The researchers hope that future effort will provide mechanisms for recognition of special topological relationships, and additional effort is being directed toward the recognition and utilization of special time relationships. If this work succeeds in sufficiently increasing the sophistication of perceptron capabilities, the Navy will sponsor intensive effort on engineering applications requiring the recognition or interpretation of complex data.

Obvious applications would be in radar and optical surveillance and reconnaissance, language processing and electronic communication, and adaptive control systems for vehicles and production plants. ■ ■

Reps Symposium to Discuss Industry Measurement Needs

The fifth annual Electronic Engineering Representatives Show, to be held in Philadelphia Nov. 12 and 13 will feature a symposium on electronic test instrumentation.

The speakers will include:

Bruno O. Weinschel of the IRE Professional Group for Instrumentation, whose topic will be "Russian Test Equipment for Audio, Radio Frequency, and Microwave Measurements."

C. P. Sherman, General Electric missile and space engineer, who will discuss "Production Testing for Research and the Development Type Components."

E. C. Wolzien of the National Bureau of Stand-

ards, who will report on "The National Standardization of Radio Measurements."

The electronic equipment of over 50 manufacturers will be displayed.

Design Has Many Faces

Remember that huge klystron at WESCON? There's a story behind it. Varian Associates built it on a crash program—when the contract principal began having trouble, Varian as alternate contractor had to step in and make good in a hurry.

Normally klystrons are processed after construction by "breaking down" the cathode (activating it) and then by drawing beam current. During both these processes large amounts of gas are liberated—in particular metallic vapor is released if a high power pulsed beam touches any of the tube sides. This of course destroys the vacuum integrity of the tube. The klystron is re-evacuated and sealed after the break-in process.

Trouble was Varian's facilities for supplying pulsed power hadn't been finished at the time. No beam current could be drawn before delivery

Giant klystron triggered some enterprising design under time pressure.

of the tube. Varian engineers' solution: tack a five liter per sec VacIon pump—also manufactured by Varian—to the top of the klystron . . . and ship on schedule. It worked. Any gas liberated during the tube's initial operation was immediately carried off by the VacIon pump.

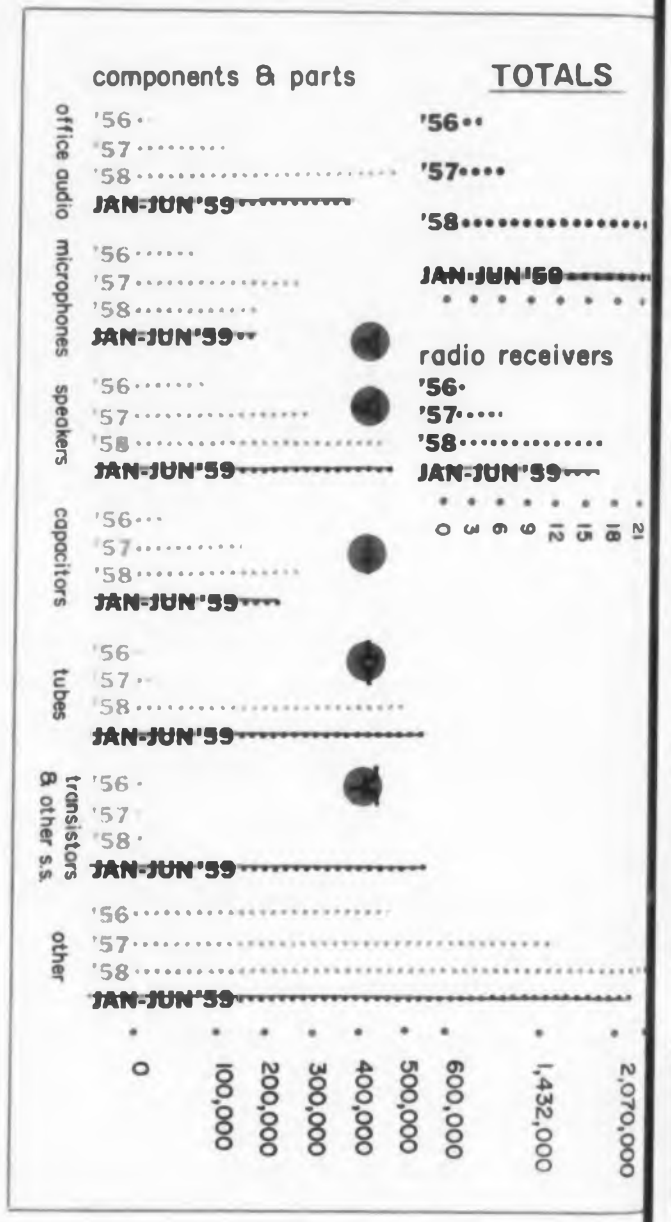
NEWS

U.S. Electronic Imports from Japan In First Half of '59 Top All 1958

The value of electronic imports from Japan totaled $22.1 million during the first six months of 1959, exceeding by over $200,000 the value of products imported during all of 1958.

The latest figures of the Business and Defense

HOW ELECTRONIC IMPORTS FROM JAPAN HAVE GROWN IN LAST THREE AND A HALF YEARS



Services Administration, summarized in the accompanying graph, show that transistors and other solid-state parts made the largest gain over last year, and that receivers comprise the largest-valued import.

Educational TV to be First Tryout For CBS Labs' Narrow-Band System

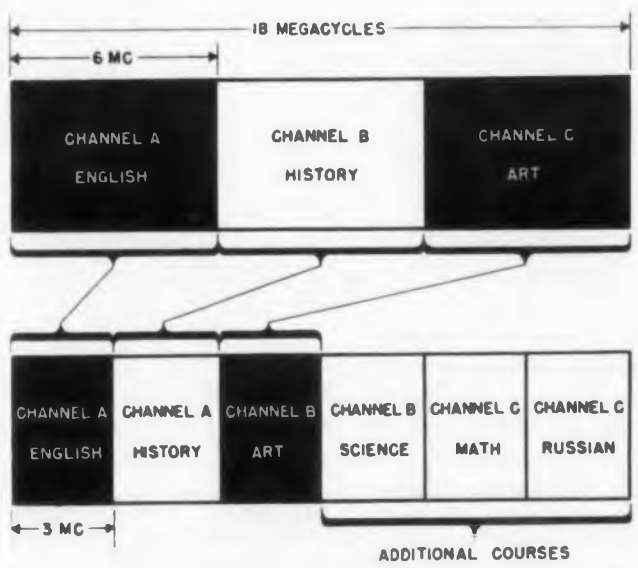
Airborne educational TV will be the first full-scale application of the CBS Labs narrow-band TV system that uses a 2.2-mc bandwidth. Special receivers designed to operate on the 441-line, 48-field standard will be installed in schools scattered over the six-state Midwest reception region chosen for the experiment, in which programs will be transmitted from a plane circling the area.

With the CBS system, developed some time ago for vhf and now adapted for uhf, two channels can be squeezed into the space normally occupied by one. Channels are 3 mc wide, instead of the normal 6 mc, and video bandwidth is 2.2 mc. Horizontal resolution will be equivalent to only a 3.3-mc-bandwidth broadcast-standard picture. But, reports CBS Labs, this is about all that is seen on the average set, which is nominally designed to handle a 4-mc-bandwidth picture.

To compensate for flicker resulting from the 48-field-per-sec standard, slow-decay phosphors will be used in the receiver picture tubes. A picture-crispener circuit will also be incorporated in the receivers.

The broadcasts will be made compatible with vhf programming by a master-receiver system in each participating school. Transmissions will be picked up by a master receiver in each school, remodulated, and will be sent by closed circuit to vhf receivers in the classrooms.

The reduced-bandwidth development is a result of research originally instituted to save TV tape; many of the classes to be transmitted in the experimental program will be taped, probably with special cameras. The first broadcasts are scheduled to begin next fall.



Narrow-band television will permit doubling of number of channels in given bandwidth. Special crispening circuits and slow-decay phosphors in receiving will compensate for low resolution of 441-line, 48-frame-per-sec system.

NEWS BRIEFS . . .

. . . **A SOVIET PUBLICATION,** Prioda, claims a new computer has been developed in the U.S.S.R. that is faster than "all existing Soviet and foreign production-model computers." The unit, designed by academician S. A. Lebedev, "opens a significant perspective in the further development of computers and control machines," and has been recommended for mass production.

. . . **IN THE SAME PUBLICATION,** the Soviets finally credited the U.S. with discovery of the Van Allen radiation belt. The credit was given in an article on the study of space by rockets and satellites. The article mentioned that the U.S. discovery was made during flights of Explorers I and III.

. . . **THE ARMY** has proposed a program of information exchange among the three services. The program would use microfilm cards and would be implemented in three control centers that would process and distribute the cards to eliminate duplication of effort and to "give engineers and designers information required for their jobs at a minimum of time and expense."

. . . **ANY NOVICE SCIENTISTS** around the house? The annual Westinghouse Science Talent Search has begun. More than 25,000 young contestants are expected to apply, hoping to win some of the more than $34,000 that will go to the 40 finalists. The search is being conducted for Westinghouse by Science Service, a non-profit organization, through the Science Clubs of America.

. . . **DEVELOPMENT OF ALLOY-DIFFUSION** junction transistors with an upper frequency limit of about 2,000 mc, has been claimed by Mullard Research Labs, England. The company also reports work on vhf power transistors with 500 mw ratings.

. . . **THE ELECTRONICS PROGRAM** conducted by the Air Materiel Command's Manufacturing Methods Division has been approved. Under the program, emphasis is placed on basic manufacturing processes for many materials, rather than on production refinements of single items such as tubes or transistors, as formerly.

. . . **ULTRASONIC GENERATOR** line of Westinghouse has been provided with solid-state power supplies, reducing weight and size of ultrasonic cleaners drastically and raising reliability according to the company.

SIGNIFICANT CONTRACTS . . .

. . . **TO KEARFOTT CO.,** Inc., from the Air Force, initial funding of $99,800 for the study phase of a contract to design and build a solid-state celestial comparator for space navigation use.

. . . **TO RADIATION,** Inc., from Northrop, $400,000 for development of an advanced pulse-code-modulation flight-test data acquisition and data-processing system.

. . . **TO SYLVANIA ELECTRIC PRODUCTS,** Inc., from the Signal Corps, $15 million for development of a high-precision weapons-locating radar designated AN/MPQ-32.

. . . **TO NCR ELECTRONICS** Div., from the Air Force, $70,000 for study of a rod-type magnetic switching and storage device. Switching speed in a coincident-current mode is expected to be about 70 μsec.

. . . **MAGNETOHYDRODYNAMIC** power generation produced 1 kw for five seconds, General Electric reports. Efficiency was negative because of the high-powered plasma arc that was used as a source of ionized gas. GE believes, however, that in a closed-cycle operation, nuclear or solar energy might be used to provide efficiency higher than that of heat-to-electricity generators known so far.

. . . **TO FXR, INC.,** Woodside, N.Y., $500,000 through Cornell Aero Labs for design and manufacture of the "most powerful radar transmitter ever built." Goal is peak power of 50 megawatts, with a variety of pulse lengths and repetition rates and average power of up to 50 kw.

. . . **TO AMERICAN BOSCH ARMA CORP.,** Hempstead, N.Y., $53.35 million from the Air Force for an advanced and lightweight all-inertial guidance system for operational Atlas ICBMs.

. . . **TO ALLEN B. DU MONT LABORATORIES,** Inc., Clifton, N.J., $266,706 from the Signal Corps for an engineering test model countermeasures set.

. . . **TO HOFFMAN LABORATORIES,** Los Angeles, $600,000 from the Air Force for development of a fully orienting large-area solar-electric power system for use in space satellites.

NEWS

Soviet Reports Moon Photo Hinged on 2 Big Advances

Man's first glimpse of the far side of the moon was accompanied by Russian claims of two major triumphs in space photography.

The Soviet said its scientists had solved the problem of turning a cosmic vehicle in space by signals from the earth, so that the lens was pointed at the moon when the camera started operating.

In addition the problem of transmitting half-tone photographs of high quality from cosmic space to the earth by television was declared solved.

The Soviet reported that four fixed antennae protruded from the top of their moon-circling satellite, in whose center was a large lens. An automatic switch controlled from the ground was said to have swung this eye toward the moon while the satellite was clipping through space about 37,000 to 43,000 miles from the sun-lit body.

After a 40-minute series of exposures, the film was developed automatically in the rocket, the Soviet said. Then, by means of a "special radio transmission system," the carrier sent its television photos to the earth as it approached the lowest point of its orbit.

Meanwhile the National Aeronautics and Space Administration has decided to try again to send a payload to the moon. The shot is scheduled for late this month and, if successful, may be followed by an attempt next month to place a payload near Venus.

U.S. plans to achieve a lunar orbit Oct. 3 died prematurely when the Atlas-Able launching rocket that was to have carried the satellite exploded during a static ground test.

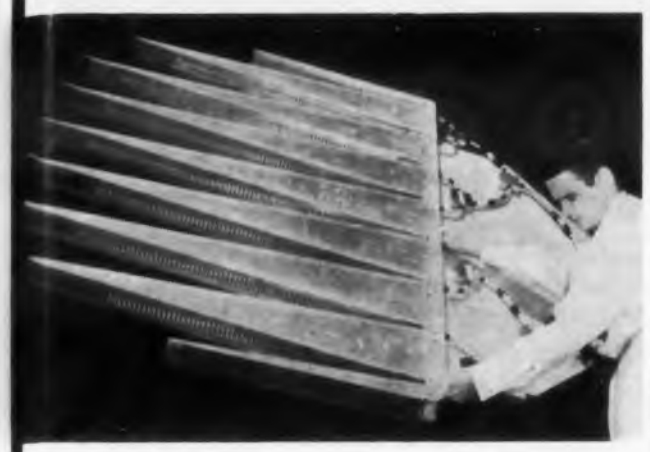
The lunar shot now planned will be more difficult in some respects than the Soviet ones so far. An attempt will be made to put the satellite in orbit around the planet. This would require not only precision in initial guidance of the vehicle but the firing of a retro-rocket to slow the satellite, trap it in the moon's gravitational field and so achieve an orbit instead of further soaring into space.

From the standpoint of science, such a satellite would be also more valuable, since it would stay near the moon, gathering and relaying data to earth for a considerable time.

The U.S. vehicle is to carry instruments to measure any magnetic field the moon may have and to find out if the planet is surrounded by a belt of charged particles, the way the earth is. A television-type scanner will also be aboard, and it is hoped to shoot a crude picture of the moon's far side.

The American lunar vehicle, weighing 375 pounds, will be on the order of the Explorer VI saddle-wheel earth satellite launched Aug. 6.

Airborne Antenna Saves Space, Weight



Engineer checks feed structure of retarded wave surface antenna built as one-sixth-size model. The antenna, said to have high gain, is designed for airborne early warning radar. A 33-foot retarded wave antenna of this design would be only 1.5 feet thick and weigh 400 pounds, significantly less than a parabola type, reports Chance Vought Electronics.

Future of Radio Astronomy Pictured at Crossroads

Attempts to commercialize more radio-frequency bands may threaten the future of radio astronomy, a University of Michigan professor warns.

Prof. Leo Goldberg, chairman of the university's Department of Astronomy and vice-president of the International Astronomical Union, notes that in the next ten years advances in space communications are almost certain to multiply demands for radio channels. The military will want to transmit messages from rockets and satellites, he says, and commercial radio and telegraph companies may seek to use the moon or satellites to bounce messages around the world.

Professor Goldberg has called on the United States to protect the bands most valuable to radio astronomy. Use of frequency bands is being discussed in Geneva by the United Nation's International Telecommunications Union, he noted.

Originally, only a weak proposal by the Dutch to protect six bands for radio astronomy was before the international conference.

The American delegation in reaction to a Washington meeting between protesting U. S. scientists and government officials, changed its proposal for protecting of only one band, the hydrogen line, to a proposal supporting allocations of 17 channels stretching from 2.5 to 30,000 mc.

NEWS

Electronic Space Camera Slated To Observe World's Weather

Weather observations from space in the form of a continuous strip of pictures around the world may soon be possible with an electronic satellite camera under development by the Radio Corporation of America.

The camera is based on a combination of television and electronic printing techniques. It uses electrostatic tape to store images for later broadcast.

Elementary details of the camera, described as "radically new and simple," were outlined by three scientists of RCA's Astro-Electronic Products Div., Princeton, N.J., to a convention of the Society of Motion Picture and Television Engineers in New York.

At the same meeting, two RCA system engineers related that environmental conditions in space were presenting new headaches to the designers of image sensors.

Camera Has Two Elements

The space camera is a compact, single unit whose basic elements are a special electrostatic tape and an electron gun of the type used in common TV camera tubes.

In the laboratory model, the elements are built into a glass vacuum tube roughtly the shape of a mushroom. The neck is a television pickup tube containing the electron gun. The bulb contains a roll of electrostatic tape mounted in an automatic assembly for winding and rewinding during exposure and readout, somewhat in the manner of standard motion picture film.

Installed in a satellite, the camera would be linked to a conventional photographic lens sys-

Face of RCA's electronic space camera, designed for global observations. Pencil points to reel of electrostatic tape upon which light image is focused by a lens system (not shown). The electrical-charge image is stored on the reel for ultimate transmission via TV-type signals to the earth.

tem and a low-power transmitter to broadcast the picture data to earth.

Key Advantages Listed

The scientists describing the camera said it had several potential advantages for remote viewing of terrestrial clouds or even the moon's surface from space. They listed these key advantages:

- Extreme simplicity and durability, contrasted with systems that combine TV cameras and magnetic tape storage.
- Very large picture capacity, because of ability to erase and re-use the tape after each passage, in contrast with photographic film.
- Reduced sensitivity to radiation effects in space.
- Widely variable speed of operation, ranging from a few pictures per orbit, if desired, to the 16-frames-per-second rate of an 8-millimeter movie camera.

Image Failures Analyzed

The two RCA engineers who discussed image sensors and the potential hazard of space environment—Milton Ritter and M. H. Mesner of the Astro-Electronics Products Div. –attributed failures outside the earth's atmosphere to these possibilities:

- Loss of atmospheric cooling.
- Explosive decompression.
- Boiling and leakage through seals.
- Solar radiation.
- Bombardment by solid particles.
- Presence of disassociated gases.

Zero gravity and thermal problems are major difficulties for the designer to overcome, the engineers said. Most operational failures of satellites to date, they noted, have been credited to improper temperature regimes.

Maximum reliability can be built into the system, the two indicated, but only at the cost of size, weight, power, performance, capacity and other vital factors. Compromises must therefore be made, they said.

The engineers described the vidicon image sensor as of the "utmost importance" in space vehicles, because it permitted operation with reduced transmitter power.

CIRCLE 19 ON READER-SERVICE CARD ➤

NEWS

CDC Computer Uses Only Two Power and Levels Throughout

Control Data Corporation's completely transistorized 1604 computer uses only two power supply levels, two signal levels and has basic bi-level amplifier-inverters that operate at an equivalent phase-rate of 5 mc.

The general-purpose, stored-program computer, which is being readied for its first delivery, is designed with single-address logic and a magnetic-core storage capacity of 32,768 48-bit words.

Input-output operations are carried out independently of the main computer program. Storage is random-access; read access time is 2.2 microseconds.

Each storage unit has a total storage cycle time of 6.4 microseconds. The storage cycles of the two storage sections overlap one another so that the effective cycle time is 3.2 microseconds when addresses of alternate memory banks are referenced.

New Nitrides and Silicons Added To Thin-Film List

Additional materials have been declared suitable for use in thin-film electronic devices.

Researchers at Batelle Memorial Institute, working under Air Force contract, have learned that chromium-titanium-nitride-is most promising among nitrides studied for resistive applications. By adjusting film thickness and nitriding temperature, resistances of 60 to 800 ohms per square centimeter have been obtained.

CLEANER, HARDER VACUUMS INCREASE TUBE LIFE

During production Eimac-designed rotary vacuum pumps evacuate gas at high temperatures. This, plus clean electrode design and non-emitting grids, helps make Eimac internal-anode tetrodes the most reliable available.

NEWEST TUBE TYPES, TUBE IMPROVEMENTS COME FROM EIMAC RESEARCH AND ENGINEERING

First to develop internal-anode tetrodes, Eimac is also the recognized leader in ceramic-metal vacuum tubes. With emphasis on new tube types, Eimac constantly improves conventional tube types, too.

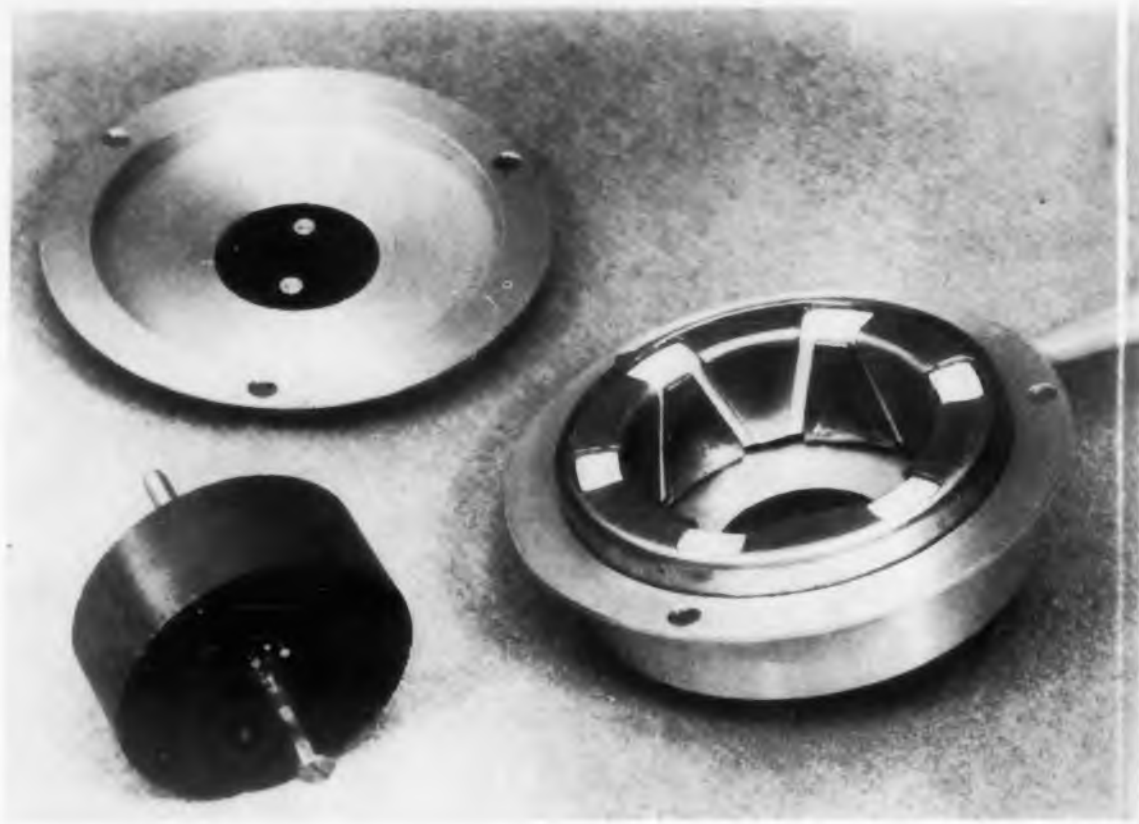
Black Box Minimizes Howling

Frequency shift modulator under researcher's arm is hooked into PA system between speaker and microphone to minimize howling. It shifts feedback frequencies of room reverberations as they enter microphone. Only about a 5-kc shift of input signal will equalize it to the mean distance between the major peaks and adjacent valleys of the room's gain response characteristic. Then energy generated at the gain peaks is quickly absorbed in the valleys of the response characteristic after one trip of the sound energy around the acoustic feedback loop. Dr. M. R. Schroeder of Bell Labs developed the unit.

$9.3 Million Contract For Advanced Radar

A contract for $9,373,728 has been awarded to Texas Instruments, Inc., by the Navy for the company's advanced anti-sub search radar, AN/APS-80.

The highly sensitive, 500-pound equipment was developed for long range detection of surfaced subs and the disturbances caused by snorkel emergence.



Trilec motor has ferrite rotor magnetized to operate with stator fingers, which bear alternate polarities. In this version, shaft rides freely in rotor within limits imposed by pins in shaft and rotor.

French Develop Ferri lot

FRENCH designers have put the properties of magnetic ferrite to work in a sub-fractional motor that promises:

- High power-to-weight ratios,
- No possibility of sparking,
- Magnetically controlled direction of rotation,
- Easily achieved stepping operation,
- Low-cost production.

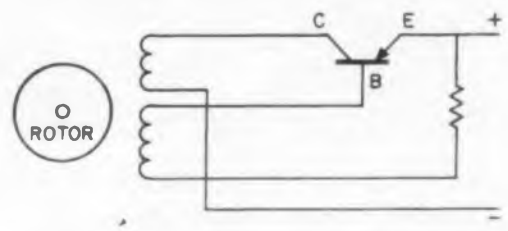
The motor has been developed in synchronous, self-starting universal, and stepping versions. All use a magnetic ferrite rotor that carries an alternating North-South field around its surface. The stators are single cylindrical windings enclosed in a sheet-iron pole-piece.

The portion of the pole-piece forming the stator's inside surface is cut into fingers, which carry a dc-excited field alternately from finger to finger. These fields work with those on the rotor.

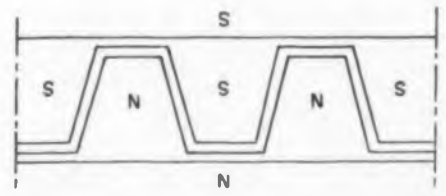
A small dc current will rotate the stator a few degrees until a rotor *N* pole is opposite a stator S pole. With an additional starting device and an ac current the motor operates as a classical synchronous motor.

How Self-Starting Is Achieved

An unusual feature of the stator is its



Transistor oscillator circuit works off dc to make motor universal, in another version.



Stator is wound to distribute poles as shown.

Other side of aluminum housing shows spring that helps rotor start turning and insures that rotation is always in desired direction.

Field-strength in ferrite rotor determines power-weight ratio.

...lotor

free-spinning shaft. Were it not for a pin in the shaft and two pins in the stator (all visible in the large photo) the stator would spin freely on the shaft, though not enough to start the motor.

When ac is applied, the rotor vibrates, kicking the shaft into rotation. Shaft rotation is affected, however, by a spring (also shown in the photo). If the shaft rotates counter-lockwise the spring unwinds. If it rotates clockwise the spring winds around the shaft, acting as a brake. Then, when the rotor moves in the opposite direction, the spring releases, helping the shaft rotate.

With this design the rotor always moves in the same direction regardless of instantaneous polarity of the starting ac. Torque is constant. Power increases with saturation of the ferrite rotor and with high frequency.

Transistor Makes It Universal

A small auxiliary winding is added to the stator to become part of a transistor oscillator circuit. This circuit, in effect, transforms dc to suitable ac. Oscillating frequency is mainly a function of the electrical constants of the circuit. Therefore, rotation speed is largely independent of supply volt-

NEWS

age and load. Any waveform will provide suitable operation.

Differently shaped pole fingers, a shaft locked to the rotor, addition of a stator secondary winding, and addition of another ferrite ring around the stator; heighten the stepping effect and, when their design is optimized, make the motor a stepping unit that rotates in one-finger steps.

In the stepping version, control is achieved with very moderate power. There are no delicate parts, no adjustments required and no moving contacts with attendant possibility of sparking.

The stepping motor can be made to work with pulses of either polarity, and with plain sine-wave ac.

The sub-fractional motor is made by the Paris firm Trilec, which states that the basic design is applicable to motors of any size, the only limit being the relative cost of ferrite to standard rotor materials. ■ ■

Microwave Satellite Communication Predicted Within Ten Years

Reliable microwave communications through use of earth satellites were predicted within five or ten years by D. W. Atchley, Jr., president of Microwave Associates, Inc. "Among the types of satellites being investigated for communications purposes, Mr. Atchley said, "from a military point of view, the moon is the only acceptable one.

"A passive reflector, such as the moon can be used simultaneously in many ways at many frequencies and within many power levels without cross-talk. It also is highly resistant to electronic countermeasures.

"However, since ground installations for passable-satellite, broad-band communication would require very costly antennas, transmitters and receivers, for commercial rather than military purposes it seems desirable to concentrate on the active repeater.

"It seems that the frequency range that will be utilized will be around 10,000 mc. However, at present, suitable low-noise repeaters, are more difficult to make above 4,000 mc, and as yet no really long-life microwave repeater tubes have been constructed.

"It is estimated that such a satellite system could be placed in use by 1965, after an initial development cost of at least $100 million.

"A 1000 channel, 3000 land-mile satellite system with several ground terminals could possibly be constructed for $7 million. This figures out at $2.50 per voice-channel mile, indicating that the active satellite is well worth pursuing."

Later, Mr. Atchley discussed Soviet electroni

devices, observed on his recent trip to the U.S.S.R. He described a potential millimeter-wave amplifying tube as "one of the most unusual tubes I have ever seen."

The tube uses a sheath of charged gas particles rather than a wire helix to interact with the electron beam. "It promises to provide amplification and generation of millimeter waves," he said.

Mr. Atchley was also shown in Moscow the Spiratron traveling wave tube, which amplifies efficiently over a broad frequency range, according to the Soviets.

Spaced-Array Radiotelescope Will Operate at 11.4 meters

What is billed as the world's largest radio telescope is nearing completion at Clark Lake in California's desert region.

Though two months short of ultimate completion, the two-mile long array of dipoles has been used to study 11.4-meter waves (26.3 mc) radiated from near the sun.

An extremely intense burst of radiation has already been recorded. Scientists of Convair, which is building and operating the telescope, suggest that the radiation was caused by atomic particles in the sun's corona accelerated by sun spot activity.

The telescope will be composed of a rectangular grid of 256 dipoles of copper wire suspended from posts in eight parallel rows covering two miles, and bisected by a two-mile transmission line.

East-west resolution is 0.25 degree, north-south resolution will eventually be 1.5 degrees. Through electrical modification of the branch feeder system, focus can be shifted as much as 45 degrees off the vertical.

"Largest" radiotelescope, now being built is able to operate during day because mountains shield against local radiation.

NEWS

Small Business Saluted By Military at Exhibit

The Department of Defense played a major role in the recent Great Lakes Exhibit of Business Opportunities, demonstrating again its policy of encouragement to small business.

The department maintained 311 booths, occupying 10,000 square feet of floor space, at the

ELECTRONIC DESIGN photo

Fig. 1. ITT Labs exhibit was one of many by large businesses at the Great Lakes Exhibit of Business Opportunities.

Allen County Coliseum in Fort Wayne, Ind. Elaborate displays of the Army, Navy, Air Force and other agencies stressed the government's eagerness to buy from small business as well as large

Large business shared the spotlight at the exhibit, showing equipment it sold to the government and displaying parts it had purchased from smaller business organizations.

At the Signal Corps exhibit a new packaging and quality assurance program was shown publicly for the first time. The program, described in a Sig-Pak Manual entitled "*Packaging Data Code System,*" spells out the requirements for packag

ELECTRONIC DESIGN photo

Fig. 2. Signal Corps exhibit showed businessmen how and what to sell to the corps.

ELECTRONIC DESIGN photo

Fig. 3. Display board highlights the Signal Corps' new Packaging Data Code System.

ng equipment for the Signal Corps in greater detail than ever before.

A display board displayed the code, which should help standardize the packaging and marking of bin-stock items.

Ceramic Stable to 3600 F

Translucence, strength, and high temperature resistance are the featured characteristics of this new ceramic, Lucalox. The polycrystalline ceramic was developed at General Electric Research Laboratory by Dr. Robert Coble, shown here comparing the new material with a disk of conventional ceramic. The basic material is fine-grain, high-purity aluminum oxide. Microscopically small pores or bubbles found in conventional ceramic materials have been eliminated, according to G.E. Possible applications include envelopes for high-intensity incandescent or discharge lamps. Lucalox is stable at temperatures up to 3600 F.

NEWS

Computers May Eliminate Future Cash Exchange

Computers supporting a universal credit-card system may eliminate cash and check transactions in the future, S. M. Humphrey, management consultant, told a group of computer users last month.

"From a technological point of view it will be possible to handle automatically transactions at stores, utilities, hotels and transportation offices merely by insertion of a credit card."

Even income taxes could be handled electronically, said Mr. Humphrey. Company payrolls would be compiled on magnetic tape and transmitted to employe's accounts at national or central banks, all of which would have inter-bank transmission equipment.

Not all payments would be handled this way, Mr. Humphrey added. "Transactions between individuals, and other low-volume transactions will not be subject to mechanization through the recording devices."

However, "almost every individual does have access to a device which could be used for sending information to the central bank's data processor—the dial telephone."

Satellite Scanner Shoots Earth

A two-pound slow-scanning device in the Explorer VI paddle-wheel satellite has taken the first "television" picture of the earth from space. Radioed shot, which covered a portion of the North Central Pacific Ocean, was made Aug. 14 as the satellite spun 19,500 miles over Mexico. Photo at left shows the result, detailed enough for scientists to discern cloud formations. Scanner, developed at Space Technology Labs of Inglewood, Calif., formed image that was sent over 1.5-cps bandwidth signal to Hawaiian tracking station. A single photo took 40 minutes to transmit. At right is National Aeronautics and Space Administration's interpretation of the signals, superimposed on a globe

Suppressed-Carrier AM Best So Far For Low-Noise in FM-AM Stereo

In a progress report to the System Specifications panel of the Electronic Industries Association's stereo committee (NSRC), a subgroup has reported that a system using suppressed carrier am gives the best signal-to-noise ratio of six fm-am systems studied.

However, the subgroup reported that another system with good signal-to-noise, but which does not use carrier suppression, would result in an appreciably simpler receiver. A receiver panel of the NSRC will report on receiver complexity of the systems under study.

Other activities underway by various NSRC groups include:

- Tests of fm-fm systems for minimum bandwidth required for good stereo broadcasting, and optimum compromise bandwidth for combined stereo and background music broadcast;
- Theoretical studies of the relative merit of fm and am subcarriers for fm stereo broadcasting;
- Classification of am stereo systems so far proposed;
- Tests of the British EMI system, which will be made by comparison listening with other systems.

SAGE System Gets New-Design Antenna

fty ton, 110-foot-long rotating radar antenna slated r SAGE defense system will be mounted on the uc ure housing the complete radar system, designated N/ PS-28. Raytheon is the antenna designer.

NEWS

Meeting to be Programmed by Electronic Computer

The Federation of American Societies for Experimental Biology will use machine methods to program its 1960 meeting.

The test of programming a meeting by computer will be made as part of a larger study to develop and test machine methods of scheduling thousands of papers at large meetings. The National Science Foundation has awarded a grant to the federation for this research.

Plans for the machine system call for development of a hierarchial subject classification of papers. Coding sheets will be provided authors who will classify their individual papers. These papers will then be automatically grouped and assigned to sections. The subject classification assigned by authors and punched on cards may also serve as a subject index.

Both the mechanical and traditional systems will be used and the two resulting programs will be compared and evaluated.

Techniques resulting from the study are expected to reduce greatly the magnitude and complexity of the scheduling process and to increase the effectiveness of scientific meetings.

"Mobot" Works in Hot Lab

Electronic control, through multiplexing units, permits this newly developed handler to work remotely in radioactive areas. Multiplexing units are installed in the control console and in the body of Mobot. Actuating circuits for hydraulic arms are in the arm-base unit on which are mounted cameras for TV closeups and claws. Over 100 commands can be sent through cable to handling unit, which draws 7.5 kva. Mobot was developed by Hughes Aircraft for Sandia Corp.

British Develop Remote Indicator of Rocket Roll, Pitch and Yaw

A new missile attitude indicator to measure the roll, pitch and yaw of research rockets in flight has been developed by British General Electric for the Royal Air Force.

The rocket is illuminated by two high-power cw X-band transmitters on either side of the range center line. In the rocket, fixed to a strong ring, are three flush-mounted microwave aerials and associated circuitry, forming two orthogonal interferometers.

The angles subtended between each interferometer base line and each transmitter are measured by a phase comparison technique. Then, by combining any three of these four angles with the rocket's known position in space, it's pitch, roll and yaw can be calculated to within a few minutes of arc.

A special circuit has been developed to overcome the difficulty of maintaining equal phase responses in two separate amplifier channels. A low frequency, from a microwave single-sideband modulator, is added to the local oscillator to one mixer. Frequency and phase differences are kept constant during mixing, and the two signals are combined and passed through a single if amplifier, followed by a detector and another amplifier.

Finally the phase of the if signal is compared with a reference frequency obtained from the modulator, the resulting voltage being a measure of the phase difference at the receiving aerials. This is fed into the telemetry transmitter for reception on the ground.

Simulator to Train Tankers

Computer-controlled system simulates tank battle situations for Marine Corps tank crews, who perform 23 operations using readings from 10 instruments. Simulator was developed by Jam Handy Organization, Detroit, Mich.

NEWS

Radiation Tracking Transducer Uses Lateral Photo Effect

A solid-state transducer making use of the lateral photo effect has been developed for the Army Ballistic Missile Agency to track radiation.

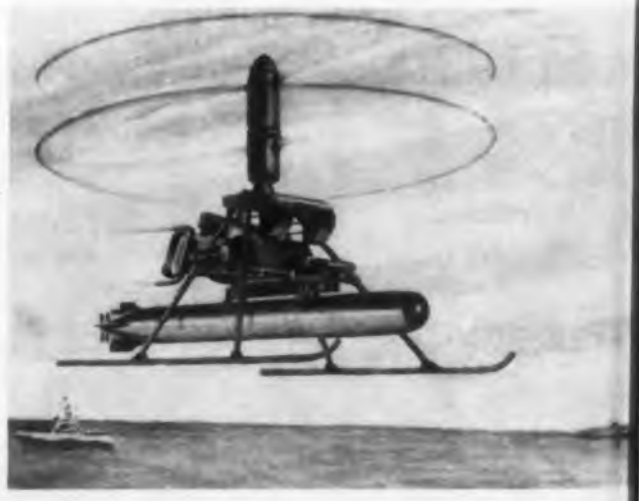
The radiation transducer, a pn junction wafer about the size of a nickel, can track aircraft or other flying objects without need for complex mechanical apparatus, according to the developer, Electro-Optical Systems, Inc., of Pasadena, Calif.

It can also be used in celestial navigation applications in place of gyroscope systems, in horizon seeking for space vehicles, missile launch orientation, target ranging, location of light flashes on the ground and specialized ground communications systems. And it is applicable, the company says, to instrumentation, automatic control and computer techniques.

The unit is said to be capable of detecting and resolving the position of emissions at angles of motion smaller than 0.1 second of an arc. It is aimed electrically, so mechanical rotation of the cell is unnecessary.

Presently available units are sensitive to light wavelengths from 0.5 to 1.1 microns.

Remotely Controlled Copter for ASW



Artist's conception of the remotely controlled DSN-1 Drone, a torpedo-carrying coaxial helicopter being developed for the Navy by Gyrodyne Co. of America, Inc., L.I., N.Y. The rotary-winged craft, carrying homing torpedoes, are scheduled for anti-submarine duty aboard destroyers as part of the Navy's DASH weapon system.

NEWS BRIEFS . . .

. . . **TV SCANNER** for first U.S. moon probe has already been built as bench model. Final version of NASA high-resolution unit will be part of system designed to relay back to earth between 10 and 100 photos of probe's approach to moon.

. . . **NAVY REVEALS** that its infrared Sidewinder missile incorporates 35 patentable inventions: in the seeker, 18; servo, 5; servo and power supply, 3; voltage supply 4; flight control, 1; gas generator package, 4.

. . . **SPECIALLY DESIGNED** transistors made possible General Instrument Corp.'s 9-1/2-oz transistorized tuners for portable TV sets. Company has also developed miniaturized deflection components for the portable receivers.

. . . **TWO MORE PATENTS** for electronic solutions to character recognition problems have been awarded to Farrington Mfg. Co. One is for an electronic extension of stroke-recognition reading machine, the other is for a shift-register recognition method. In this technique, output of a scanner is introduced to the first stage of a tapped delay line, which is sampled to pick up combined signal outputs introduced to the line at different times.

. . . **SEARCHING SCANNER** designed by Western Reserve University for retrieval of library information will be built in a high-speed prototype version by General Electric. The GE-250 computer-like scanner will be able to search 100,000 abstracts per hour; the WRU scanner, used successfully in a metallurgical literature program, searches 30 abstracts per hour.

NEWS

. . . **NEW YORK'S HI-FI SHOW** displayed $5-million worth of equipment to about 60,000 viewers during its run earlier this month. Hi-fi dealer sales for 1959 are expected to reach $300 million, a 15 per cent increase over 1958 sales. As expected, stereo dominated the show. But still unresolved is tape question: will stereo tapes come in cartridges or reels? Bell Labs showed a precedence-effect stereo system that permits "monophonic" reception of stereo programs on one speaker through use of a 10 millisec delay in signal transmission.

. . . **A NEW WORD** has been coined to name the newly formed Intellectronics Laboratories of Ramo Wooldrige, which will work in industrial process conctol, automatic language translation, information retrieval and man-machine systems.

. . . **DIFFUSED MESA TRANSISTORS** with switching speeds of less than a tenth of a microsecond and 10 amp ratings have been delivered to the Air Force by Pacific Semiconductor. Company is also working on 20, 50 and 100-amp units.

. . . **SPACE SURVEILLANCE** Operations Center, at Dahlgren, Va., is capable of displaying on a screen map of the earth the path of missiles or satellites that cross a radar "fence" reaching across the southern U.S. Two transmitters, in Alabama and Arizona, provide the entire coast-to-coast coverage.

. . . **TELEMETERING LINK** has been extended by telephone by Boeing engineers relaying Bomarc flight data from Cape Canaveral range to Seattle (photo below). Flight telemetry data recorded on 60-ips tape is recorded at 1-7/8 ips at acquisition station, for transmission by telephone with frequency and bandwidth compressed by a factor of 32. At Seattle station, data is re-recorded at 60 ips.

QUOTES IN THE NEWS...

On data processing:

"Experience to date shows that the introduction of data processing equipment is often accompanied by an explosive increase in communications requirements . . . if a data processor requires only one day to prepare a report . . . [a] . . . three-day delay in the mail becomes the overwhelming factor determining report preparation time, and an obvious bottleneck." *W. E. Leubbert, Army Signal R & D Lab, Fort Monmouth, in a paper at the Fall AIEE meeting, Chicago.*

On meeting Japanese competition:

"Instead of breaking our necks and integrity to cut costs by using imported parts of dubious quality, we are continuing to concentrate on top performance, outstanding convenience features, and appealing new designs of our instruments . . ." *L. C. Truesdell, Zenith V.P. at a marketing meeting.*

On the data processing market:

"The electronic data processing market, including general-purpose and special-purpose computers, and other digital systems, this year will amount to more than $1 billion. And all present indications are that the market will at least double itself by 1965, and keep right on rising." *R. E. Lewis, president of Sylvania at the dedication of a new Sylvania computer plant.*

On the instrument lag:

"The necessary instrumentation for thorough exploration of space is not on the drawing boards at the present time." *Dr. Thomas Gold, Cornell University at a physics colloquium* during which he predicted that scientists would be able to produce basic instruments to measure magnetic fields and gas densities in space.

CIRCLE 36 ON READER-SERVICE CARD ➤

WASHINGTON REPORT

Ephraim Kahn

New Weapons And Space Projects, A Budget Worry

Budget problems are perplexing the Pentagon. Proposed solutions range from suggestions of ways in which bigger budgets might be made palatable to reluctant admissions that belt-tightening will probably be the course that must be followed. Coincidentally, high officials have implied that there is no "space race" with Russia and that U.S. space projects will be at least as impressive as the Soviets' as soon as proper booster capacity is developed.

In the purely military field of missiles, however, no such graceful acceptance of the U.S. situation can be found. Philip B. Taylor, Assistant Air Force Secretary for Material, reflected prevailing opinion when stating bluntly that this country must "match or surpass" Russia's missiles lest the deterrent effect of American military forces be jeopardized and the country find itself "drifting toward the position of falling victim to Soviet nuclear blackmail."

The fact is that the Pentagon is becoming more and more concerned about being squeezed between rising weapons costs and a relatively rigid budget. There seems to be little hope that the defense budget will rise substantially. In fact, the Air Force budget director has observed that this "would be completely out of the question without a drastic reorientation of the nation's attitude toward taxation."

For the present, the solution would appear to consist in a judicious, but unflinching, pruning of projects whose promise is limited. The extent to which this will adversely affect the electronics industry can not be foretold, though it is clear that cancellation of any advanced weapons (or space) project will cost the industry money. The electronics industry is, however, fortunately situated in that it is heavily involved with R&D. It is quite clear that the government is determined to keep acquiring knowledge.

National Program Of Research

Thus, Secretary Taylor has called for a constant level of R&D as a national policy "if we are to counter the balanced offensive of our opponent

with a balanced defense of our own." Similarly, the Army's R&D chief has warned that "a national program of dynamic research" by government and industry is necessary if the U.S. is to avoid the danger of "running out of new basic knowledge."

Specifically, Lt. Gen. Trudeau, in charge of Army R&D, would like to get more money so that "every area of research that promises a profitable return" can be exploited. "Management," he said, "must place the emphasis in research where it is needed." He also urged that all organizations engaged in research promote interchange of scientific information. Only by diligently fostering basic investigations can "the background of theories and information so vital to the proper pursuit of applied research and development" be provided.

Budget Difficulties

There are, of course, limits to the extent that any organization can indulge its desire to explore all promising research areas—and the limits are budgetary. This at times may lead to seemingly anomalous situations. For example, a rocket booster project might show great promise and be well advanced in terms of the current state of the art. It might nevertheless be out of line with anticipated needs by the time its end-product is ready. In such a case, it might be judged discreet to cancel the project and devote the funds required for its completion to something else which, upon completion, would better fill the needs of the military. On the other hand, a good case might be made that completion of such a well-advanced project that does not quite fill the bill is fully justified because it would give this country a leg up in space exploration, provide valuable experience, and improve America's international public relations.

Defense officials recognize that fine lines must be drawn, but they would like to hedge a bit. This could be done more easily if there were some sort of yardstick for defense funds which could be recognized as reasonable by industry, labor, the public, and Congress. Trial balloons concerning this are being sent up by the military. One proposal is to gear the defense budget to the U.S. Gross National Product—the total output of goods and services. The defense budget is now "running somewhere around nine percent of the GNP," says Maj. Gen. R. J. Friedman. "If we can agree that a defense effort of this level is not damaging the economy today—and that if this ratio is maintained it would not damage the economy in the future—we then might reasonably expect dollar increases in the defense budget proportionate to the gain" in GNP. About $1.5 billion a year in new money might accrue to the military if this system were adopted. (By contrast, the 1958 Rockefeller Report recommended $3 billion.)

MEETINGS

Calendar of Events

November

*16-19 **Conference on Magnetism and Magnetic Materials, AIEE, Office of Naval Research, American Physical Society, IRE, and the Metallurgical Society of A.I.M.E. Sheraton-Cadillac Hotel, Detroit, Mich.**

*16-20 **14th Annual Meeting and Astronautical Exposition, American Rocket Society, Sheraton Park Hotel, Washington, D. C.**

*16-20 **5th International Automation Congress and Exposition, New York Trade Show Building, New York, N. Y.**

17-19 **Northeast Electronics Research and Engineering Meeting, IRE, Boston Commonwealth Armory, Boston, Mass.**

*19-20 **6th Annual Meeting of the Professional Group on Nuclear Science, IRE, Somerset Hotel, Boston, Mass.**

23-24 **Symposium on Solid State Techniques in Instrumentation, ISA, IRE, AIEE, Benjamin Franklin Hotel, Philadelphia, Pa.**

December

1-2 **1959 Eastern Joint Computer Conference, AIEE, ACM, PGEC, Statler Hilton Hotel, Boston, Mass.**

1-2 **4th Midwest Symposium on Circuit Theory, Marquette University, Milwaukee, Wis.**

3-4 **Professional Group Vehicular Communications, Colonial Inn & Desert Ranch, St. Petersburg, Fla.**

3-5 **3rd Annual International Visual Communications Congress, Society of Reproduction Engineers, SRE, Statler Hilton Hotel, New York, N. Y.**

8-10 **2nd National Conference on the Application of Electrical Insulation, AIEE, NEMA, Shoreham Hotel, Washington, D. C.**

*Includes meetings described herewith

5th Conference On Magnetism and Magnetic Materials, November 16-19

The Conference on Magnetism and Magnetic Materials will be held in Detroit, Mich., at the Sheraton-Cadillac Hotel. This Conference, sponsored by the Magnetics Subcommittee of the Basic Science Committee of the AIEE, seeks to bring together those interested in basic and applied work in magnetism. *For further information contact the Local Conference Committee Chairman: D. M. Grimes, Dept. of Electrical Engineering, University of Michigan, Ann Arbor, Mich.*

14th Annual Meeting and Astronautical Exposition, November 16-20

The American Rocket Society's Annual Meeting will be held at the Sheraton Park Hotel in Washington, D. C. The Opening session will cover: Guidance and Navigation; Physics of the Atmos-

phere and Space; Propellants and Combustion; Ion and Plasma Propulsion; Man in Space; Flight Mechanics; Human Reliability and Physics of the Atmosphere and Space. Meetings and Public Relations Manager is Roderick L. Hohl, 500 Fifth Ave., New York 36, N.Y.

5th International Automation Exposition and Congress, November 16-20

Richard Rimbach Associates, management for the International Expositions, announces the New York City Trade Show Building as the site for the IAE. The exhibit is expected to present over 100 clinic sessions covering computers, process instrumentation, machine tool control, materials handling and office automation, servomechanisms and components in control. Also temperature pressure, flow and dimensional measurement and control will be treated. In addition to the clinic sessions the Technical Program for the Congress will include 12 separately sponsored conferences of professional interest. Managing Director is Richard Rimbach, 845 Ridge Ave., Pittsburgh 12, Pa.

Northeast Electronics Research and Engineering Meeting, November 17-19

The NEREM will be held at the Boston Commonwealth Armory, Boston, Mass. Some of the areas to be covered will include: electron devices, medical electronics, circuit theory and practice, machine control, equipment design consideration, semiconductors, instrumentation, Doppler radar techniques for air navigation, reliability quality control and computer techniques. Technical papers will be presented at sessions scheduled to run concurrently with the exhibitions. *Address correspondence to: Miss Shirley Whiteker, IRE Boston Office, 73 Tremont Street, Boston, Mass.*

6th Annual Meeting of the IRE Professional Group on Nuclear Science, November 19-20

The IRE Professional Group on Nuclear Science will hold its 6th Annual Meeting on November 19 and 20 at the Somerset Hotel, Boston, Mass. Special emphasis will be placed on Nuclear Rocket Propulsion. The Technical Program will include sessions on: Nuclear Science and Space Exploration, Electronics for Plasma Production and Diagnostics, Research Instrumentation for High Energy Nuclear Science, Nuclear Reactor Instrumentation and Control, and Automatic Systems for Nuclear Data Processing. This meeting will overlap the NEREM which will have complementary technical sessions and exhibits. Chairman is Hugh F. Stoddart, Atomium Corp., 940 Main St, Waltham 54, Mass.

(Advertise

NEW PRODUCT

Printed Circuit Connector With Crimped, Snap-locked Contacts

A new addition to the HYFEN® line, a pin-typ printed circuit connector is in production by th Omaton Division of the Burndy Corp.

This connector, type MC combines the high re liability and the wiring technique embodied i the HYFEN principle for use with printed cir cuits. This principle allows crimping to be don before or after the harness or wires are in place It also allows sockets to be easily and quickly snapped in, to be removed with a simple extrac tion tool for circuit changes or checks, and to b reinserted.

The printed circuit HYFEN is available in 3 and 45 place configurations. The male side of th connector utilizes right angle pins with one side assembled to the board and the other to the re ceptacle. The side assembled to the board is held in place mechanically and the connection to th circuit is usually dip soldered with the other com ponents on the board. Guide pins align the plug and receptacle, which is mounted on the chassis Three sizes of HYFEN solderless crimp-type snap locked sockets, accommodating wire sizes #22 #14 and combinations of these sizes, are available for the receptacles. These crimped connections eliminate time-consuming solder operations and the high rejection rate inherent in the use o fluxes and dissimilar metals characteristic of solder

Both hand-operated and semi-automatic instal lation tooling can be used for crimping these sockets. The blocks are made of diallyl phthalate

Burndy Corporation, Norwalk, Connect.

CIRCLE 42 ON READER-SERVICE CARD

EDITORIAL

Helping Education Catch Up

The Ford Foundation's grant of $19.5 million to 10 major schools for modernizing engineering education deserves both our gratitude and our close attention.

Most of the money will be used to strengthen faculties, raise salaries, and improve teaching and research facilities—all solid actions that will eventually affect the quality of design engineers.

The rest of the "magnificent" grant will be used on bold innovations in engineering education. These could have an earlier and deeper effect on our industry.

Cleveland's Case Institute of Technology will use its $1 million grant to create pioneering centers in engineering design and in systems research. Believing that "the greatest emphasis in engineering education should be placed upon the close relationships and interdisciplinary character of modern engineering and science," Case is setting up (1) an engineering design lab that will specialize in "authentic design problems" (many of which will be electronic) and (2) a systems research center that will make use of the entire faculty to teach systems thinking in design.

Massachusetts Institute of Technology will use part of its nearly $10-million grant to "evolve new syntheses of courses to couple the basic sciences with the newly emerging fields of engineering and to introduce students to the 'hard-headed' purposefulness of engineering."

Exactly fitting some of the important needs of the electronic industry are three of the "themes" being considered by MIT for the new curricula: materials—manipulating atoms and particles to produce new devices; energy processing—new ways of converting one source of energy to another; and information processing—developing computer systems and other devices for communication, analysis and control.

We would do well to watch closely and to consider expanding these two imaginative projects to help engineering education meet tomorrow's needs. As Dr. H. T. Heald, president of the Ford Foundation says, we must help this education catch up in the "hopeless race against time and reality," where "most engineering students . . . are being equipped for the engineering of the last half of the century by being indoctrinated with the art and practice of the Nineteen Fifties."

Alan Corneretto

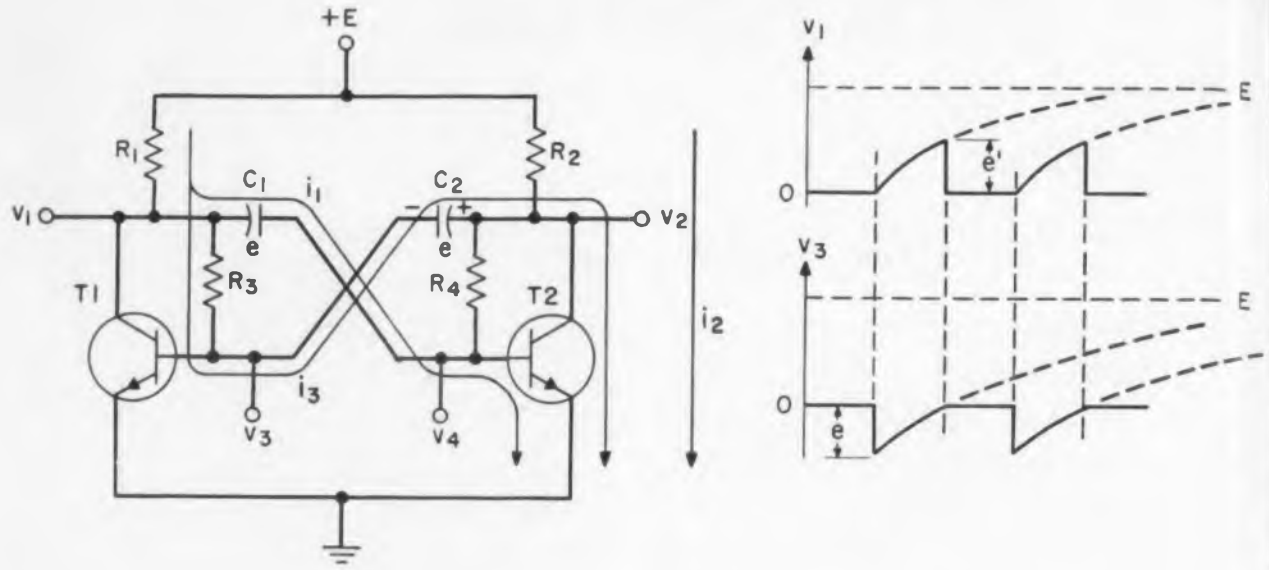


Fig. 1. Circuit and waveforms of the basic self-starting multivibrator.

How to Design a Sure-Starting Multi and Couple It to a Load

Irwin Dorros
Bell Telephone Laboratories
Whippany, N. J.

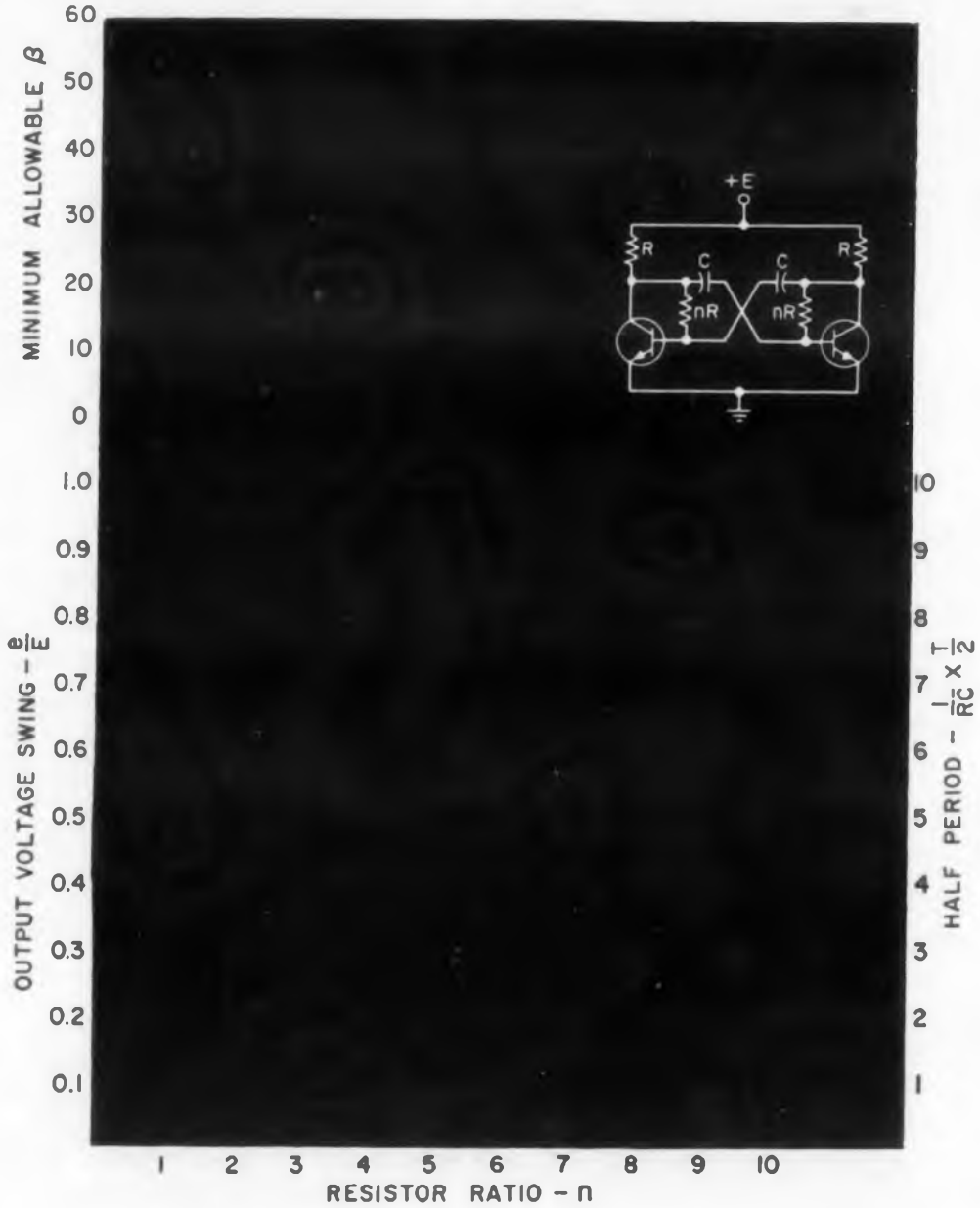


Fig. 2. Design curves for determining voltage swing, half period, and minimum allowable beta for the self-starting multi.

Irwin Dorros had a problem. He needed a master clock oscillator that would be self-starting and would start every time. He describes the circuit here and shows how to design it with simple curves and how to couple it to a load.

SOME MULTIVIBRATOR configurations do not start reliably. Coupling to the load alters the calculated operating conditions. Often capacitor coupling to the load is undesirable. Faced with these problems the engineer finds it difficult to obtain design information covering these areas. This article provides the answers to these problems.

The circuit shown in Fig. 1 is self-starting. The feature leading to self-starting is the forward bias voltage, which is applied as v_3 and v_4. It results in the transistors having gain whether or not current is passing through the capacitors C.

How The Circuit Operates

Assume the state of each transistor has just changed. *T1* is cut off, *T2* is saturated, the voltage on C_1 is zero, and the voltage on C_2 is some value e, with indicated polarity. Neglecting leakage currents and voltage drops across forward junctions, $v_1 = v_2 = v_3 = v_4 = 0$, and $v_3 = -e$. The currents prevailing until the transistors again change state may be divided into three components. At E/R_2

i_3 is fixed and i_1 and i_3 follow complex exponential paths towards zero. Throughout this part of the period $v_2 = v_4 = 0$. The voltage v_3 follows a complex exponential path from $-e$ toward $+E$, and v_1 follows another complex exponential path from 0 toward $+E$.

The transistors will not switch under two conditions: (1) If the current i_1 through C_1 be sufficient to keep T_2 saturated. (2) If the voltage across C_2 remains greater than zero with the indicated polarity.

The transistors will switch if either of these two conditions are not satisfied. If the circuit is designed to switch due to insufficient i_1 the switching speed is slow, and the period dependent upon the Beta of the transistors. This circuit is therefore designed to preclude condition 2.

Assuming that i_1 is at all times sufficient for T_2 to remain saturated, the first part of the period ends when v_3 crosses zero on its excursion toward E. During this interval, C_2 becomes discharged to zero volts by i_3, and C_1 becomes charged by i_1 to some voltage e'. A solution for the unknowns e and e' leads to the necessary design information. Only the symmetrical case in which $e = e'$ is treated in this article.

How To Design The Basic Unloaded Oscillator

A set of curves is shown in Fig. 2 from which the half period, the voltage swing e and e', and the minimum allowable Beta can be determined. The reader interested only in choosing parameters for application with negligible load need not refer to Fig. 5.

Circuit equations were solved for the two half periods, and the initial and final conditions were matched at the transition times. The two lower curves on Fig. 2 are plotted from the results.

For all resistor ratios n, there is a lower limit to the permissible value of Beta due to the necessity for providing sufficient current to the base of the saturated transistor to insure saturation for the entire half period. Because $i_1(t)$ is a minimum at $t = T/2$, this limiting condition is:

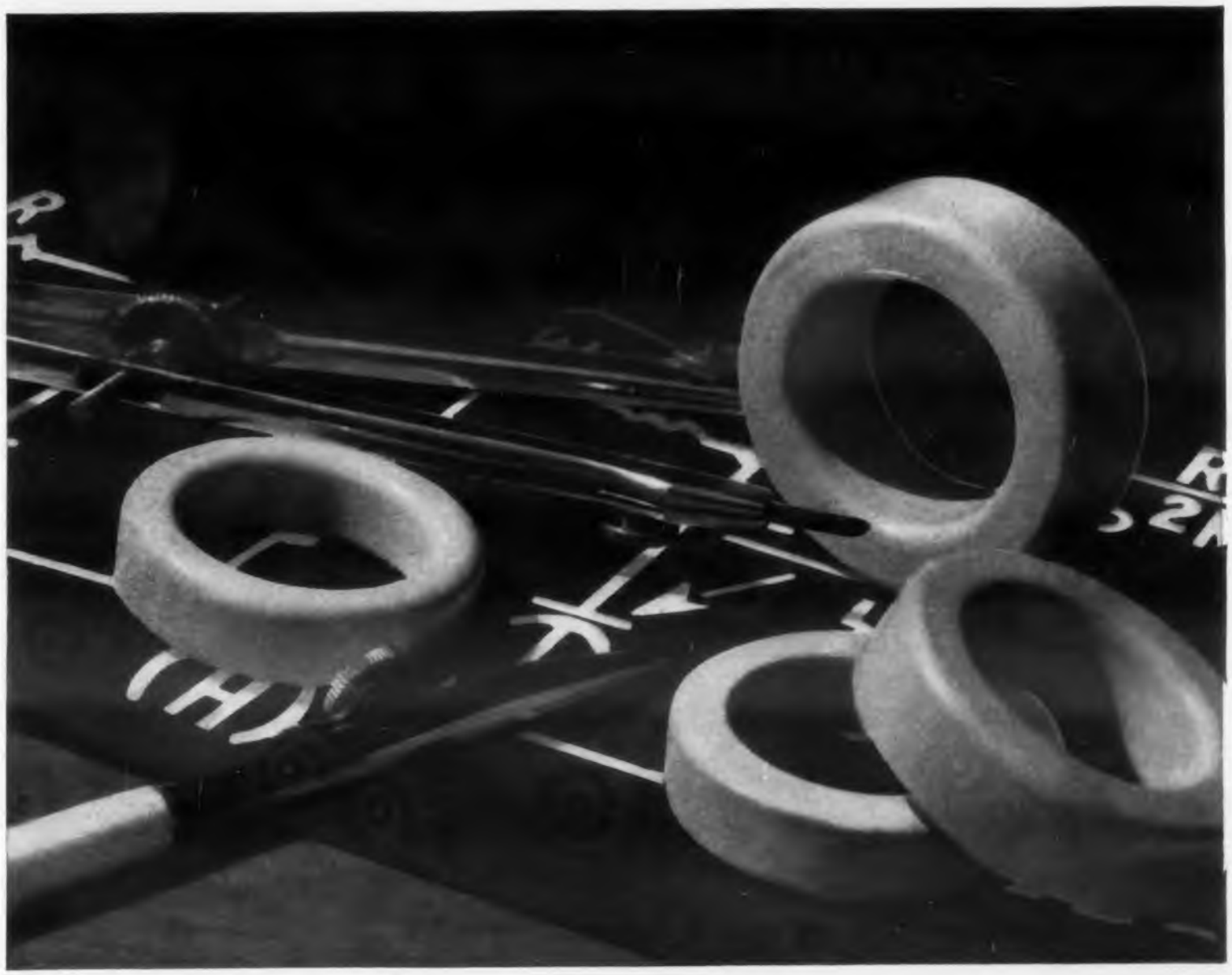
$$\frac{E-e}{R_1} - \frac{e}{R_3} > \frac{\frac{e}{R_3} + \frac{E}{R_2}}{\beta}$$

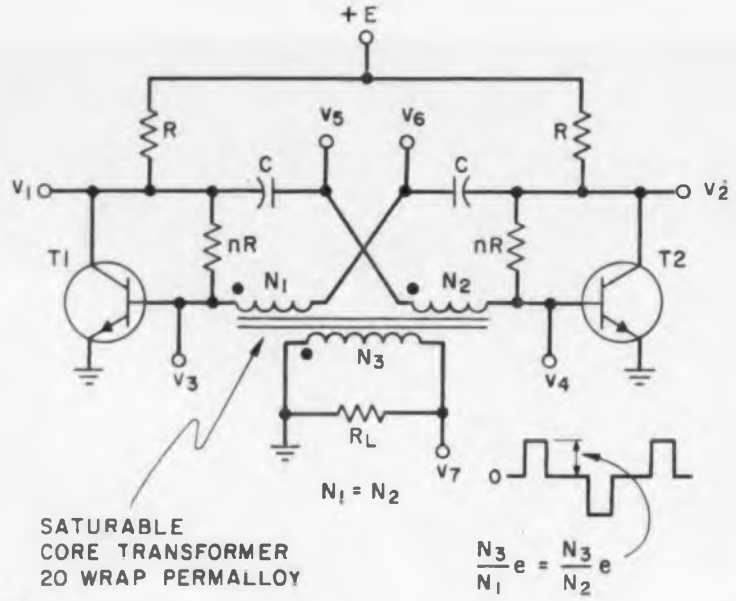
where the resistors are as shown in Fig. 1. For $R_3 = R_4 = nR_1 = nR_2 = nR$, this condition becomes:

$$\beta > \frac{1 + \frac{e}{E}\,\frac{1}{n}}{1 - \frac{(n+1)}{n}\,\frac{e}{E}}$$

In Fig. 2 the minimum Beta is plotted along with the e and $T/2$ curves for practical values of n.

From the curves the reader can choose the parameter values for a required frequency and voltage amplitude, and determine the minimum allowable





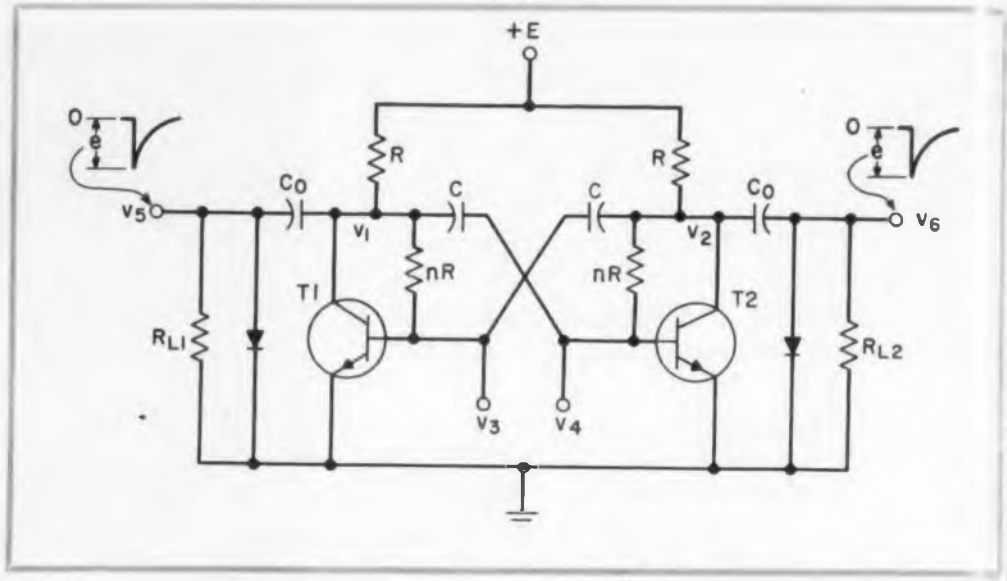


Fig. 4. Circuit for capacitor-coupling to a load.

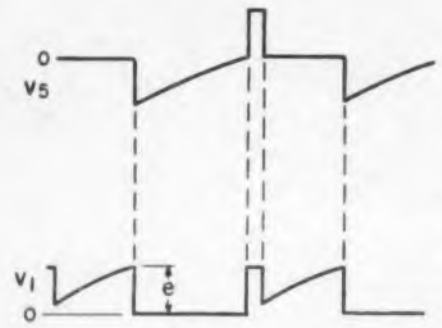


Fig. 3. The transformer-coupled self-starting multi, and its waveforms.

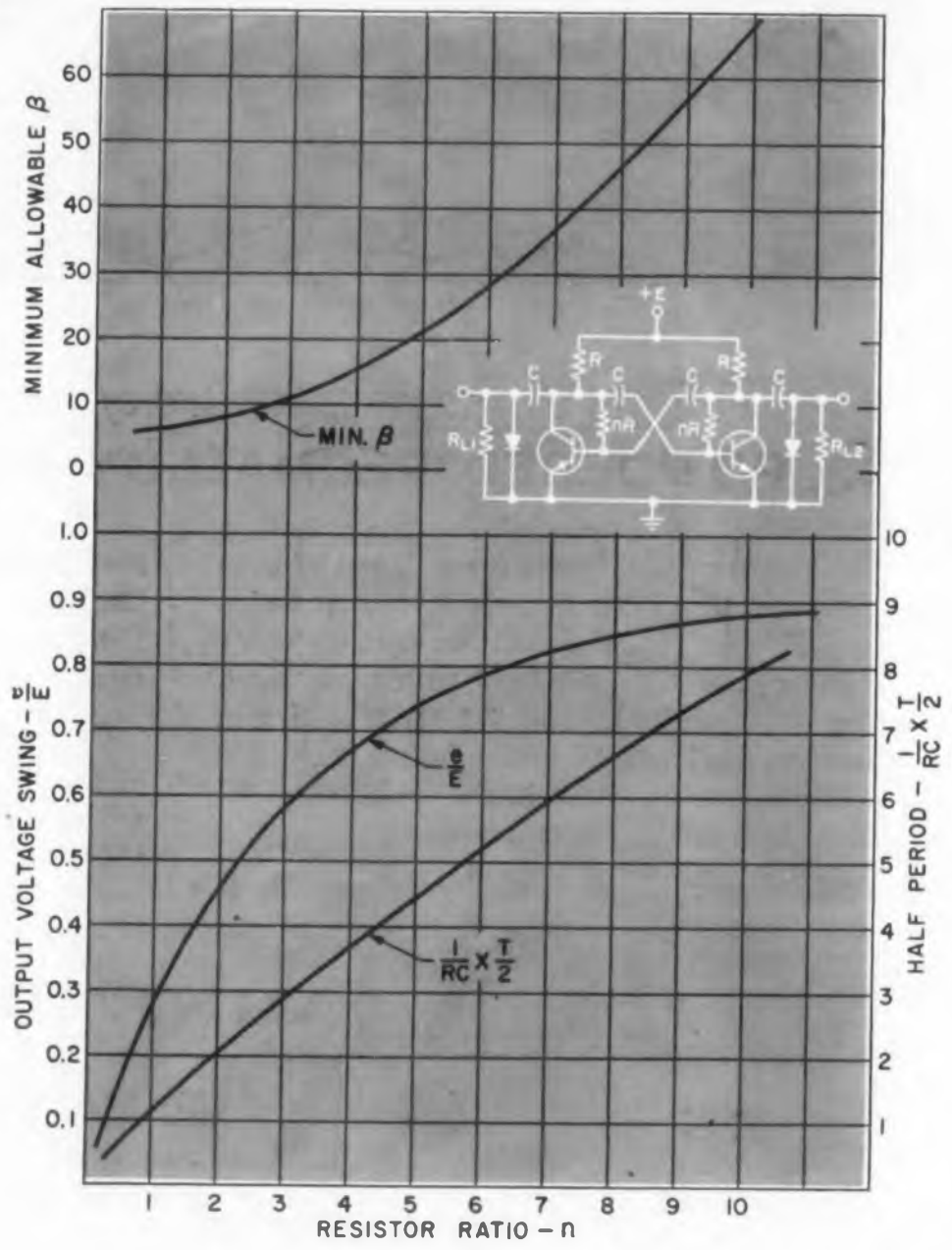


Fig. 5. Design curves for the capacitor-coupled multi.

Beta under those conditions. Supply voltage E has little effect on frequency and is therefore chosen for power and output amplitude requirements.

Forward biased junction voltage drops and leakage currents are neglected, causing some error, particularly for low values of E. The curves are not continued beyond $n=10$, since Beta becomes prohibitively large.

Transformer Coupling The Load

In Fig. 3 a method of transformer output coupling is illustrated. The transformer core is made of square loop material to shape the flat-topped output pulses. It is assumed the reader has a basic familiarity with square loop magnetic material techniques. N_1 equals N_2, and N_3 is chosen for load requirements. The currents in windings N_1 and N_2 aid in inducing current in N_3. As the transistors change state the currents in N_1 and N_2 reverse and the core goes into its high inductance state. The voltage across $N_1=N_2=e$, and the output voltage becomes v_7.

$$v_7 = \frac{N_3 e}{N_2} = \frac{N_3 e}{N_1}$$

Although the windings have high impedance at this time, the saturated transistor is sustained by the constant magnetizing current, (nI_0), through the windings.

The length of time that the core persists in the high impedance state determines the output pulse width. This is given by:

$$T = \frac{N_1 \Delta \Phi}{e}$$

where $\Delta \Phi$ is the change in flux necessary to switch the core. When the core saturates, output voltage

drops and the windings look like "short circuits." This condition continues for the remainder of the half-period. The circuit operation differs from that in the previous section only during the output pulse. During this time the high winding impedances cause the calculated timing transients to be delayed until the end of the Pulse when the core saturates. To a first approximation the curves in Fig. 2 for the unloaded case apply, with the half-period lengthened by the output pulse width.

This coupling method allows accurate control of pulse width, provides a means for impedance matching to the load, and draws energy from the circuit only during the pulse.

The circuit was built with $R=2$k, $R_L=200$ ohms, $n=1$, $C=0.012$ mfd., $E=25$ v, $B_1 \cong B_2 > 30$, $N_1=N_2=64$ turns and $N_3=16$ turns. The core was 20 wraps of #479 permalloy, 0.125 mils thick, wound on an Arnold Engineering Corp. #1 bobbin. The resulting voltage swing e was 9.3 and the half-period was 26 μsec including a 3 μsec output pulse. This agrees closely with the predicted operation from Fig. 2.

Capacitor Coupling The Load

The more conventional RC type coupling is shown in Fig. 4. The output pulses are decaying exponentials of amplitude e and a time constant fixed by the coupling capacitors and load resistors. If capacitors C_0 are small compared to C_1, circuit operation becomes the case of negligible load considered earlier. If C_0 is much larger than C_1, the circuit is heavily loaded and it is difficult to fulfill the condition of supplying enough current to the saturated transistor during the entire half-period. The somewhat arbitrary case of $C=C_0$ is therefore considered here. Modified circuit equations were solved for this case and the results are plotted in Fig. 5.

Minimum Beta is raised by a factor of 2 for this configuration since the current available to sustain the saturated transistor must be shared by C and C_0. The condition becomes:

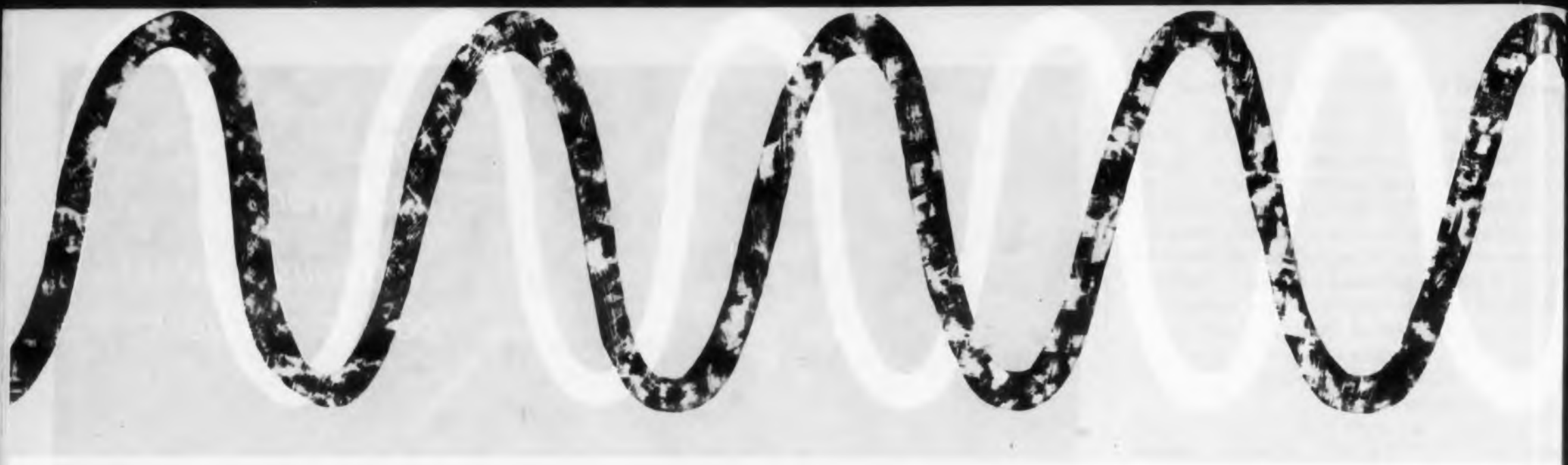
$$\frac{1}{2}\left(\frac{E-e}{R}-\frac{e}{nR}\right) > \frac{\frac{e}{nR}+\frac{E}{R}}{\beta}$$

which reduces to:

$$\beta > \frac{2\left(1+\frac{e}{E}\,\frac{1}{n}\right)}{1-\frac{(n+1)}{n}\,\frac{e}{E}}$$

The circuit designed in accordance with the material presented here fulfilled the requirements for a self starting relaxation timing oscillator. ■ ■

The author is indebted to A. Feiner for suggestions concerning circuit configurations, and to D. F. Hemmer for laboratory assistance.



Calibrating Frequency Standards

Klaus Jaensch
Stromberg Carlson Co. Rochester, N. Y.

When assigned to set up a frequency standard for Stromberg Carlson, Mr. Jaensch, Test Engineer, investigated various possibilities for calibration. After analysis and check of several systems, he came to the conclusion that newer techniques could be used with marked improvement in accuracy without essentially higher cost. His article deals with the newer versions along with a comparison of methods in use.

Seven methods of calibrating frequency standards are described. An outline of procedures, types of equipment required and comparison of results is also included.

VARIOUS methods, ranging from simple beat-frequency checks to elaborate electronic counter systems, are applicable for calibration of commercial frequency standards. To achieve the same order of accuracy, however, a time interval of many days is required with less complicated, and cheaper procedures as compared with several hours for the more complex and expensive counter techniques.

Definition of Accuracy

The actual accuracy of a frequency standard is the sum of the following three factors of uncertainty:

- Stability of the standard, meaning the greatest possible change in frequency over a specified interval of time. Stability is a property of the individual frequency generator, resulting from design and make, and from the properties of its components.
- Greatest possible error in checking the standard in question against a master standard. The present article describes various methods for this check, and specifies practical tolerances for each of them. Moreover, possible deviations of received master frequency or time signal may be included in this factor, as far as they are caused by wireless transmission between master and test station.
- Accuracy of the master standard used for calibrating or checking the frequency standard in question. In most practical cases, standard frequencies or time signals transmitted by WWV station are used as master standard. These signals provide the highest accuracy available to the public in this country. Table 1 lists the specifications of WWV transmission as far as they are of interest for calibrating frequency standards.

Primary and Secondary Frequency Standards

Easily misleading common terms should be mentioned. Time is a fundamental unit of physics; frequency is not. Therefore, standard frequency sources are often classified as primary or secondary standards.

A Primary Frequency Standard is defined as one whose frequency is determined directly in terms of time. This is done by integrating a certain great number of cycles of the frequency, and comparing the elapsed time with time signals of a master primary standard, such as time pulses from WWV.

A Secondary Frequency Standard is defined as one whose frequency is determined by comparison with the frequency of a primary or secondary standard. The beat method described is the typical way of checking a Secondary standard.

It should be realized, that the classification as Primary or Secondary standard does not specify restrictions for accuracy and stability, though these two factors actually determine the usefulness of a frequency standard.

Method 1: Beat Frequency—Observation by Individual

The easiest and fastest way of checking a standard oscillator against WWV is the well-known beat method. A radio receiver is tuned to a WWV frequency, for example, the 10 mc channel. The output of the oscillator under test is loosely coupled to the receiver's antenna.

Assuming the oscillator frequency is approximately 1 mc, its tenth harmonic mixed with 10 mc of the WWV carrier will produce beats. One beat per second would indicate the tenth harmonic of the oscillator is actually 10,000,001, or 9,999,999 cycles. In other words, the oscillator is off frequency by one part in ten millions, or 1×10^{-7}. This resultant frequency deviation, multiplied by the possible error in determining the frequency of beat cycles, states the accuracy of the test.

Transmission Fading

When the master frequency is received through the air over a distance of more than several miles, transmission "fading" deteriorates the accuracy in two ways:

First, fading of the received signal strength interferes with the actual frequency beat, making determination of very slow beats in the order of several seconds impossible. This can be overcome by deliberately setting the oscillator off frequency a small amount, so as to produce a higher beat frequency. At the same time, this trick eliminates any doubt whether measured frequency

changes are directed to the high or low side. For most applications of the standard, such slight deviation from the nominal value is acceptable as long as the actual frequency is exactly known.

The second disadvantage of wireless transmission is more serious. The effect commonly called fading is caused by sky waves of the transmitted signal changing their path to the point of reception. At frequencies above 3 mc, transmission to distances over 100 miles depends entirely on such sky waves reflected from the ionosphere.

Changes of Time Signals and Frequency by Wireless Transmission

To explain the influence of wireless transmission on remote frequency and time measurements, a simplified numerical example is shown.

Assume the following conditions (Fig. 1):

Distance between transmitter and receiver, 500 km (310 miles).

Height of reflecting layer in ionosphere during daytime, 100 km.

Height of reflecting layer in ionosphere during night time, 110 km.

Resultant length of path during daytime, 538.5 km, during night time, 546.3 km.

In the present context, only changes of transmission conditions are considered. Difference of path length, 7.8 km, is important and equals a difference in time of travel:

$$\frac{7.8\ \text{Km}}{300{,}000/\text{Km/sec}} = 26 \times 10^{-6}\ \text{sec}$$

Under conditions assumed, at night a signal is received with 26×10^{-6} sec longer time delay.

During either period of constant path length, the frequency received is exactly the same as that at the transmitter. But, while the reflecting layer is moving from one position to the other, the Doppler effect causes the received frequency to be different from the one at transmitter. As a further assumption, in the example, the path length may change steadily from one extreme to the other in half an hour (1800 sec). During these periods, frequency received will vary from the one at transmitter for

$$\frac{26 \times 10^{-6}\ \text{sec}}{1800\ \text{sec}} = 14 \times 10^{-9} = \frac{\Delta f}{f}$$

being slow in the evening (path extending), but fast in the morning (path shortening).

The above example is extremely simplified for demonstrating the action of fading and the order of magnitude of its effects. Actually, many more variables are involved. Different layers of the ionosphere are responsible for the reflection, depending on frequency and distance of transmission. This results in almost unpredictable frequency deviations between zero and several parts in 10^{-7}. Most correct reception of a frequency can be assumed to occur when the amplitude of incoming signal remains constant. Over periods of more than ten seconds, deviations in frequency can rarely be expected to be less than 1×10^{-9}.

In case of wireless reception of master frequency, the beat method with direct visual or aural observation of beat frequency is therefore usually limited to an accuracy in the order of 5×10^{-9}.

Method 2: Beat Frequency—Evaluation of Recorded Beats

Errors caused by wireless transmission can be cut down considerably by recording the beats over a longer time. A chart recorder may be connected in place of, or in parallel with, the tuning meter of the receiver. Using a suitable speed as time axis, a continuous record of beat waves ver-

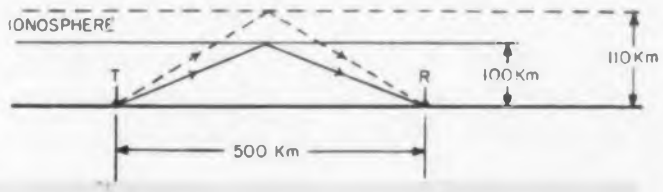


Fig. 1. Wireless transmissions; example of skywaves with different path length, 538.5 km, or 546.3 km, respectively.

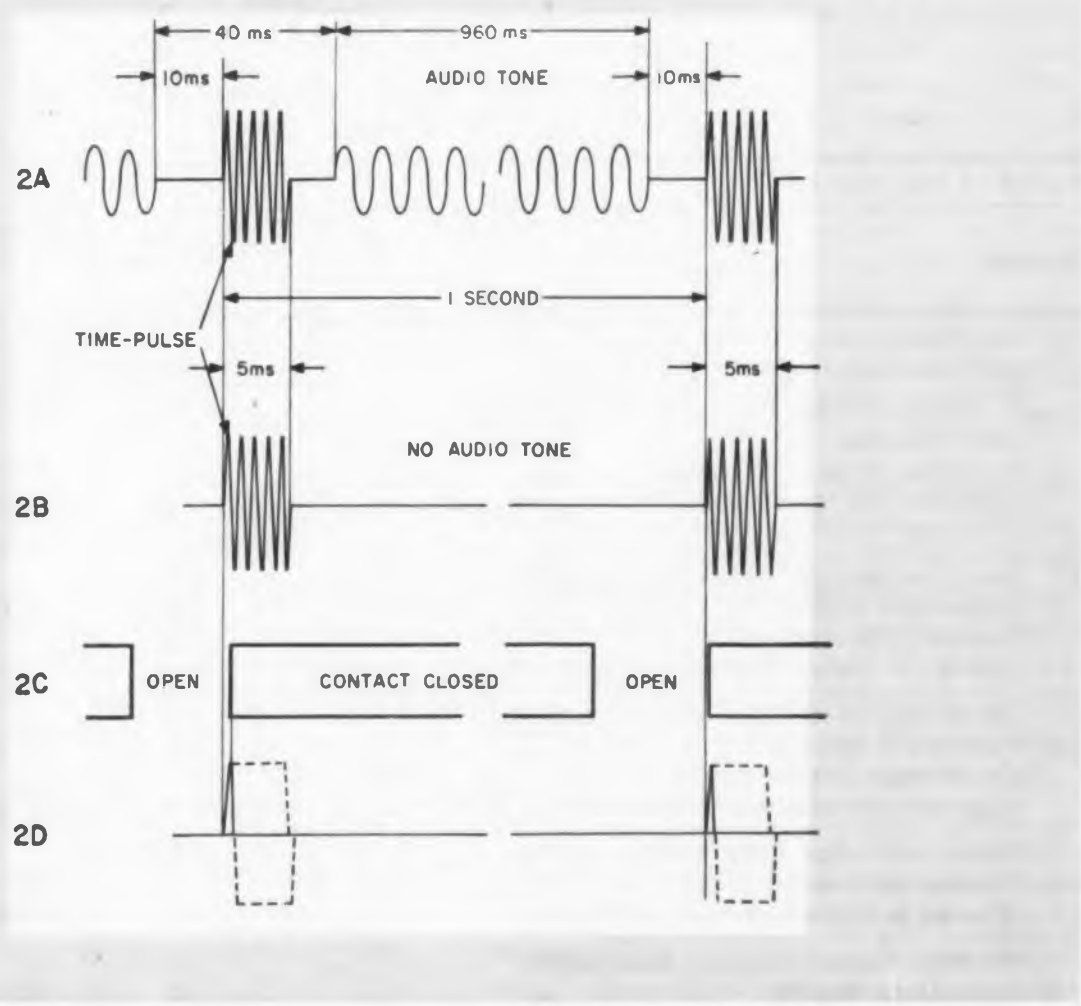


Fig. 2. Time-check waveforms. *A:* WWV modulation for 3 minutes; *B:* WWV modulation for 2 minutes; recurring in 5 minute periods. Time pulse occurs in either case, consisting of 5 cycles of 1 kc; *C:* Contact of synchronous clock opens for a short instant each second; *D:* WWV signal *B*, cut by clock contact to limit of audibility.

***Table 1:* Specifications of WWV transmission**

	WWV	WWVH
Location of Transmitter	**Washington, D.C.**	**Hawaii**
2.5 Mc	0.7 KW	—
5 Mc	8 KW	2 KW
10 Mc	9 KW	2 KW
15 Mc	9 KW	2 KW
20 Mc	1 KW	—
25 Mc	0.1 KW	—
Carrier Frequency Stability	1×10^{-9}	5×10^{-9}
Max. Deviation	2×10^{-10} per day	4×10^{-10} per day
1 second Time Pulse	5 cycles 1,000 c/s	5 cycles 1,200 c/s
Accuracy of Time Pulse	$1 \times 10^{-8} \pm 1$ microsecond	
Audio Tones	440 and 600 c/s	
Accuracy of Audio Tones	1×10^{-9}	

sus time can be obtained for later evaluation.

As a practical example, oscillator frequency may be set off nominal value by 2×10^{-8}. Checking against 10 mc WWV, the resulting beat period is about five seconds. A recording speed of six in. per minute produces one beat wave on every half inch of strip, thus allowing the evaluation of one hundred beat periods without difficulty. Figuring the accuracy of paper speed and evaluation as 2 per cent, the overall accuracy of frequency reading comes out to 2 per cent of 2×10^{-8}, or 4×10^{-10}.

Electro-Mechanical Clock for Checking Frequency Against Time

The common method for checking frequency against time is by means of a special electric clock. By means of dividers such as triggered multivibrator or synchronized tuned circuits, the frequency of the standard oscillator is divided down to a frequency in the audio range. The resultant frequency, having essentially the same accuracy as the standard, is used to drive a synchronous clock. Comparing the indication of this clock over a longer interval of time with standard time, shows the deviation of oscillator frequency from its nominal value.

For precise reading of this clock, a contact is operated by the shaft of the second hand. The contact is adjustable and a dial indicates the relative setting of the contact in fractions of a second.

Method 3: Electro-mechanical Clock—Acoustical Observation

The simplest procedure uses acoustical observation of the WWV time pulse. The clock contact is connected to short the output of the receiver. During a brief time of contact opening every second, the audio signal from WWV can be heard.

The opening period of the contact is adjusted to coincide with the received time pulse.

This pulse consists of exactly five cycles of 1 kc frequency (Figs. 2a, 2b). Finally, the contact is adjusted to let only a fraction of the first 1 kc wave through, which can be observed as the lowest audible "click" (Fig. 2d). Limit of this acoustical observation may be stated as 5×10^{-4} sec.

The same procedure is repeated after a certain interval of time, for instance, once every day. Each time, after obtaining the same condition of audibility, the final setting of the contact dial is written down. From these readings, frequency deviation can be calculated. The difference in dial setting between two readings, expressed in fractions of a second, divided by the time interval between two readings, equals the frequency deviation of the oscillator to be tested.

Method 4: Electro-mechanical Clock-Oscilloscope Observation

Using the same contact clock, accuracy can be improved by observing WWV time pulses on an oscilloscope. The clock contact is used to start the sweep of the oscilloscope. A small battery may be connected through the contact to trigger the sweep externally at a repetition rate of one second. Employing a slow sweep speed, the five 1 kc waves appear somewhere on the trace. By operating the contact adjustment, the instant of sweep triggering with respect to the WWV signal can be adjusted. By this means, the WWV pulse is shifted to the start of the trace. Now, sweep speed is switched to faster values for more precise observation on the oscilloscope screen.

The practical limit of accuracy in this type observation is about 1×10^{-5} sec. In addition to the possible error in observation, the uncertainty of

Table 2: Comparison of Methods

Attainable accuracy of frequency test—versus period of test, for different test methods described. Figures in ( ) include error to be expected by wireless transmission.—Refer to text for basis of individual figures.

Period of Test (Seconds)			100	10^3	10^4	10^5	10^6
Method	Tolerance of Reading $\times 10^{-6}$ Item	Tolerance of Reading $\times 10^{-6}$ Total	Accuracy of Test $\times 10^{-9}$				
1 Beat Frequency Individual Observation (Frequency change by wireless transmission)	.002 (.005)	.002 (.007)	2 (7)	2 (7)	2 (7)	2 (7)	2 (7)
2 Beat Frequency Evaluation of recorded beats (Frequency change by wireless transmission, evaluating intervals of constant amplitude only)	.0004 (.002)	.0004 (.0024)	0.4 (2.4)	0.4 (1.0)	0.4 (0.5)	0.4 (0.5)	0.4 (0.5)
3 Electro-mechanical Clock; contact stability Contact-dial Reading Acoustical Observation (Change in wireless transmission Time)	100 500 500 (10)	1100 (1110)	11,000 (11,100)	1,100 (1,110)	110 (111)	11 (11.1)	1.1 (1.1)
4 Electro-mechanical Clock; contact stability Contact-dial Reading Oscilloscope Observation (Change in wireless transmission Time)	100 500 10 (10)	610 (620)	6,100 (6,200)	610 (620)	61 (62)	6.1 (6.2)	0.6 (0.6)
5 Electro-mechanical Clock; contact stability Oscilloscope Reading (Change in wireless transmission Time)	100 10 (10)	110 (120)	1,100 (1,200)	110 (120)	11 (12)	1.1 (1.2)	0.1 (0.1)
6 Electronic Counter as Clock; pulse stability Oscilloscope Reading (Change in wireless transmission Time)	0.2 10 (10)	10.2 (20.2)	102 (202)	10.2 (20.2)	1.0 (2.0)	0.1 (0.2)	
7 Electronic Counter as Clock Other Electronic Counter for Reading (Change in wireless transmission Time)	0.2 2 (10)	2.2 (12.2)	22 (122)	2.2 (12.2)	0.2 (1.2)	0.02 (0.12)	

dial reading has to be considered. This applies to both of the methods described above. Usually, the dial is designed to allow a smallest reading in the same order as the limit of acoustical observation, which was stated as 5×10^{-4} sec.

Method 5: Electro-mechanical Clock-Oscilloscope Reading

For measuring minute deviations of frequency, the setting of the clock contact may be left unchanged for the successive readings. In this case, the exact positions of the WWV pulse waves on the trace have to be noted as individual readings. Shift of position between two readings shows difference in time.

In contrast to methods three and four, observation and reading are here the same operation. Therefore, possible error in reading, including observation, can be stated the same as in method four for observation only: 1×10^{-5} sec.

All three methods described thus far contain one more factor of uncertainty, namely the stability of clock contact operation with respect to the oscillator output. A synchronous clock converts the output of the frequency standard under test into steady mechanical rotation. From this rotation, the time pulse required for the check is produced by means of a mechanical contact.

Thus, the pulse is not directly related to a certain period of the oscillator frequency. Changes of friction in bearings and gears of the clock result in slight phase shift of the pulse with respect to the driving frequency. Assuming clock driving frequency of 1 kc, a clock motor phase shift corresponding to one electrical degree of this driving frequency produces an error of $1/(1000 \times 360)$, or 2.8×10^{-6} sec. Moreover, pulse phase is subject to the general limits in stability of mechanical contacts.

For a well-designed and built synchronous contact clock, the sum of these variations need not exceed 1×10^{-4} sec.

Electronic Counter to Replace Electro-mechanical Clock

An electronic counter can fulfill the same function as a synchronous clock. It can integrate a great number of cycles of a fixed driving frequency and display certain multiples of cycles.

By contrast to an electro-mechanical clock, the counter delivers pulses at certain multiples of frequency periods as a by-product of its operation. These pulses appear in exact relation to a fraction of a period of driving frequency, which is the oscillator frequency itself in this case. Superiority in pulse accuracy of an electronic counter over a synchronous clock for measuring a frequency of 1 mc is in the order of 1,000. (Clock contact and phase stability, 10^{-4} sec, compared with electronic counter accuracy, 10^{-7} sec.)

For precise readings, the 1 sec pulse from the counter must be brought into coincidence with the master time pulse from WWV. Versatile commercial counters permit doing this by means of a gate. Oscillator frequency to be measured is fed into the counter permanently, but initially the gate is closed. When the receiver output is connected to the "Start" input, the first WWV time pulse opens the gate and allows the instrument to start counting. The one-second output pulses then appear immediately after the start front of WWV time pulse. This operation can be done conveniently during the minutes with no audio tone transmission.

The shape of the counter output pulse needs attention to achieve full accuracy of this method. This pulse, used to trigger the oscilloscope sweep, should have a steep front with a rise time in the order of one microsecond. Directly at the unloaded output of the appropriate binary unit, the requirement is fulfilled. However, loading this point with the capacity of a shielded cable would increase the rise time, thereby permitting inevitable small amounts of superimposed hum to influence the instant of triggering. Therefore, it is advisable to employ a buffer amplifier between this output and the trigger input of the oscilloscope. A double-triode amplifier may be located inside the counter cabinet, thus allowing a short unshielded connection to the sensitive binary output.

Method 6: Electronic Counter as Clock-Oscilloscope Reading

This method uses an electronic counter as a frequency integrating device. Reading is done on an oscilloscope the same way as described in method five which used electro-mechanical clock contacts.

Method 7: Electronic Counter as Clock With Additional Counter for Observation

A further improvement can be achieved by using an additional electronic counter for indication. This counter must have separate inputs for opening and closing the gate, usually designated "Start" and "Stop" inputs.

The time pulse of the clock counter, formerly used to trigger the sweep of the oscilloscope, is now applied to the "Start" input of the indicating counter. Receiver output delivering WWV signals is connected to the "Stop" input. In this arrangement, the front of the clock time pulse opens the gate. The first wave of the WWV pulse following this instant closes the gate. The time between both events, a fraction of a 1 kc wave, is indicated by the counter.

A digital recorder connected to the output of the indicating counter is convenient. It allows taking an average over a greater number of successive readings, thus improving the accuracy.

Comparison of Methods

Table 2 presents a compilation of the seven methods described. The factors of uncertainty characterizing each method are listed separately. The sum of these individual factors indicates the total tolerance of reading for the respective method.

As previously explained, methods of measuring frequency against time consist of two readings, one at the start and one at the end of a certain interval of time. The difference between both readings, divided by the time interval, equals the deviation of frequency during this time. Five columns itemize different intervals of time, from 100 sec to one million sec. At the cross points of these columns with the various methods, the accuracy of frequency test can be found.

These results demonstrate that a frequency standard can be tested with the same accuracy using any one of the different methods. The qualitative difference between methods is distinguished by the time interval over which the test has to be carried out to achieve a certain accuracy. For example, method three requires a period of approximately 1,000,000 sec, equal to 11.6 days to attain an accuracy of 1×10^{-9}. By contrast, only 10,000 sec, or 2.8 hrs, are needed for a test with the same accuracy using method six.

Obviously, shorter test periods are desirable for several reasons. "Slow" methods do not allow measuring short time stability of the frequency standard under test. Temporary failure of power during the period of a test spoils the result. This is more likely to happen during a long test period.

When the master time signal is received by wireless transmission, possible variations in transmission time influence the actual accuracy of each reading. This effect has been described in connection with beat frequency methods. Maximum uncertainty caused by it may be assumed as 10 mμsec on each reading for methods three to seven, provided that both readings of a test are done either during day or night, and during normal ionospheric conditions.

Figures in brackets ( ) of Table 2 include this factor of uncertainty for wireless transmission.

Actually, limits for this factor are quite different, depending on frequency, distance from transmitter, geographical direction of transmission, and type of terrain in the area of receiver. The value of 10 mμsec is based on experience in Rochester, N.Y., for transmission of 5 mc from WWV in Washington, D.C. (320 miles). ■ ■

Oscilloscope Trace Recording With Polaroid Land Photography

Part 3

Tube Phosphors and Filters Special Techniques

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THOUGH LAND film can capture traces on all commonly-used scope phosphors, an engineer is wise to know the effects on his film of different phosphors and filters.

Phosphors and Filters

Polaroid* Land films can be used on all tube phosphors commonly employed for cro work, P-1, P-2, P-5**, P-7, P-11, and P-15**. Two of these phosphors, P-2 and P-7, have different color outputs in initial phosphorescence and in afterglow.

The light output of some phosphors makes them better suited for photography than others. For example, the P-11 and the P-15 are the most efficient for recording high speed transients. Of the phosphors intended primarily for visual work, the P-1 and P-2 are effective for stationary patterns and low speed transients.

Filters—green, amber, and blue—are commonly furnished by cro manufacturers to separate the initial fluorescence and afterglow and to aid the observer during extended observations. A blue filter is used to eliminate cathode glow on unaluminized phosphors and for cutting out the long-persistence yellow afterglow on P-2 and P-7 traces.

In general, a filter absorbs a considerable amount of light and can cause slight degradation in image quality from surface interreflection. A standard blue filter, for example, will require an additional exposure of from 2 to 2-1/2 stops.

A brief description of tube phosphors, their use with filters, and their application in photography are presented here and summarized in Table 4.†

P-1. This phosphor is the most commonly used in oscilloscopes. Its green output is efficient in recording repetitive traces. It is not recommended for recording high speed transients. Green filter is frequently used for viewing but is not beneficial for photo recording.

P-2. Versatile, especially for tubes with high accelerating potentials. Has initial fluorescence and afterglow. Blue-green fluorescence is efficient for photography. Blue filter can be used to eliminate the yellow afterglow which can cause blurring with moving traces. Before taking pictures, it is necessary to remove any amber filter used for long persistence observations, because the initial fluorescence is most actinic for recording. Not recommended for recording high speed transients.

P-5. This has a blue trace of very short persistence. It may be used for photographing high speed transients, though not as efficient as the P-11 phosphor. Blue filters are commonly used for visual work but not for photographic work.

P-7. Similar to the P-2, with an initial blue fluorescence and yellow afterglow. P-7 has greater persistence at lower accelerating potentials and can be used for seeing as well as recording stationary patterns and low speed transients.†† Relatively low fluorescent output and high afterglow make this phosphor not as desirable as P-2 for photo recording of transients. Blue filter can be used for recording only the initial actinic blue fluorescence. Amber filter (for visual comfort) should be removed before photo recording.

P-11. Highest actinic output with short persistence makes it most valuable for recording steady state patterns as well as high speed transients. Blue filter is used for visual work but not for photographic purposes except to reduce cathode glow fog.

P-15. Common in television and kinescope recording. Has blue-green output almost as efficient as the P-11 for photography. Usually more pleasing than the P-11 because of its green color. A green filter improves visual contrast but has no benefit for photo recording.

A double image, as seen in Fig. 14, is sometimes recorded by cameras using beam splitter mirrors with P-1 or P-2 phosphors. Since these mirrors are designed primarily for P-11 phosphors with blue output, some of the green light from P-1 and P-2 phosphors is reflected from both surfaces of the mirror. A blue filter will eliminate the double trace. This double image usually occurs only with excessive exposure.

Fig. 14. (right) D ubl image traces are c use by reflections from bot surfaces of beam s litte mirror with P-1 pho phor. Blue filter wi eliminate second ima

*Polaroid is a registered trademark of the Polaroid Corporation.

**P-5 and P-15 are usually available only on special order.

†Source: DuMont Industrial Cathode Ray Tubes, Industrial Tube Sales Dept., DuMont Laboratories, Passaic, N.J., 1956.

††The P-2 is a mixed phosphor screen while the P-7 is a cascaded screen with a blue fluorescent layer and a yellow persistence layer.

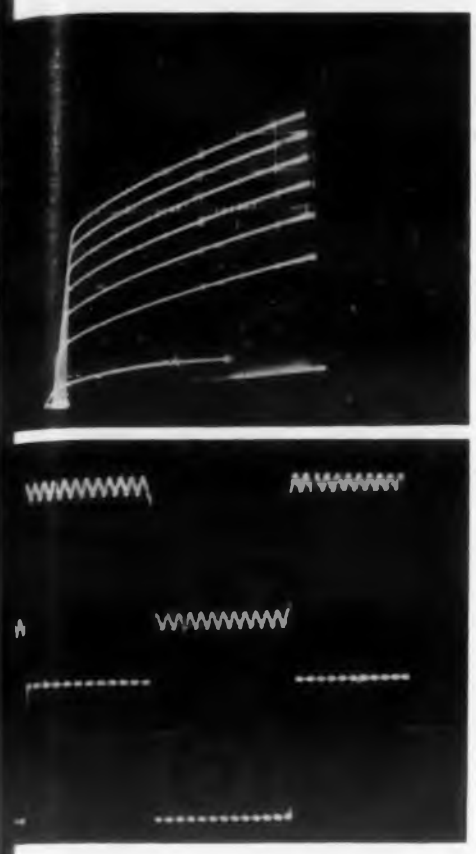


Fig. 15. (above) Vertical pips are added for time interval calibration in upper trace. Lower trace has Z-axis signal modulating intensity for time calibration.

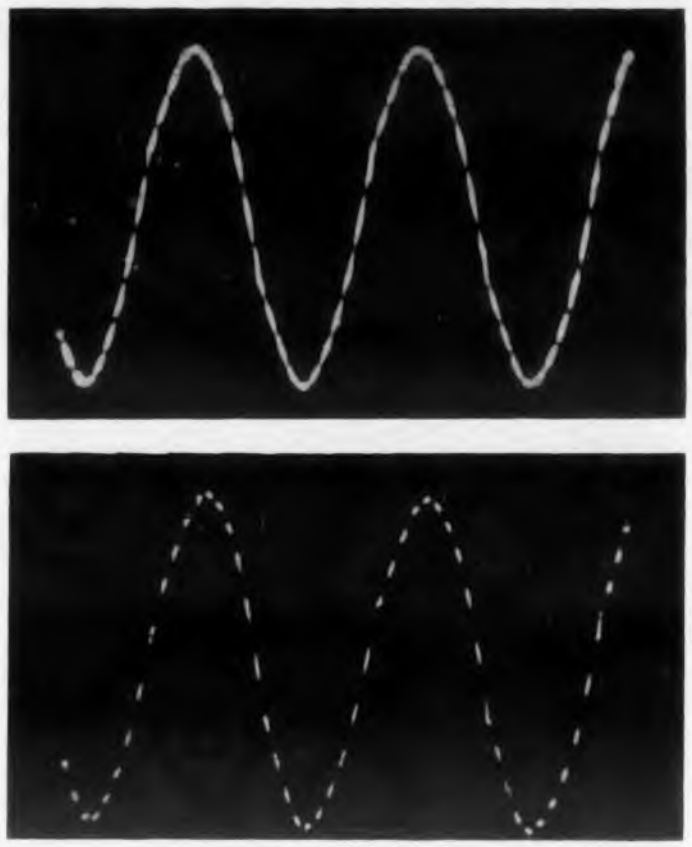


Fig. 16. Upper trace has insufficient Z-axis amplitude. Lower trace has picture improved by lowering intensity setting and increasing development time.

(*Courtesy AVCO Corp.*)

Fig. 17. A convenient technique for recording long time-base sweeps. Time base is presented as a raster with Z-axis markers every 10 microseconds.

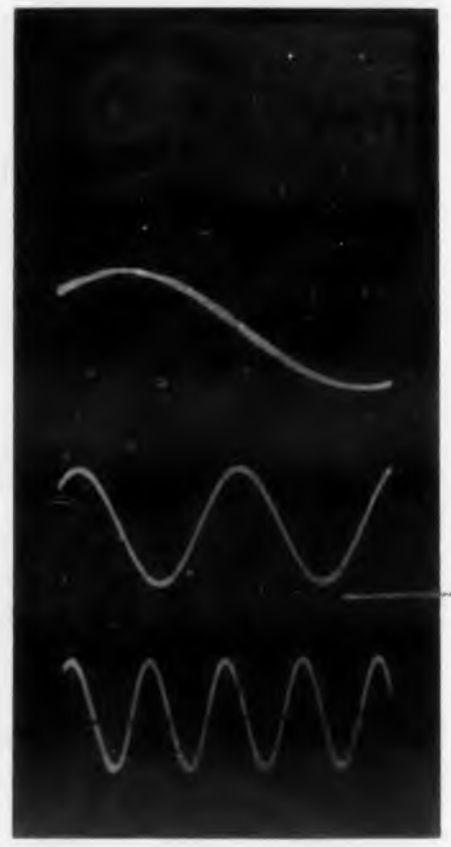


Fig. 18. Data card exposed to identify trace recordings at f/5.6 and 1/2 sec on Type 47 film.

Special Techniques

It is often useful to record markers, graticules, data charts, and calibrated wave forms on the same picture as the trace recording. These records are made by exposing both the trace and data at the same time or by exposing the film with the extra information before or after recording the trace itself.

Calibration Markers. For adding time information to a trace, calibration markers are usually either superimposed on the vertical axis of the trace or they are used to modulate the intensity of the trace. Examples are shown in Fig. 15.

If the intensity modulation signal is not strong enough to provide noticeable effect on the photograph, improvement is possible by reducing the cro intensity and increasing the contrast of the Land print through increased development to two or three minutes, as shown in Fig. 16.

Another interesting technique for using calibration markers is indicated in Fig. 17, where an especially long time base had to be recorded in one picture. The time base is converted into a raster which is displayed on the crt face with time markers.

Graticules. Illuminated graticules can usually be recorded with the trace on a single exposure by turning up the graticule scale brightness and lowering the cathode ray tube intensity.

With some oscilloscopes it is more convenient to make two separate exposures to record both the graticule and the trace. This is especially true when one does not wish to change the trace intensity from a convenient viewing brightness level.

One should first record the graticule with its illumination turned up and the crt intensity turned down. One should then turn off the graticule and record the trace with cro intensity at normal setting.

Where there is a choice between white or colored graticule illumination, best results are in photographing white light illumination.

Care should always be taken that the graticule is in sharp focus because graticule and trace are not in the same object plane. One should keep camera apertures to a minimum and make sure that the glass or plastic plate is positioned so the lines face the crt screen and are flush against it.

Data Charts. Some oscilloscope cameras have a ground glass surface on which identifying data can be written with pencil. Internal illumination exposes this data on the film. The data card, as shown in Fig. 18, required another exposure.

The intensity of the trace and of the graticule scale must be turned down before exposing the data card to avoid double exposure of the trace. For Type 47 film, an exposure of about 1/2 second at f/5.6 is sufficient with the light emitted from two No. 112 lamps driven by a 1-1/2 v battery. (Du Mont type 302 camera).

Continuously Varying Patterns. A continuously varying pattern often can be "stopped" for study only by a photograph. When using a cro with built-in beam gate, the driven sweep and external sync controls permit triggering the gate for one sweep during a continuously varying pattern without difficulty. When scopes are used without built-in beam gates, the shutter speed can sometimes be adjusted to an "open" time which is short relative to the rate of change of the pattern.

Notice the differences in the recordings of a varying signal in Fig. 19. The first trace is blurred because many cycles of the signal were recorded; the second varying exposure was electronically gated to display only one trace.

Radar Displays. Recording the high intensity PPI scope radar returns is very simple and straightforward. Usually a long persistence P-7 phosphor is employed. With an aperture setting at f/11 or f/16, and the shutter open on "B" or "T," a test exposure or two will establish the proper intensity level of both the radar display and the azimuth scale setting. Care should be taken to record

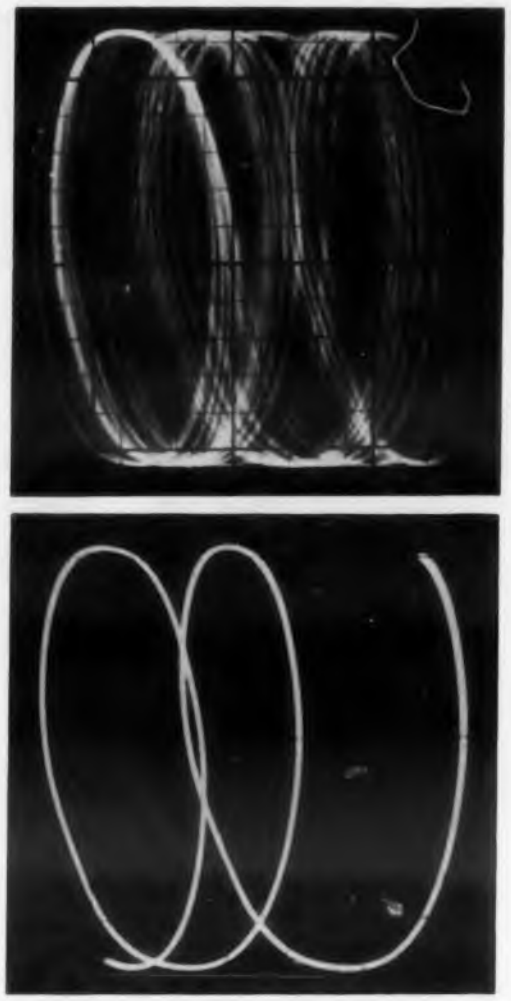


Fig. 19. Continuously varying trace is blurred as several cycles are recorded in the upper photo with camera shutter at 1/10 sec. Below, electronic gating displays only single cycle for camera recording with shutter held open.

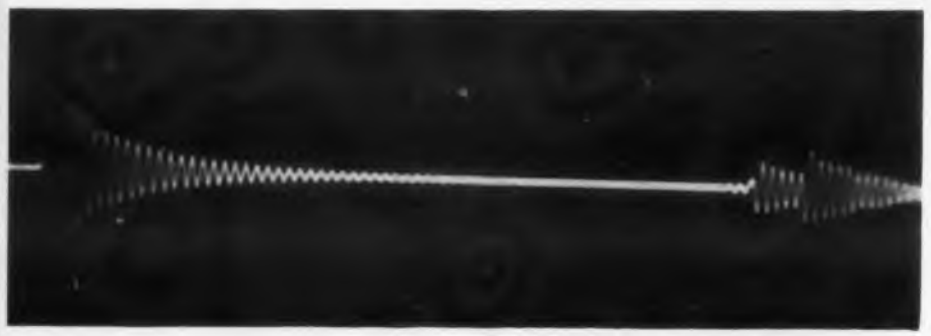


Fig. 20. Cathode glow fogging from unaluminized phosphor resulted from shutter being left open for eight minutes waiting for a random transient.

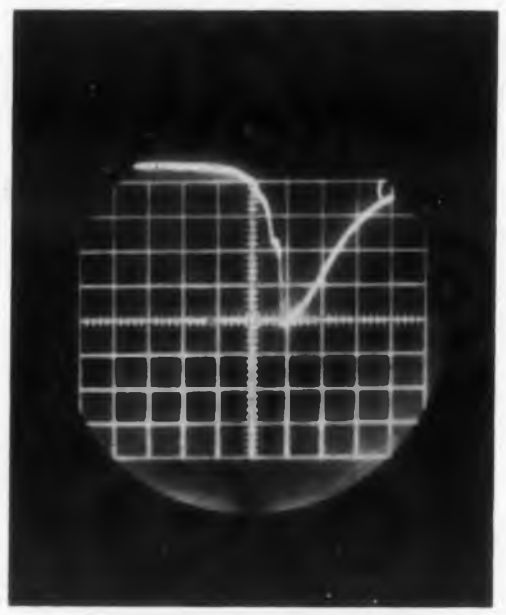


Fig. 21. Inadequate mounting and bright ambient light permitted light to leak into camera, causing fog. Camera shutter was left open two minutes to await random transient.

only a single complete sweep and to avoid the overlap. Hand controls on the camera shutter are usually sufficient.

Single frame recordings of A-Scope patterns have limited applications because the trace is usually varying so rapidly. To record traces on this crt, usually with a P-5 phosphor, one should open the aperture wide, turn the intensity level of the A-Scope to as high a level as is feasible, and keep exposure time to an absolute minimum.

Most cameras will mount directly on the standard five inch A-Scope flange. For the common seven inch PPI scope, a special mount must be constructed. A number of special radar camera

Phosphor	Color: Initial Fluorescence	Color: Afterglow	Persistence	Application	Filters	Use Of Land Films
P-1	Green	Green	Medium	General purpose cro work, repetitive or transient waveforms. Most frequently used on low voltage scopes.	None	Relatively efficient for recording stationary or repetitive patterns. Brilliant output at low accelerating voltages.
P-2	Blue-Green	Yellow-Green	Long	General purpose. Needs higher accelerating potentials. Durable phosphor for high accelerating potential cro's.	Dark blue filter eliminates long persistence yellow component for photography. Amber filter eliminates initial blue-green flash.	Blue component is short persistent and has high photographic efficiency. Records successive transient phenomena, and low rate repetitive traces.
P-5	Blue-Violet	Blue-Violet	Very short	Display of high speed transients such as Radar A-Scope.	None	Relatively efficient for single frame recording. Not as high light output as P-11 phosphor.
P-7	Blue-White	Yellow	Blue-White is short. Yellow long	Similar to P-2, operates at lower accelerating potentials with longer persistence. Useful for radar, low speed transients, and integrating repetitive phenomena.	Blue filter eliminates long persistence yellow component. Amber filter eliminates initial blue flash.	Relatively high photographic efficiency for single frame recording. Not as efficient as P-2.
P-11	Blue	Blue	Short	Photographic recording of transient phenomena. Longer persistence than P-5.	None	Highest photographic efficiency makes it most useful for recording transients and repetitive traces.
P-15	Blue-Green	Blue-Green	Extremely short	Flying spot scanners, TV kinescope recording.	None	Not as high actinic output as P-11, but is effective with Land films for high resolution, high frequency recording.

have been developed for military radar systems.

Avoiding Fogging

Though undesirable fogging can take place from several sources, in most cases it can be easily eliminated. Fogging usually comes from one of three general sources:

1. The crt trace itself.
2. Internal sources within the crt (cathode glow).
3. Light leaks within the camera.

The most common source of fogging is from the crt itself. High intensity traces or overexposure can cause halation due to interreflections in the crt face and excessive reflection from the internal walls of the camera. This fogging is controlled by careful adjustment of camera settings and cro intensity settings.

When recording transients on a cro without automatic beam blanking a stationary spot on the screen can cause film fogging. To eliminate this fogging, position the spot near, but not beyond, the edge of the screen. Mask the stationary spot with tape or black opaque paint. Do not move the spot too far off the screen, or the mask will not cut off the glow caused by reflection.

Cathode glow and stray emission are two sources of fog that come from internal parts of the crt. Cathode glow, shown in Fig. 20, is caused by the red and infrared radiation of an incandescent cathode, penetrating an unaluminized thin phosphor screen. It can cause serious fogging when the shutter is open for long periods of time.

This type of fogging does not occur on cameras which have backs perpendicular to the crt because the blue reflecting dichroic mirror does not reflect this part of the spectrum. A blue filter can help eliminate the glow when the cro does not use a metalized screen and very long exposures are required.

The stray emission due to electron reflections from deflection plates on some older type oscilloscopes will show a slight glow on the crt and can cause fog on the film. Slight adjustments in the position of the electron beam or reduction in the deflection amplitude can usually eliminate such defects.

Fogging caused by camera light leaks is shown in Fig. 21, where fogging is due to light leaking in between the bezel and the cathode ray tube mount. As with cathode glow, this problem sometimes occurs when the shutter has to remain open for long periods. The only practical answer is to exercise more care in mounting the camera and to shield it from very bright external light.

Fog can also occur when the operator neglects to close the viewing ports or the camera lens setting ports before making an exposure.

(*Continued on p. 58*)

Fig. 19. Continuously varying trace is blurred as several cycles are recorded in the upper photo with camera shutter at 1/10 sec. Below, electronic gating displays only single cycle for camera recording with shutter held open.

Fig. 20. Cathode glow fogging from unaluminized phosphor resulted from shutter being left open for eight minutes waiting for a random transient.

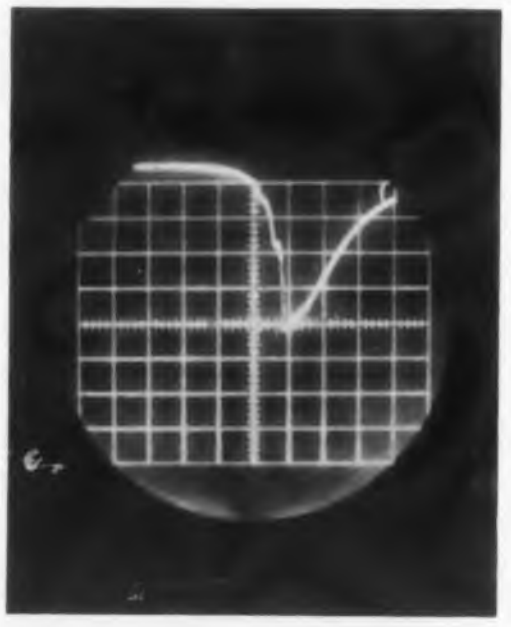


Fig. 21. Inadequate mounting and bright ambient light permitted light to leak into camera, causing fog. Camera shutter was left open two minutes to await random transient.

only a single complete sweep and to avoid the overlap. Hand controls on the camera shutter are usually sufficient.

Single frame recordings of A-Scope patterns have limited applications because the trace is usually varying so rapidly. To record traces on this crt, usually with a P-5 phosphor, one should open the aperture wide, turn the intensity level of the A-Scope to as high a level as is feasible, and keep exposure time to an absolute minimum.

Most cameras will mount directly on the standard five inch A-Scope flange. For the common seven inch PPI scope, a special mount must be constructed. A number of special radar cameras

Phosphor	Color: Initial Fluorescence	Color: Afterglow	Persistence	Application	Filters	Use Of Land Films
P-1	Green	Green	Medium	General purpose cro work, repetitive or transient waveforms. Most frequently used on low voltage scopes.	None	Relatively efficient for recording stationary or repetitive patterns. Brilliant output at low accelerating voltages.
P-2	Blue-Green	Yellow-Green	Long	General purpose. Needs higher accelerating potentials. Durable phosphor for high accelerating potential cro's.	Dark blue filter eliminates long persistence yellow component for photography. Amber filter eliminates initial blue-green flash.	Blue component is short persistent and has high photographic efficiency. Records successive transient phenomena, and low rate repetitive traces.
P-5	Blue-Violet	Blue-Violet	Very short	Display of high speed transients such as Radar A-Scope.	None	Relatively efficient for single frame recording. Not as high light output as P-11 phosphor.
P-7	Blue-White	Yellow	Blue-White is short. Yellow long	Similar to P-2, operates at lower accelerating potentials with longer persistence. Useful for radar, low speed transients, and integrating repetitive phenomena.	Blue filter eliminates long persistence yellow component. Amber filter eliminates initial blue flash.	Relatively high photographic efficiency for single frame recording. Not as efficient as P-2.
P-11	Blue	Blue	Short	Photographic recording of transient phenomena. Longer persistence than P-5.	None	Highest photographic efficiency makes it most useful for recording transients and repetitive traces.
P-15	Blue-Green	Blue-Green	Extremely short	Flying spot scanners, TV kinescope recording.	None	Not as high actinic output as P-11, but is effective with Land films for high resolution, high frequency recording.

have been developed for military radar systems.

Avoiding Fogging

Though undesirable fogging can take place from several sources, in most cases it can be easily eliminated. Fogging usually comes from one of three general sources:

1. The crt trace itself.
2. Internal sources within the crt (cathode glow).
3. Light leaks within the camera.

The most common source of fogging is from the crt itself. High intensity traces or overexposure can cause halation due to interreflections in the crt face and excessive reflection from the internal walls of the camera. This fogging is controlled by careful adjustment of camera settings and cro intensity settings.

When recording transients on a cro without automatic beam blanking a stationary spot on the screen can cause film fogging. To eliminate this fogging, position the spot near, but not beyond, the edge of the screen. Mask the stationary spot with tape or black opaque paint. Do not move the spot too far off the screen, or the mask will not cut off the glow caused by reflection.

Cathode glow and stray emission are two sources of fog that come from internal parts of the crt. Cathode glow, shown in Fig. 20, is caused by the red and infrared radiation of an incandescent cathode, penetrating an unaluminized thin phosphor screen. It can cause serious fogging when the shutter is open for long periods of time.

This type of fogging does not occur on cameras which have backs perpendicular to the crt because the blue reflecting dichroic mirror does not reflect this part of the spectrum. A blue filter can help eliminate the glow when the cro does not use a metalized screen and very long exposures are required.

The stray emission due to electron reflections from deflection plates on some older type oscilloscopes will show a slight glow on the crt and can cause fog on the film. Slight adjustments in the position of the electron beam or reduction in the deflection amplitude can usually eliminate such defects.

Fogging caused by camera light leaks is shown in Fig. 21, where fogging is due to light leaking in between the bezel and the cathode ray tube mount. As with cathode glow, this problem sometimes occurs when the shutter has to remain open for long periods. The only practical answer is to exercise more care in mounting the camera and to shield it from very bright external light.

Fog can also occur when the operator neglects to close the viewing ports or the camera lens setting ports before making an exposure.

(Continued on p. 58)

How to Develop Prints

In general, 45 seconds is long enough to develop prints of cro traces. The 60-second standard development time serves only to build up contrast in the middle gray areas of the picture—a characteristic not important for most cro traces.

To record complex detail, a full 60-second development time is recommended when adequate brightness and exposure are available. To increase writing rate, reduced development time of 20 to 30 seconds will help, but will cause a slight loss in trace sharpness and background density.

The effect of overdevelopment, up to two to three minutes, will increase contrast, increase the blackness of the background and eliminate some details in high writing rate portions of a trace. Occasionally, faint, undesirable, high-frequency noise can be eliminated from a photograph by overdevelopment.

Copying Prints

There are three direct ways of copying Polaroid prints. These are outlined in Table 5.

Care and Storage

For permanent retention of important experimental data, it is essential that all prints be coated and all transparencies be treated in Dippit after removal from the camera. In storage, Land prints and transparencies should be given the same careful attention as any photographic material. The best way to store both prints and transparencies is in acetate sleeves.

Land prints should not be glued or taped directly to other sheets. Glue and bonding agents in tape often contain harmful chemicals which may deteriorate a photographic image.

Polaroid transparencies can be safely handled and stored in regular Polaroid slide mounts. For even further protection, the transparencies can be placed between conventional lantern-slide cover glass. Glass is essential if transparencies are to be used in projectors with inadequate cooling.

One should not write directly on the image surface or back of a Polaroid print, either before or after coating with any material. Writing can crack the coating. One may write on margins or tabs with grease pencil or ballpoint pen.

Projection Film

Polaroid Land Projection film produces a positive transparency from the back of the camera in much the same way a positive print is produced. However, the handling and the use of the film is quite different from that of the positive print.

Standard developing time is two minutes, but as with paper prints, one can remove them from the camera in less than the standard time for most cro work. One minute after the picture is taken a transparency can be pulled out of the back of

Original Picture	To Reproduce As: Print	Transparency	Submitting for Publication
Print (Types 42 and 47)	Direct copies produced on Land film with Print Copier. Direct copies on conventional photographic paper from Polaroid Copy Service.	Direct copies produced on Polaroid Transparency Film with Polaroid Print Copier.	Originals or copies can be submitted.
Transparency (Types 46 and 46-L)	Diazotype direct copy to produce on any diazotype papers. Direct copies on conventional photographic paper through Polaroid Copy Service.	Diazotype direct copy easy to produce on any diazotype films. Direct copies on conventional photographic film through Polaroid Copy Service. Enlarged conventional negatives easy to produce.	Transparencies and printed material on translucent master easy to reproduce for inter-office reports. Polaroid print copies or conventional 3-1/4 x 4-1/4 print copies are desirable. Most publications prefer not to have transparencies.

the camera with only a slight loss in the density of the background.

Another useful feature of the transparency film is that one does not have to wait for development time between pictures. As soon as a picture is taken, a frame can be advanced; another picture can be taken and the tab advanced again, so that the incompletely developed transparency is pulled through the slot-opening of the camera.

It must be kept in mind that the transparency has to stay in place on the negative-positive sandwich for at least one minute. Removing it in a shorter time interval usually causes some of the image to be left behind on the negative.

Accurate measurements of time intervals, amplitudes, and slopes can be made from a projected transparency more readily than they can be made from a print. Another technique is to make projection enlargements from a transparency onto matte surface photographic paper. Measurements again are traced from this enlargement.

The emulsion layer of the transparency is wet and delicate before it is placed in a Dippit. Therefore, it provides a good surface for writing information directly with a sharp instrument such as a pen point or pencil. The transparency is then placed in a Dippit as usual.

One of the most desirable features of the transparencies is the ease with which they can be used for illustrating a small number of copies of report papers. Any diazotype machine (such as Ozalid, Tecnifax, Bruning, Pease, etc.) can be used.

By attaching a transparency directly to the translucent original of a report page for diazotype reproduction, both the printed information as well as the illustration can be produced in one pass through the machine.

Here's how it is done: First, information is typed onto a high quality vellum tracing paper, producing a master sheet. (Some manufacturers of diazo-type papers provide papers ideal for this purpose.) For best results one should use an electric typewriter. Unless an acetate ribbon is in the typewriter to give deep, black, sharp letters, the master sheet should be backed with a soft carbon paper.

The Polaroid transparency is then taped on the *back* of the master sheet in the open area where the illustration is to appear. For a "right-reading" reproduction, the transparency must go emulsion side *down*. (Or, if the oscilloscope trace is reversed by the camera, one should place the emulsion side *up* to obtain a "right-reading" trace.) Minnesota Mining and Manufacturing Company's Tape No. 810 can be used for taping the transparency down to eliminate dark borders.

The master sheet is placed face up on top of the diazo-sensitized paper and fed into the machine. Any inexpensive standard blue-line or black-line diazo-sensitized paper can be used. ■ ■

How To Specify High Level Audio Transformers

Wallace W. Wahlgren, Technical Director, Electro Engineering Works

TWO TRANSFORMERS may fully meet what is apparently a complete specification for the transformer. But they may react differently in a specific application on which complete details were not given to the transformer designers. This happens when engineers, who would ordinarily know better, forget pertinent factors when specifying transformers.

These factors cover particularly modulation transformers for wide-range broadcast transmitters and special-purpose communications transmitters—used for telemetering and high-speed facsimile transmission. It also includes high-level output transformers used in sonar, ultrasonics, vibration machines and sound systems, and variable high-cycle power applications.

One problem in specifying transformers is terminology. It is customary to think of audio transformers in terms of impedances and ratios. But a high-level audio transformer is a power transformer. The designer must reduce audio terms to voltages and turns ratios and produce a product made of iron and copper wire.

Physical Aspects

With respect to the physical environment, the designer must know the extremes of temperature to be met and duration. Other considerations include shock and vibration and requirements of magnitude, humidity, corrosive atmosphere and altitude.

When space and weight are not limiting parameters, tight low-frequency response specifications can be easily met by oversize construction. These transformers are often much larger than equivalent power transformers. The trend, however, is toward smaller units because of improvements in core materials, insulation and general know-how. It is now possible to meet almost any desired performance parameters without oversize construction.

What Type Construction?

The designer should know if the buyer prefers a specific type of construction (cased or open type) or if he is free to use the best design for the specific application.

When space is at a premium and power handling requirements are less than 2 kw, the designer might specify a cased transformer with oil or oil silicol solution as the insulation and heat conductor. Since oil, when not in motion, is not a good coolant, an oil-based solid organic potting compound is often used in this class of transformer. The compound provides oil insulation, yet because of direct contact through a mineral material, effective heat conduction is achieved.

For handling higher power and where space is available, dry-type transformers are often specified. Spacings are large enough to permit application of relatively high voltages without danger of breakdown. The trend in dry-type transformer construction is toward encapsulation. The coils are impregnated in resin or varnish. Epoxy-resin and caps prevent entrance of moisture and provide physical protection.

When voltages in the order of 6000 v dc and higher are to be encountered, oil-filled construction is desirable to provide adequate insulation for high peak voltages. Also, because of the presence of high frequency audio at high voltages, oil is needed to keep the insulation from overheating owing to dielectric losses.

A typical spec sheet in which the buyer notes his desired objectives and mandatory requirements is shown in Table 1.

Signal and Duty Cycle Important

The transformer design engineer must also know what kind of a signal is to be handled. A smaller transformer, for example, will suffice if the signal has a complex and varying waveform, as in music or speech, than when the signal is a sine wave of higher average power. More power must be handled by an output transformer in a vibration machine than in a high-power sound system, because of the character of the waveform.

There can be a vast difference in size, weight and cost of a transformer that is used only for a few minutes at a time, compared with one operated continuously. It is important to know how many minutes per hour the transformer must handle full power. This is customarily specified in terms of percentage of full-power volt-amperes. Sometimes, particularly in the case of modulation transformers, capacity to handle half-power (kva) on a full-time basis or 100 per cent modulation 30 per cent of the time, is specified. In the case

Applicable MIL specs (if any)_____

Grade_____ Class_____

Ambient temperature range – _____ C, + _____ C

Life expectancy_____ hours

Shock_____ Vibration_____

Altitude_____ Feet. Temp. rise_____ C.

Duty cycle_____

Is electrostatic shield required?_____

Type of construction_____

Type of mounting_____

Maximum dimensions_____

Weight limit objective_____

Kind of terminals_____

Other data_____

Table 1. In specifying transformers the above physical considerations should be spelled out.

a broadcast transmitter, the duty cycle requirements will be far more severe than in a communications transmitter operated on a push-to-talk basis.

Electrical Aspects

It is vital for the transformer design engineer to have full details of the electrical environment. The character of the load must be known, how it varies and to what extent.

The performance of a modulation transformer, for example, is affected by the load, which is generally a radio frequency amplifier. High-frequency response can be affected by the shunt capacitance imposed on the modulator by the rf tank tuning capacitors, by-pass and blocking capacitors, and the capacitance of the rf amplifier tube. This shunt capacitance can vary, depending upon the tuning of the transmitter. At the low end of the transmitter's tuning range, more capacitance to ground customarily exists because of the settings of the tuning condensers. At the high end, the reverse is true. An rf choke in the circuit may cause slight attenuation of higher audio frequencies. Thus it is important for the designer to know what shunt capacitance and series inductance the load will impose.

Compensation Possible

If the designer is aware of these factors, he can provide compensation in the transformer to offset their effects. Leakage inductance, for example, can be calculated and used to advantage in offsetting capacitance in the load.

When a transformer is fed through a capacitor into a reactor, as in a transmitter, the shunt reactance of the transformer should be related to the inductance of the reactor. Thus the designer needs data on the reactor, the values of the coupling, by-pass and filter capacitors in the associated circuits and the load. Their values may have a significant effect on the transformer's frequency-response curve.

In the case of an output or modulation transformer, the plate voltage applied to the tubes must be specified. Not just the optimum value, but the minimum and maximum limits between which satisfactory performance is required. While the equipment designer may think of normal voltage conditions, allowance should be made for over and under voltage conditions that could occur in the field. It may be necessary to deliver more audio power under high-voltage conditions to achieve 100 per cent modulation in a transmitter.

Turns Ratio Figured

Dealing with voltages and power, the transformer designer must know what turns ratio to provide. He takes into consideration peak voltages across the entire primary (plate-to-plate) as well

Modulation Transformer Performance Specification No._____

Transmitter classification — Standard Broadcast_____watts. Other_____

Modulator: Tube Type_____ Plate Voltage_____ ± _____%

Class of operation_____ Power Output_____ w. Distortion_____%.

With resistive load of_____ohms plate to plate (objective)

Bias volts_____ Peak input volts per grid_____

Final amplifier. DC volts_____; DC current_____amp, ± _____%

Total capacitance load on modulation reactor_____max _____min μμfd

RF choke_____mh Secondary Series Capacitor_____μfd

Modulation reactor rating, _____henry _____amp _____dc volts

Final filter capacitor: Modulator_____μfd; TF amp_____μfd

Frequency response, ± 1 db limits _____cps to_____cps

Overall distortion objective, _____% _____to_____cps: _____% _____to_____cps

Reflected impedance. (above conditions)_____to_____cps = _____ohms ± _____%

Table 2. The buyer should also list electrical considerations as itemized above.

Transformer Characteristics: Type of construction:_____

Rating duty cycle:_____va @_____minutes per hour: _____va continuous

Max. volts, half primary_____rms @ min_____cps. No load current

_____amp. Tol. ± _____%: 60 cps_____v _____amp _____watts ± 10%

Leakage ind. half primary (with full primary shorted)_____mh max.

Leakage ind. half primary (with secondary shorted) min._____mh, max._____mh.

Secondary no load volts (max.)_____, — _____, — _____v rms.

Max. sec. load current_____amp. Max. I^2R loss (1-2) _____w (2-3) _____w

Typical Test Results (half primary)

Response, Rs = _____ohms, 1 db points_____, _____cps. _____db points_____, _____cps.

Reflected impedance peaks: (1)_____cps._____ohms (2)_____kc_____ohms (3)_____kc_____ohms

Receiving dielectric tests: Prim. & Sec. to ground_____kv RAC*

Primary to secondary:_____kv ac. 60 cps. *Rectified AC. RMS Value.

Marking: Primary, plates (1-3) Centertap (2) Secondary; low end (4)
Secondary; high end (5) to R.F. load. Sec. taps L,M,H (connect jumper only.)

Tap impedance ratio (half prim,); L = $\frac{p}{s}$ _____ ohms - M = $\frac{p}{s}$ _____ ohms - H = $\frac{p}{s}$ _____ ohms

Remarks:

Customer approval. Date_____ by_____
name title company

Approved transformer: EEW #E_____ Rev._____ Date_____

Table 3. The transformer design engineer is the best qualified person to specify what tests should be made on transformers. He fills out a sheet, like this, outlining production test specifications.

rms voltage required by the load.

In a class B modulator or power amplifier operating at 60 to 70 per cent efficiency, the rms voltage developed across the full primary is almost the same as the dc plate voltage. At 66 per cent efficiency, this voltage is 94 per cent of the dc plate voltage. Peak voltages are considerably higher and should be taken into account, particularly in the case of transmitters where the 5000-v peaks of a 3500-v signal may cause overmodulation.

It is undesirable to have any substantial portion of the windings unused. Where more than 10 per cent of the over-all windings are unused, performance is severely handicapped. If taps are required and part of a winding is unused, it is necessary to make the transformer bigger to offset degradation of performance. It is not feasible to design a transformer that will provide the best performance for a large number of different conditions. Taps, when necessary, should be provided only for minor adjustment of ratio.

Some Distortion Unavoidable

The distortion limit objectives are customarily specified. Even when a pure resistive load is used, some distortion will result. While it is not produced by a properly designed transformer, distortion may be in the circuit.

While it is not necessary for the designer to know what tubes are to be used, this data is generally wanted to double check the other information received. Bias and peak grid voltages are also of importance to him as supplemental information.

Since it is practical to build transformers that provide a constant impedance reflected load within ± 10 per cent or better, with high power factor over wide frequency range, these requirements should be spelled out in the specification. Heretofore the scientific feasibility of this has not been generally recognized.

A typical spec sheet giving the electrical environment data, filled in by the buyer, is shown in Table 2.

Tips on Testing Transformers

While it is the responsibility of the transformer maker to ensure that his product meet the requirements of applicable specifications, some buyers stipulate what tests should be made. Sometimes these test specifications are inadequate, too strict or just plain inept.

A transformer should be subjected to tests that determine its usefulness in its intended application. Arbitrary test specifications may result in a transformer considerably larger and more costly than required. Only the transformer designer knows how the windings are interleaved. He is the only one qualified to determine what kind of hipot tests should be made. A typical production test spec made up by the design engineer after designing the transformers is shown in Table 3. ■ ■

Voltage Controls This Variable Bandwidth Amplifier

Joseph L. Dautremont, Jr.
TelAutograph Corporation, Los Angeles, Calif.

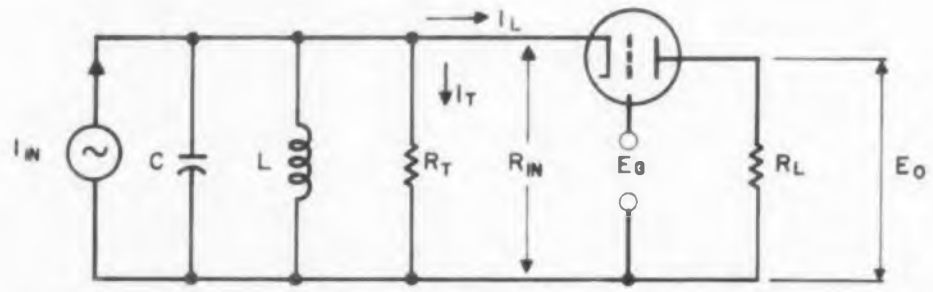


Fig. 1. Equivalent circuit of the basic variable bandwidth amplifier, including circuit losses.

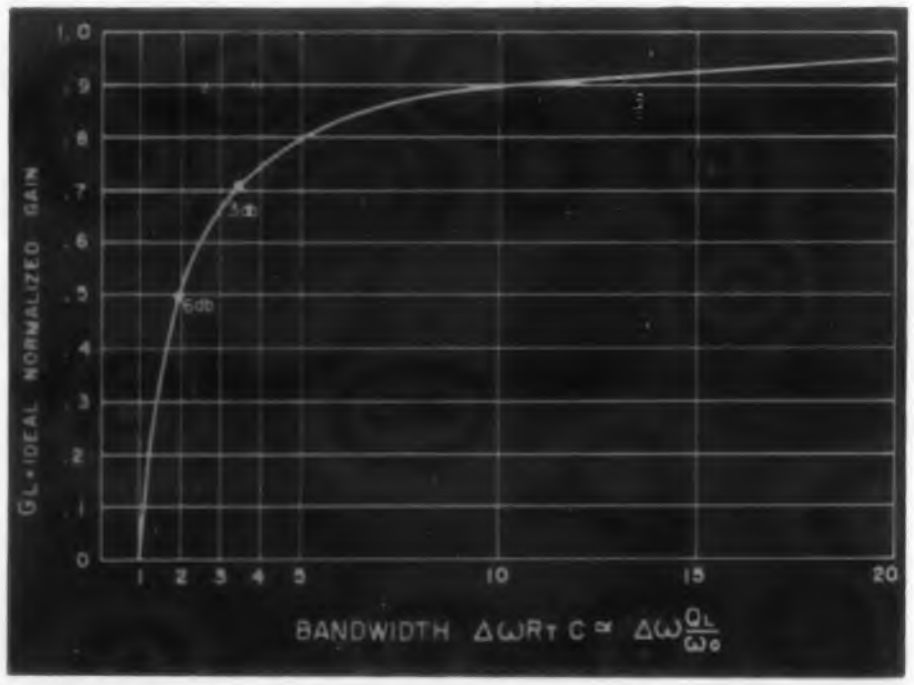


Fig. 2. Ideal normalized gain vs bandwidth for the variable bandwidth amplifier.

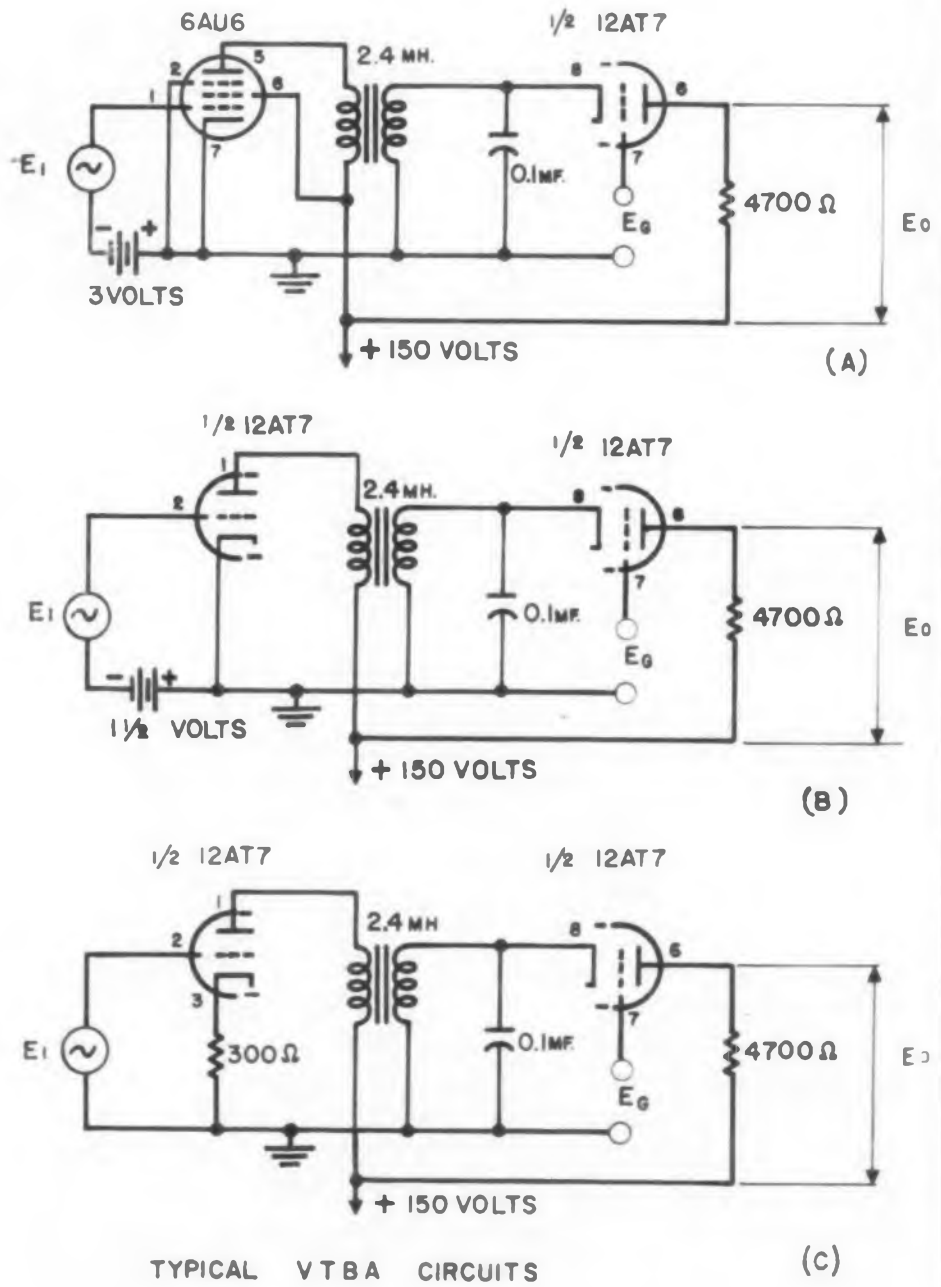


Fig. 3. Three typical VBA circuits. (A). A pentode serves as an ideal current source. (B). A simpler circuit with quality almost matching that of the pentode circuit. (C). An improved version of the circuit in (B).

BANDWIDTH of this amplifier varies as a function of control voltage. Applicable from audio through very high frequencies, this simple circuit may also be used to alter the bandwidth of a nonlinear servo system with respect to a derivative of the output, thus improving system stability.

The basic VBA schematic is shown in Fig. 1. The 3 db bandwidth of the amplifier is that of the tuned circuit:

$$\Delta\omega = 2\pi\Delta f = \frac{1}{RC} \tag{1}$$

Since

$$R_{in} \cong \frac{1}{G_m}$$

for a grounded grid amplifier, Eq. (1) becomes:

$$\Delta\omega \cong \frac{G_m}{C} \tag{2}$$

Bandwidth Varied By Small Bias Voltage

The bandwidth is reduced by increasing the tube bias, E_g. Losses in the inductance cause a loading effect limiting the minimum bandwidth and reducing the gain as R_{in} increases. These effects may be calculated as:

$$G_i = \text{normalized gain at resonance} = \frac{i_L}{i_{in}} = \frac{R_t}{R_t + R_{in}} \tag{3}$$

(R_t is the effective parallel resistance of the losses in the inductance).

$$\Delta\omega = 2\pi\Delta f = \frac{1}{\left(\frac{R_t R_{in}}{R_t + R_{in}}\right) C} \tag{4}$$

Combining Eqs. (2) and (3):

$$G_i = 1 - \frac{1}{\Delta\omega R_t C} \tag{5}$$

Knowing R_t and C, the gain for any bandwidth may be found using Eq. (5), which is plotted in Fig. 2. Note from Eq. 3 and Fig. 2 that gain is reduced 6 db when $R_t = R_{in}$.

The three variations of VBA in Fig. 3 were tested. R_t was 10,000 ohms for all three. Circuit 3A, a pentode, is nearly an ideal current source. The previously derived equations apply directly, and the overall gain is:

$$\left.\frac{e_o}{e_i}\right|_T = -G_m R_L G_i \tag{6}$$

where G_m is the transconductance of the pentode. Measured results are given in Figs. 4, 5, and 6.

Circuit 3B is simpler, without appreciable loss in quality, as shown in Figs. 4, 5 and 6. The voltage gain, assuming infinite Q_1, is:

$$\left.\frac{e_o}{e_i}\right|_T = -\frac{\mu_1 (1+\mu_2) R_L}{R_{p1}(1+\mu_2) + R_{p2} + R_L}$$

(Continued on p 66)

(Continued from page 65)

Subscripts 1 and 2 refer to triodes 1 and 2 respectively. Choosing circuit parameters such that:

$$R_{p1}(1+\mu_2) >> R_{p2} + R_L$$

then:

$$\left.\frac{e_o}{e_i}\right|_r = -G_{m1} R_L$$

Response curves for various values of tuning bias are given in Fig. 6.

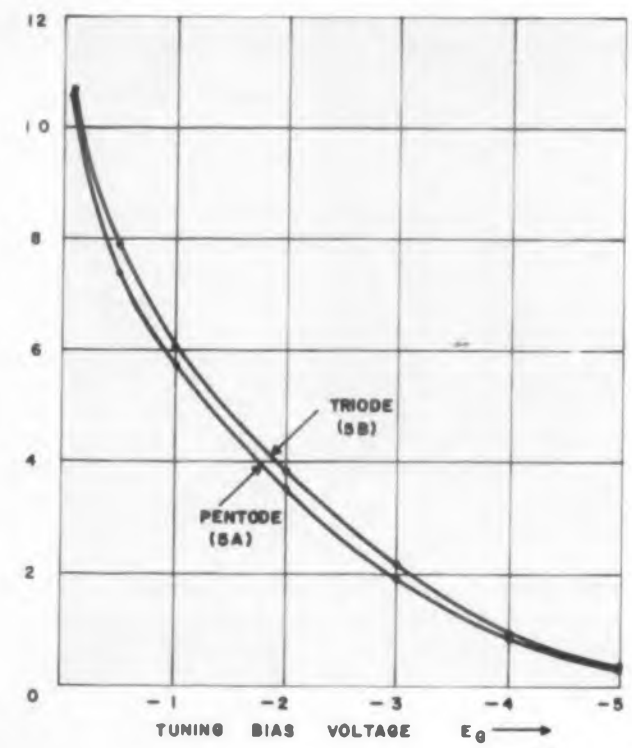


Fig. 4. Bandwidth vs tuning bias for the circuits of Figs. 3A and 3B.

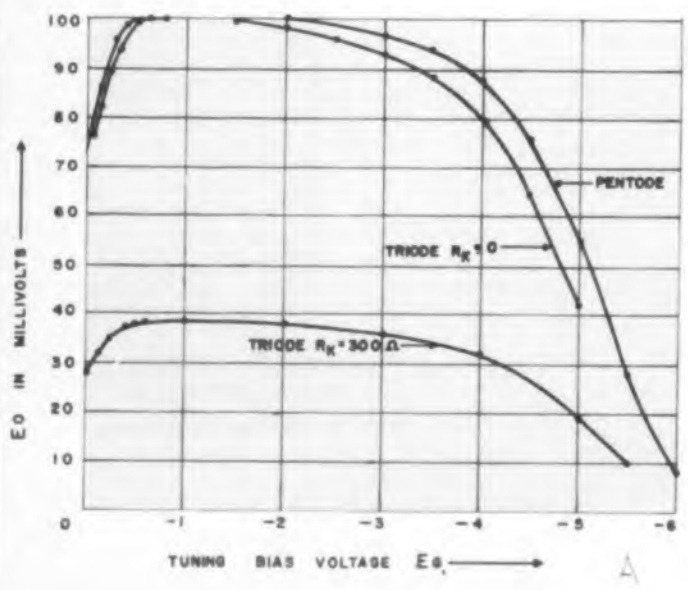


Fig. 5. Output at resonance for the circuits of Fig. 3.

The response curve of 3B may sometimes be improved by adding cathode resistor R_k as in Fig. 3C. The resistor is not justified in this case, since it decreases gain. with little improvement in response.

This method is useful when a tube with low plate resistance must be used, since current feedback increases output impedance. The gain. assuming infinite Q_1, is:

$$\left.\frac{e_o}{e_i}\right|_r = \frac{\mu_1 (1+\mu_2) R_L}{(1+\mu_2) R_{p1} + R_k (1+\mu_1) + R_{p2} + R_L}$$

If

$$(1+\mu_2)[R_{p1} + R_k (1+\mu_1)] >> R_{p2} + R_L$$

then:

$$\left.\frac{e_o}{e_i}\right|_r \cong \frac{\mu_1 R_1}{R_{p1} + R_k (1+\mu_1)}$$

which implies that the gain at resonance is dependent on the parameters of the first triode only.

Useful In Low Noise Applications

A modified Wallman cascode lends itself to the VBA principle, as in Fig. 7. This circuit is significant because the cascode is often used in the first stage of i-f amplifiers. The noise figure of the VBA is not noticeably affected till the bias decreases the gain of the cascode beyond the 3 db point.

A low pass VBA is shown in Fig. 8, functioning as a resistive shunt across the plate capacitor. In this case, the dc level of E_o is affected, therefore the dc plate voltage of the pentode must be confined within the limits over which it acts as a current source. This reduces the useful bandwidth

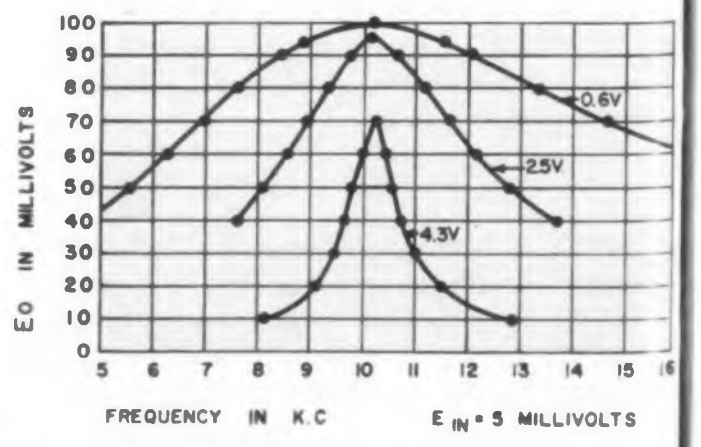


Fig. 6. Response of the circuit in Fig. 3B at three values of E_g.

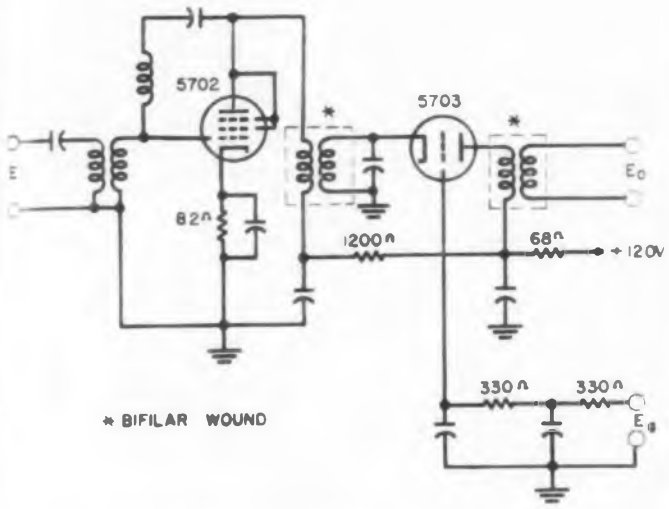


Fig. 7. Modified Wallman cascode as a VBA.

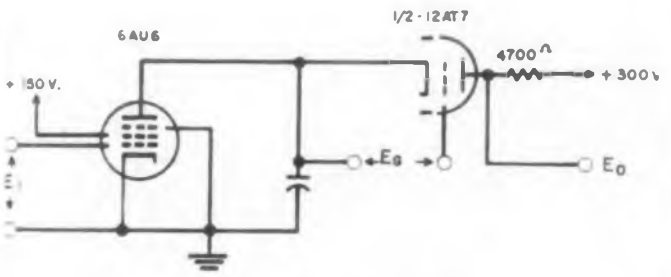


Fig. 8. A low pass VBA.

to approximately a three to one range.

Design Procedure

Given the cascode of Fig. 7 with an i-f frequency of 30 mc. The tube used has a minimum R_{in} of 300 ohms.

The desired bandwidths are one mc minimum, and ten mc maximum, with 3 db maximum change over the tuning range.

From Eq. 1:

$$C \leqq \frac{1}{2\pi\,(\max \Delta f)\,(R_{in}\ \min)} \leqq \frac{10^{-6}}{2\pi\,(10)\,300} = 53\mu\mu f \text{ or less}$$

From Fig. 2:

$$\Delta\omega\, R_t\, C = \Delta\omega \frac{Q_1}{\omega_o} \geqq 3.42$$

Hence:

$$Q_1 \geqq 3.42 \frac{30\,(10^6)}{1\,(10^6)} = 105 \text{ minimum}$$

Suitable values are:

$$C = 10\mu\mu f \qquad L = 2.8\mu h \qquad Q > 105$$

(C is the total capacity, including stray and inter-electrode capacities). The rest of the circuit is designed as if it were a conventional cascode. ■ ■

Thanks are extended to John La Terra for his valuable assistance in preparation of this paper.

Picking a Potentiometer: Film or Wir

A DESIGN ENGINEER specifying potentiometers can use either a wirewound or film unit. Which should he choose? A look at the record will help the careful engineer explore the advantages and disadvantages of each.

In performance, the carbon film potentiometer is better than the wirewound, as shown in the accompanying table. This is a result of the configuration and construction of the film unit. But cost must be considered, too: the film unit is more expensive. So let us compare further.

Although the film potentiometer has a higher degree of accuracy and reliability, the wirewound shows a smaller variation with temperature and humidity. Special resistance wire alloys are available with a resistance change of not more than +0.002 per cent per degree F.

Carbon film units have a temperature coefficient of about −0.01 per cent per degree F. In continuous 100 per cent relative humidity, wirewound potentiometers have shown a resistance decrease of about 5 per cent. Carbon film units have shown a resistance increase of about 25 per cent.

In wirewound units, the resistance change with humidity is usually accompanied by a change in linearity and resolution because of internal shorting of windings. In carbon film units there is no deteriority of linearity or resolution with humidity.

Construction of Wirewound Pots

The wirewound potentiometer is made by winding a fine insulated resistance wire around a straight insulated metal core. In a non-linear unit, the core is of non-uniform cross section. The turns may be spaced and the wire diameter varied.

The wound core is left straight in a translatory unit. It is bent in circular form in a rotary unit. And it is bent in a helical shape in a multi-turn potentiometer. The wiper traverses the length of the wound core in a direction transverse to the windings.

The potentiometer output voltage thus varies in a series of small steps, corresponding to the wiper contact, with successive turns of wire. This resolution ability deteriorates in nonlinear units where varying wire diameter or spacing is used.

Shortcomings of Wirewound Pots

Shortcomings in wirewound potentiometers that result from their construction are:

- Integrity of resistance element depends on hair-like wire.
- High speed is limited by wiper bounce.
- Shorted turns develop because of fragility of insulation.
- Linearity is limited by the discrete nature of winding.
- Resistance values obtainable are limited by wire size.
- Output becomes noisy with running.
- Wiper riding transverse to winding is abrasive and shortens life.
- Windings are reactive. They are capacitive to the core and inductive to each other, producing errors when excited with high frequency voltages.
- Corrosive products produce shorted turns, opens in the output, poor shelf life.

Construction of Film Pots

The film potentiometer is made by applying a thin, continuous resistive film to a base having a shape compatible with the types of wiper motion. It is straight for translatory motion, circular for rotary, single-turn or multi-turn motion. The film

A Comparison of Film And Wirewound Potentiometers

Characteristic	LINEAR POTENTIOMETER		SINE-COSINE POTENTIOMETER	
	Wirewound	Carbon Film	Wirewound	Carbon Film
Case Diameter	2 in.	2 in.	2 in.	2 in.
Resistance	10 K	10 K	10 K/quadrant	10 K/quadrant
Linearity (best)	0.075%	0.03%	0.25%	0.1%
Resolution	0.05%	0.001%	0.1%	0.001%
Starting Torque	0.75 oz.-in.	0.30 oz.-in.	2 oz.-in.	0.7 oz.-in.
Operating Speed (max.)	300 rpm	2000 rpm	150 rpm	2000 rpm
Life (at 100 rpm)	2 x 10^6 rev.	20 x 10^6 rev.	1 x 10^6 rev.	20 x 10^6 rev.

Herbert H. Adise is the president of the largest producer of film potentiometers in this country. He believes that too many engineers specify wirewound potentiometers more out of habit than analysis. In this article he hopes to stimulate a closer look at the film potentiometer.

Herbert H. Adise
Computer Instruments Corp.
Hempstead, L.I., N.Y.

or Wirewound

is permanently bonded to the base and presents to the wiper a continuous, smooth, low-friction surface. Resolution is virtually infinite. The only resolution effects are secondary ones introduced by wiper spring and play in shaft bearings. The resolution is independent of the nature of the output, being the same for linear and nonlinear types.

Film potentiometers are made with metal or carbon films. To achieve useful values of resistance, the thickness of metal films is so small as to limit film life. The carbon film unit is consequently much more widely used and has been developed to a high state. Since it is representative of film potentiometers, carbon film characteristics are discussed below.

By control of film properties—thickness, width, and resistivity—very high linearities or nonlinear conformities may be achieved. In effect, carbon film may be regarded as a surface across which a potential difference is applied. A family of orthogonal equipotential, current flow lines exist in the film, uniformly spaced for the linear case. The wiper serves as a pick-off, indicating the potential at its contact point with the film.

Wear, which occurs along a current flow line, does not disturb the field nor impair accuracy. At the end of the film's life, wear does, however, manifest itself in increasingly erratic output voltage that ultimately shows opens. Relocating the wiper path restores potentiometer output to its original quality.

The carbon film potentiometer offers flexibility, because of the ease with which the "resolutionless" film may be deposited in narrow or irregular paths.

Film Pots Give Failure Warning

The film potentiometer has an "early warning" characteristic and indicates impending failure. The wirewound unit does not.

In the wirewound pot, the transverse-wound fine wire is subjected to maximum wiper abrasion and local heating because of the construction developed by wear.

The failure of any one of the thousands of turns of wire results in an open winding. Failure in the wirewound unit is sudden and catastrophic.

The resistance element of the carbon film potentiometer, on the other hand, can be likened to a single slidewire. It has a thickness several times that of the wire used in wirewound units and has at least 100 times the width. The wiper path occupies but a small fraction of the width. Thus, as the carbon film wears under the abrasion of the sliding wiper, the current-carrying capacity of the resistance element is not limited. Wearing does not develop any hot spots. As the element thickness is reduced from wear under the wiper, the voltage output begins to show local irregularity. With continued wear, this irregularity becomes more pronounced.

At the extreme end of life, irregularities may appear as loss of signal (opens). But these will be localized. Thus with carbon film units there is a gradual deterioration in output that gives the "early warning" of system failure.

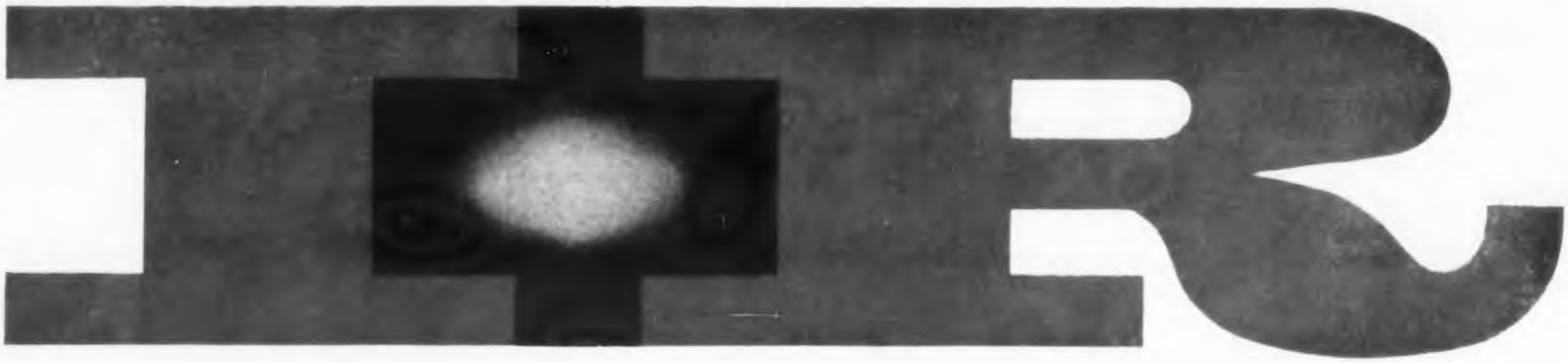
How Surge Currents Affect Pots

It is not unusual that the failure of some other component in a system will produce an imbalance in the electrical circuit—resulting in a surge of current through the wiper of a potentiometer. In the wirewound unit, the turn of wire immediately under the slider at that instant overheats, softens, melts and tears. The winding opens, and the unit is completely inoperative.

With the carbon film potentiometer, this surge of current causes only local carbonization of the film. The remainder of the film is unaffected. The carbon film unit continues to operate normally with an irregular output appearing only when the wiper traverses the locally burned spot.

Because of its higher resistance stability, the wirewound unit may be more suitable for use as a rheostat where a close tolerance is required on resistance variation with shaft position. A typical application of the precision rheostat is its use in an RC network for frequency control.

For instrumentation and control applications, where the potentiometer is used as a voltage divider and the resistance stability is of secondary importance, the carbon film unit may be the preferred component because of its better accuracy and reliability. ■ ■



Infrared Measurement and Calibration

Loren H. Ford and Paul Mengers
LMED, General Electric Co.
Ithaca, N. Y.

Loren H. Ford, left, presently engaged in advanced photics engineering for General Electric, LMED, is a graduate of Michigan State University. He has been in various phases of military electronics since joining GE in 1951. Paul Mengers, right, is a mathematician and is currently developing techniques for making rapid approximate determinations of the spectral content of radiation. The authors wrote this aricle to disclose some of the test methods used at GE which they hope will prove helpful to others in the field.

Many new techniques for making infrared measurements are being developed. In this article some of the present measuring methods and equipment in use are discussed.

IN INFRARED system design and synthesis, a knowledge of detector characteristics is of great importance. The system designer often has to utilize their capabilities to the limit. Uniformity of detector characteristics has improved during the past few years but considerable variation still exists among individual detectors of the same nominal performance. Because of these two facts, the designer often finds it advisable to make measurements on individual detectors. For most system applications, the following characteristics are of most interest: (1) optimum bias; (2) time constant; (3) responsitivity; (4) noise spectrum; and (5) spectral response.

The order in which the measurements are made is important. For example, optimum bias should be determined before the noise spectrum is measured. It is also convenient if the frequency of the radiation input signal does not exceed the time constant limitations of the detector. Data on spectral response may be taken when convenient but must be known before the Noise Equivalent Input can be calculated.

Optimum Bias

Many infrared detectors require some form of bias supply. A typical circuit is shown in Fig. 1. The optimum bias is that value of bias current through the detector which maximizes the signal-to-noise output from the detector-load resistor network. To determine this value for photoconductive cells, a radiation signal whose magnitude does not need to be known as long as it does not saturate the detector is put into the detector. The output signal is then measured for increasing values of bias current. Usually the signal output increases approximately linearly and then flattens out. Next, with no signal applied, the noise volt

ge output in the frequency region of interest is measured as a function of bias current. This will generally increase with bias also. Computing the signal-to-noise ratio and plotting as a function of bias will generally result in a broad maximum for most detectors. Fig. 2 shows the results of a typical optimum bias measurement on a PbS cell.

For thermistor detectors, a different procedure is used. This consists of determining the peak voltage attainable across the detector under steady state thermal conditions. That is, after each change in bias is made, sufficient time is allowed for a new thermal equilibrium to be established before measurements are made. Fig. 3 is a typical voltage-current curve of a thermistor. The peak voltage is determined by Eq. 1.

$$\frac{V_P}{R_p} = C_t\,(T_t - T_a) \qquad (1)$$

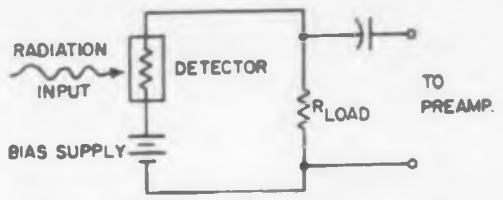


Fig. 1. Infrared detector bias supply.

where:

V_p = peak voltage
R_p = peak resistance
C_t = steady state rate of heat dissipation
T_t = thermistor temperature
T_a = ambient temperature

Maximum voltage is due to the high negative temperature coefficient of resistance which causes the resistance to drop at increased power levels. Optimum bias is chosen to be 0.6 of the peak voltage. At this level current noise is small compared to the limiting noise which is thermal. Since signal-to-noise ratio is proportional to bias voltage, 0.6 V_p is found to be a good compromise which allows for some variation in ambient temperature.

Time Constant

There are two commonly used methods of measuring the time constant of an infrared detector. The first method utilizes a neon flasher which is capable of producing pulses of light with a frequency which can be easily varied from dc to about 10 kc. By plotting the signal output as a function of input frequency, a graph similar to Fig. 4 will be obtained in which the output will begin to fall off beyond a certain frequency. The frequency at the break-point where the output is

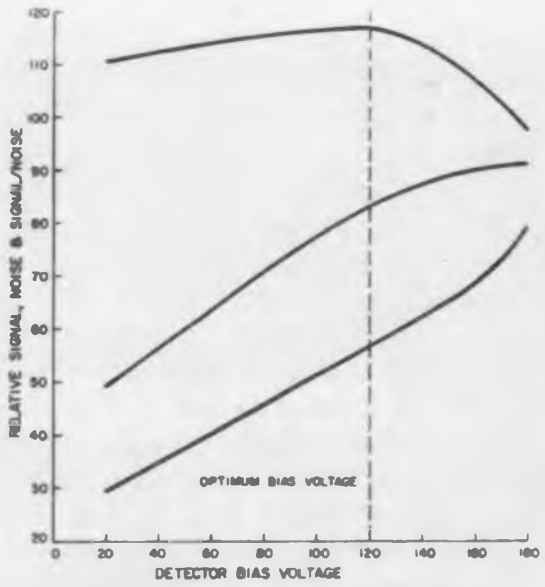


Fig. 2. Typical optimum bias curve.

down 3 db, is the reciprocal of the time constant. The disadvantage of this technique is that the output of the neon lamp is in the visible part of the spectrum and may not give an accurate measure of the frequency response of the detector to radiation of longer wavelengths.

A preferable technique which is simpler, though slightly less accurate, is to apply a square wave radiation input from a blackbody source to the detector and display the output on an oscilloscope. By making the square wave duration in the neighborhood of three of four time constants and photographing the trace displayed on a calibrated sweep, a sufficiently accurate determination of the time constant can be made by measuring the time

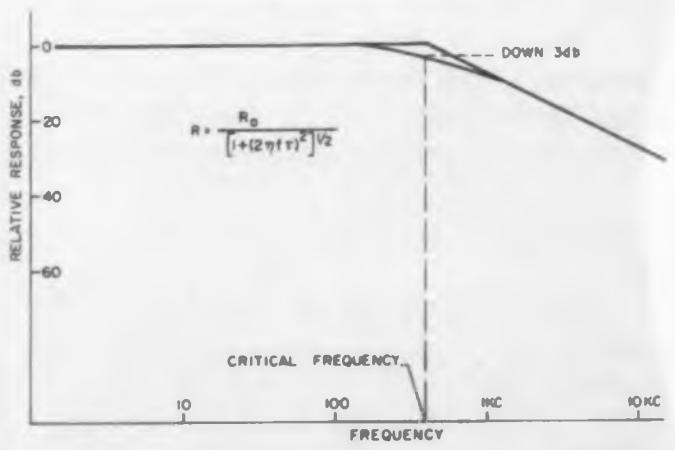


Fig. 4. Typical photoconductor frequency response.

for the trace to rise to 67 per cent of its asymptotic value. This method will also determine the existence of any significant second time constant the detector may possess.

A typical setup for this measurement is illustrated in Fig. 5. The beam defined by the collimating apertures should be as small as practicable in relation to the chopper slit in order to cut the rise time of the radiation input signal.

Responsivity

This quantity is defined as the ratio of output signal voltage to the radiation input signal. Several qualifications are in order here. First the chopping frequency should be less than the break-point or critical frequency. Second, the detector should be operated under optimum bias conditions. Third, the input and output signal should be measured in terms of the root-mean-square of the third requirement. When the input signal is a square wave, the rms of the fundamental is 0.45 times the peak-to-peak value.

With the equipment shown in Fig. 5 a narrow band filter and an rms voltmeter to replace the oscilloscope, would be adequate for responsivity measurements. There are a number of calibrated and temperature controlled blackbody sources

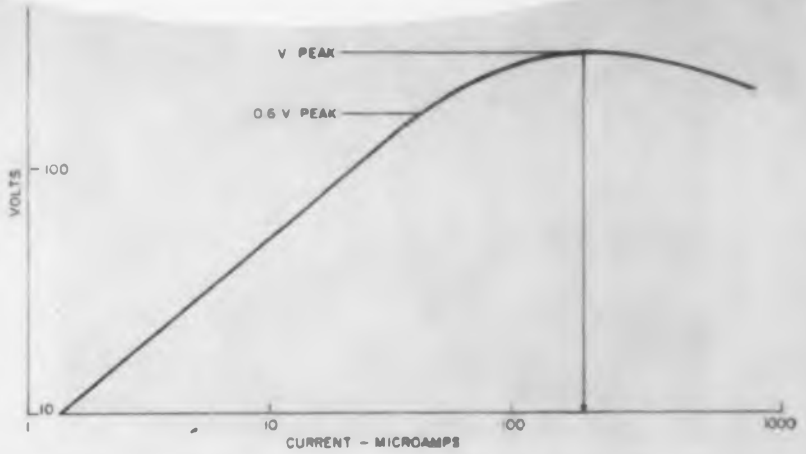


Fig. 3. Typical voltage-current relation for thermistor detector.

commercially available. The input signal is the difference between the radiation input from the blackbody and a reference (usually the chopper blade). Radiation input from which the responsivity or more accurately, the total responsivity is calculated is the difference in the integrated radiation inputs from the source and reference as indicated in Eq. 2.

$$R = V_s\left[B_1\left(\int_{\lambda_1}^{\lambda_2} J_{bb}\,(\lambda)\,S_d\,(\lambda)\,d\lambda - \int_{\lambda_1}^{\lambda_2} J_{ref}\,(\lambda)\,S_d\,(\lambda)\,d\lambda\right)\right]^{-1} \qquad (2$$

where

B_1 = ratio of rms of fundamental to peak-

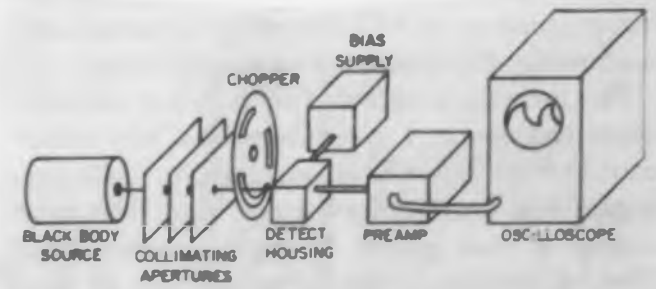


Fig. 5. Trace-time measuring equipment.

peak radiation difference

V_s = rms of output signal voltage

λ_1, λ_2 = spectral response limits of detector

J_{bb} = spectral distribution of blackbody

J_{ref} = spectral distribution of reference source

S_d = relative spectral response of detector

Note that R will depend on the temperature of the blackbody. Thus it is necessary to specify this temperature in reporting such data. Since the responsivity also depends upon the temperature of the detector itself, this fact should also be noted.

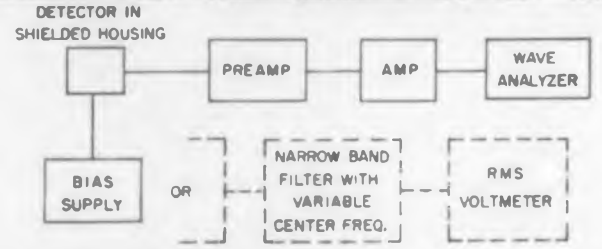


Fig. 6. Measuring setup for NEI, chopping frequency and bandwidths (a), and its block diagram (b).

Noise Voltage Spectrum

A knowledge of the noise voltage spectrum of the detector is essential in determining such system parameters as NEI, chopping frequency, and bandwidths. Fig. 6 shows a measuring setup.

The detector is shielded as in other measurements and operated at optimum bias. The output noise voltage is fed to an adjacent low noise preamplifier and is then further amplified. This noise voltage is then passed through a narrow band filter of variable center frequency but of fixed bandwidth. Output is then measured with an rms voltmeter. Care should be taken to shield the detector and preamp and keep the preamp lead as short as possible. In most cases, a low noise triode such as a 12AY7 or a 6533 is desirable in the preamplifier first stage. A 6CB6 pentode has also been found to be excellent for this purpose. The filter bandwidth is usually about 4 or 5 cps. Since most meter movements have a similar bandwidth, the needle tends to fluctuate about a mean at this frequency which makes estimation of the mean difficult. We, therefore, use an auxiliary meter with an integrating network thereby relieving the operator of the necessity of mentally performing this integration. Dividing by the gain and the square root of the filter bandwidth, and plotting the values obtained against frequency results in a graph as shown in Fig. 7.

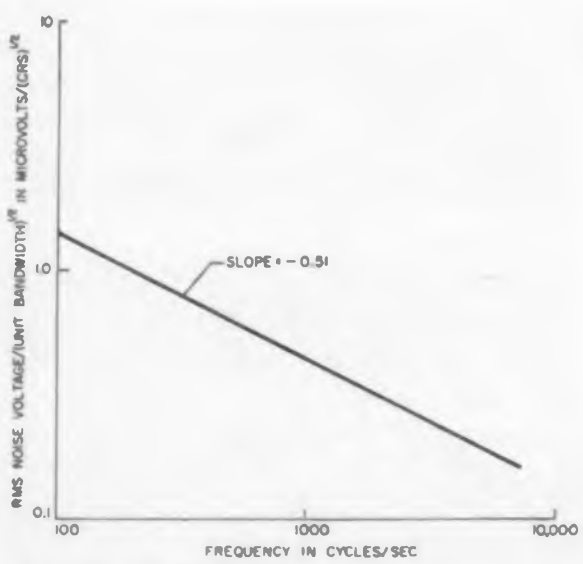


Fig. 7. Noise-frequency spectrum.

Spectral Response

The setup for measuring spectral response is shown in Fig. 8. A Nerst Glower is used to provide a strong and concentrated source of infrared radiation. An image of the source is focused on the slit, s, of a monochrometer. The radiation is twice dispersed by the prism, and chopped between the first and second pass through the prism. The entrance slit is then focused on the exit slits, s', which passes only a small portion of the spectrum onto either the thermocouple detector by means of the movable mirror, m, or onto the detector being measured.

At this point, two procedures may be followed. The first is to leave the slit width fixed as the wavelength of the radiation on the detector is changed. The output of the detector and thermocouple are recorded at each wavelength setting. Since the source intensity decreases at longer wavelengths, both the detector and thermo-couple output will change due to this effect. If the thermocouple is properly blackened, its responsivity is independent of wavelength so that if the ratio of detector output to thermocouple output is plotted, the variations with wavelength should be due only to variations in detector responsivity.

An alternate procedure is to adjust the entrance slit width at each wavelength so that the thermocouple output is maintained at a fixed level. The radiation is then directed to the detector and the output so obtained is a direct measure of the response at that wavelength. It should be noted that both procedures essentially eliminate any extraneous effects due to such things as radiation absorption or slow changes in source output during the course of the measurement.

One of the most useful equipments for taking accurate radiation measurements such as sensitivity vs. wavelength and sensitivity vs. angular view angle of an optical equipment is the collimated optical bench shown in Fig. 9. It is capable of simulating targets at an infinite distance within a reasonable dimension of space by collecting radiant energy from a point source and projecting it along parallel paths in a beam the diameter of the projecting mirror. In so doing, an optical system which is to be tested for image quality, absolute sensitivity, losses due to vignetting or spectral response can be placed within the parallel radiation beam and thus receive realistic radiation incidence for precise measurements.

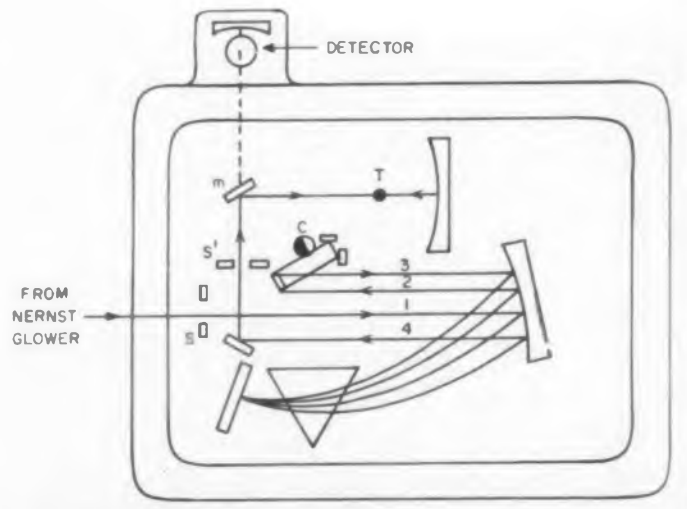


Fig. 8. Setup for measuring spectral response.

A point source whose temperature is controlled and whose spectral passband is variable by insertion of spectral filters is placed at the focal point of the collimating mirror. Its energy is masked so that radiation from the source is only toward the mirror. The mirror collects this energy and re-radiates it in a parallel path down its major axis. The test optics gathers the parallel energy and focuses it upon its detecting element which in turn passes the detected signal in the form of

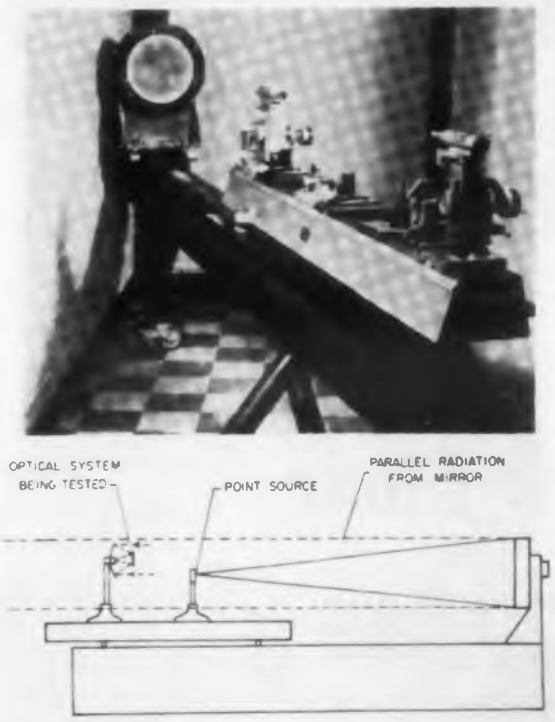


Fig. 9. Collimated optical bench (a), and drawing showing its parts (b).

chopped voltage to a readout meter calibrated to give the required test data. Generally, this is in the form of rms amplitude which is proportional to the energy received by the test optic. If the test optic is large the projected area of the source must be subtracted from the gathering power of the test optic since the source blocks this amount of energy.

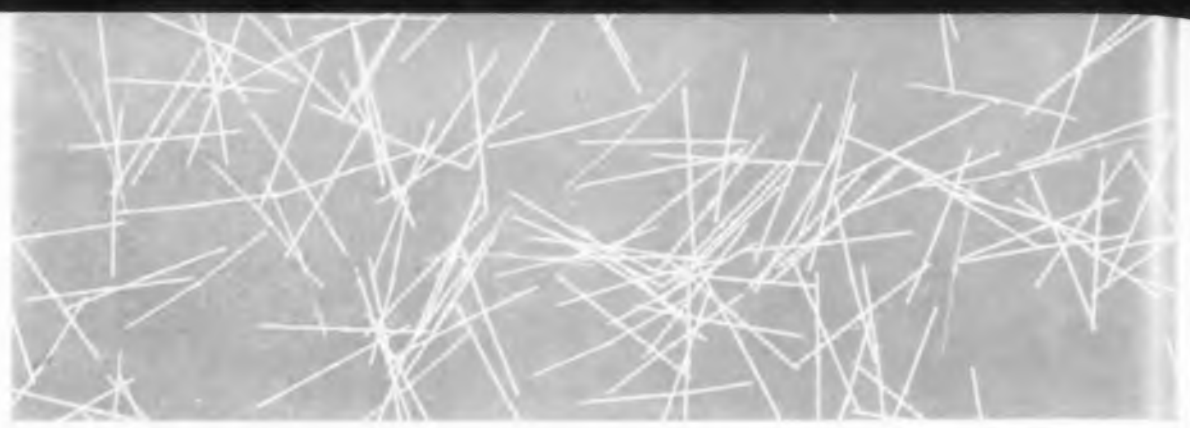
The bed which supports the optical elements and source has been constructed to eliminate errors due to stresses and strains due to movement of the bench or temperature changes. The bench bed is constructed of 12-inch tubular steel reinforced at the ends with welded plates for rigidity. The collimating mirror is kinematically mounted on three points to allow for expansion and contraction without distortion to the alignment of its major axis.

A precision 3-point suspension, optical bench is used as the test bed for the source and the test optic. Its alignment is maintained by the same type of mounting as the collimating mirror.

Bench Specifications are:

Collimating mirror—Spherical First Surface
Focal length—231.03 cm
Diameter collimating mirrors—28 cm
Resolution—usable to 1 deg off axis
Height of image above optical bench—11 in.
Souce—any point source of size required by test optics for image definition.

The entire unit is made mobile by three large casters allowing the test bench to be located in any convenient area. The system can be leveled easily and ready for a test installation within 10 minutes. ■ ■



Flyspeck Diode Stands 20,000 g

ONLY SLIGHTLY larger than a pen's ball point and weighing 14.09 mg, the micro diodes in the PD-100 series can withstand a shock of 20,000 g. The units —20,400,000 fit in a cubic foot—are said to be the smallest commercial-type computer diodes and fill two per cent of the volume occupied by the average subminiature diode.

The diodes—made by Pacific Semiconductors, Inc., 10451 W. Jefferson Blvd., Culver City, Calif.,—measure 0.08 in. long and 0.035 in. in diameter, excluding the leads. Some of their claimed uses are "hand-sized computers," and "pocket-sized space instrumentation systems."

A molecular bonding process is one of the contributing factors to the diode's small size. The molecules of the silicon crystal are chemically bonded with the surface elements that serve as a protective coating. This process is called a "chemical

Electrical Specifications

Type No.	Min. Sat. Voltage @ 100 μA (v)	Min. Fwd. Current @ + 1.0 V (mA)	Maximum Reverse Current (μA)		Reverse Recovery Characteristics	
			25°C	100°C	Reverse Res (Ohms)	Max. Recov. Time (μS)
PD-101	50	5	1 (10v)	25 (10v)	100K	1.0
PD-102	50	20	0.5 (10v)	25 (10v)	100K	0.3
PD-103	50	100	0.5 (10v)	25 (10v)	100K	0.3
PD-104	100	5	0.5 (10v)	25 (10v)	100K	0.3
PD-105	100	20	0.5 (10v)	25 (10v)	100K	0.3
PD-106	100	50	0.5 (10v)	25 (10v)	100K	0.3
PD-107	100	100	0.5 (10v)	25 (10v)	100K	0.3
PD-108	200	10	0.5 (10v) 5 (100)	25 (10v)	200K	0.3
PD-109	200	10	0.025 (10v) 1 (100)	5 (10v)	200K	0.3

A contributing factor in miniaturizing the diode is the process which molecularly bonds the silicon crystal and the protective surface elements.

surface passivation technique." Diode crystals are normally encapsulated in a container which contributes to their larger size.

All nine of the PD-100 series diodes are rated at 250 mw dissipation at 25 C. This is derated linearly to 150 C. The maximum storage and operating temperature range is −65 to +150 C. The typical inverse capacitance at −10 v is 2 μμf, and the peak pulse current is 20 amp for 1 μsec at a one-per-cent duty cycle.

The units will survive thermal shock tests in accordance with Method 107 of MIL-STD-202 as well as repeated immersion cycling from 0 to +100 C and the moisture resistance test of Method 106 of the same specification. In storage at very high temperatures—that is, above 150 C—and when used within published ratings, the reliability of the diodes are "at least one order of magnitude greater than that of any conventional diode," it is reported.

All of the diodes are tested 100 per cent to the electrical specifications, and receive a 200 hr, 175 C "burn-in" process for reliability.

Mechanical Data

The gold-plated nickel leads, which have a minimum length of 1/2 in., are easily soldered or welded, and they can be bent to meet 0.1 in. grid spacing on printed circuit boards. The materials and construction are good to temperatures above 200 C, no soft solders or fluxes are used. More than 10 180-deg bends, at a repetition rate of two bends per second, can be withstood by the leads. They can also withstand 2.5 to 4.5 lb of tensile force.

A rosin-flux is recommended for soldering purposes; the diodes may be dip-soldered within 0.06 in. of the diode body for 60 sec at 230 C. And they can be cleaned for at least 10 min at 35 kc in any of these common solvents: water, trichloroethylene, ethyl alcohol, methyl alcohol, and toluene.

In calculating the packing density of 20,400,000 units per cubic foot, it is assumed that diodes are packed side by side with a space allowance for the leads equal to the diode's body volume, which is 0.04×1^{-3} cu in.

For more information on these diodes, turn to the Reader-Service Card and circle number **101**.

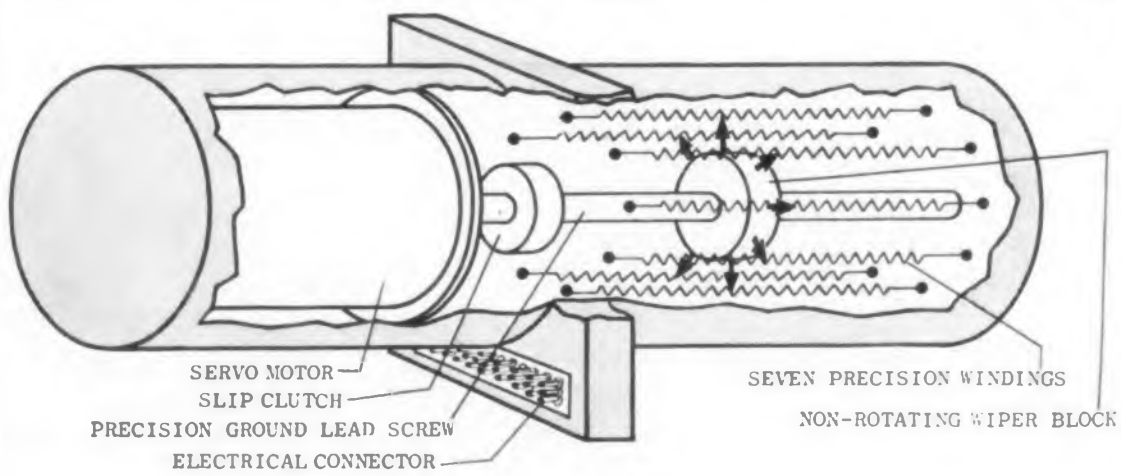
Avoid Gear Reduction with Se

Standard gear trains can be omitted between servo motor and precision ground leadscrew of this multi output servo driven potentiometer, saving space and weight.

HIGH GEAR RATIOS and good precision can be obtained by using only the leadscrew of a new multi-output servo-driven potentiometer. No gear train is necessary. With straight-line resistance windings instead of the conventional rotary windings, the seven-gang pot provides a high accuracy network package in a small cross section.

Manufactured by Bourns, Inc., P.O. Box 2112, Riverside, Calif., the Model 801 is used, typically, to provide servo-controlled attenuation of gain with altitude for missile controls. With seven gangs, simultaneous control, feedback and telemetry signals can be provided.

A typical special function would require six outputs with 20 db attenuation, plus one output with 40 db attenuation.



Straight-line resistance elements permit good linearity, accuracy, reduce potentiometer diameter.

th Servo Driven Pot

Attenuation is provided as a change in resistance with a ±0.5 db conformity.

In operation, a servo motor's input function is converted to linear motion through the pot's precision ground leadscrew, which can, if desired, accommodate various gear ratios. As the leadscrew is turned, it pushes a set of contacts ahead of it along the length of straight resistance windings. A slip clutch is provided to be sure that overtravel will not damage the unit and will, in turn, stall the motor at the range extremities without allowing it to continue free running.

Supported by Class 5 bearings, the precision-ground leadscrew permits low breakout voltage for servo motor inputs.

Linearity is an independent ±0.1 to ±0.25 per cent. In the past such linearity has been common only to large diameter potentiometers.

Resistance available in the Model 801 ranges between 1 K and 100 K, with 1.5 w per element power rating. Torque required is 0.15 oz-in. variable with turns ratio. There is no back-lash. Resolution is 0.03 to 0.2 per cent.

The 801 is rated at two million traversals life. It is filled with dry nitrogen and hermetically sealed; meets MIL-E-5272A requirements for humidity, salt spray, sand and dust and fungus. Temperature range of operation is −40 to +165 F and shock rating is 60 g in 11 msec.

For further information on this servo-driven multi-output potentiometer turn to the Reader-Service card and circle 102.

Count Individual Electrons with High Z Voltmeter

Precision voltmeter has input impedance higher than free space surrounding instrument. Mercury cells for powering isolated amplifiers can be seen through door and shields.

SIXTY ELECTRONS per second can be sensed by a new precision voltmeter which measures from one to 250 v. Input impedance is 10^{17} ohms —greater than the impedance of the free space surrounding the instrument, greater than the teflon insulating the input terminal contacts.

Output impedance, however, is much less than ten ohms, perhaps as low as 0.2 ohm. Manufactured by Halex, Inc., 310 E. Imperial Highway, El Segundo, Calif., the Model 301E voltmeter is a precision follower suitable for driving test equipment and control devices, external oscilloscopes, low voltage meters, servo systems and the normally-highly accurate, but relatively low impedance, digital voltmeters.

Voltage-following accuracy of the instrument is 0.02 per cent with the low impedance output terminal. It is the same or better with the high impedance ($5{\cdot}10^{5}$ ohms) output jack. Input signal can be low frequency ac or dc up to 250 v, of either polarity—500 v peak-to-peak ac. The meter is calibrated to two per cent full scale, and overall accuracy is held to two per cent. The meter is protected from overvoltage of either polarity by a Zener diode and registers the actual voltage at the 301E output terminal. It has 11 ranges.

Grid current is adjustable to 10^{-18} amp or less; the output/input following ratio is 0.9998 at the low impedance terminal. Zero drift is adjustable from the front panel.

Operating on a new principle of "relativistic coupling" (see below), the voltmeter's first ampli-

How It Works— No Feedback in Output-Ground Connections

RELATIVISTIC coupling is what Donald Dimon, consultant to Halex, Inc., calls his approach to electronic design. He says it's the "connecting of active systems into another, more complex system wherein the relations existing in each component system are undisturbed."

In analog circuitry, for example, very few ground connections are used. Instead, moving reference planes serve as grounds for each internal system.

Relativistic coupling, a powerful analysis and synthesis tool, paid off in the design of Halex's precision voltmeter. Let's see how it works.

A block diagram of the voltmeter is shown in Fig. 1. Three precision unity gain amplifiers are surrounded by three distinct shields. Ground for the innermost amplifiers is the shield for the succeeding amplifier.

Approximate electrical properties of the three amplifiers are given in the Table. Note the input impedance of the first precision unity gain amplifier—10^{14} ohms. But the overall properties of the entire system include an input resistance of $5{\cdot}10^{17}$ ohms. Input capacitance is $2{\cdot}10^{-3}$ μμf; voltage gain on the low jack is 0.9996, high jack 0.99999; output impedance of the low jack 10 ohms (or less), high jack $5{\cdot}10^{5}$ ohms.

How is the input impedance of the first

Unbuttoned, precision voltme shows nesting of relative-coupled a plifiers. Note concentric input jack.

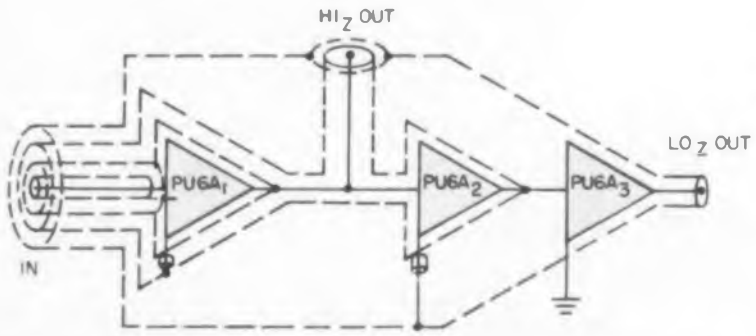


Fig. 1. Block diagram of precision voltmeter, showing relativistic shielding.

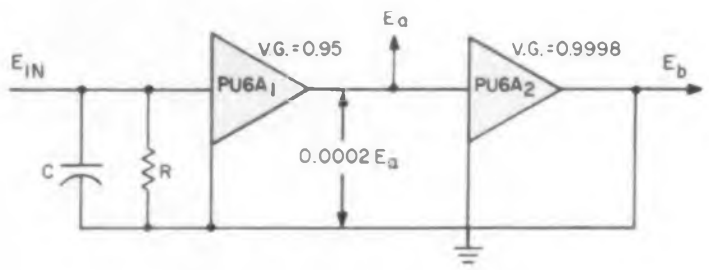


Fig. 2. To raise effective input impedance of first amplifier (*PUGA*$_1$), circuit is connected like this. Note the voltage between the output of *PUGA*$_2$ and the output of *PUGA*$_1$ is only 0.0002 E_a.

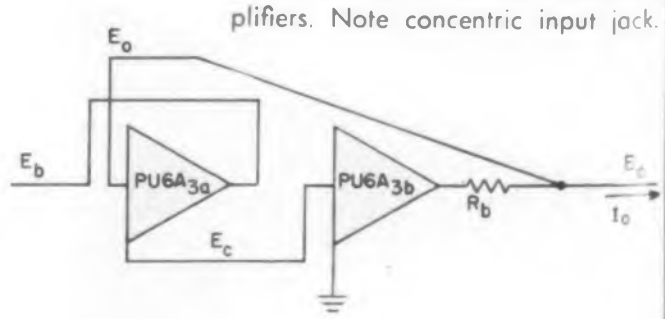


Fig. 3. The third precision unity gain amplifier in t package is made up of two amplifiers, connected shown. Output impedance is less than ten ohms.

is isolated, self-powered, shielded by its own ground and independent of the rest of the system. This separate amplifier has an input impedance of 10^{14} ohms, as is commonly available with electrometer amplifiers; and is arranged as a voltage follower having a gain of 0.95, an output impedance of about 100 ohms. This amplifier floats on the output of another complete precision unity gain amplifier (voltage gain: 0.9998), which has an input impedance of 50 meg, output impedance of 100 ohms.

The second amplifier's output becomes the relative ground plane for the first amplifier and is also connected to the input of a third amplifier, which has an output impedance of less than 10 ohms.

The Halex Model 301E is 10 x 7 x 4 in. in size, has a large number of accessories for high-precision integrating, low impedance circuit voltage measurements, high voltage measurements, use as a regulated power supply, precision current source, micromicroammeter (actually giving an analog presentation of electron counting) or as a micromicrocoulombmeter.

For further information on this precision high impedance voltmeter, turn to the Reader-Service Card and circle **103.**

amplifier, $PUGA_1$, effectively raised? See Fig. 2. For the purpose of the input impedance is considered to be separate and external to the amplifier; and is made up of R and C in parallel.

But the overall input impedance is seen by an external source to be E_{in}/I_{in} of the system. In the case of Fig. 2, E_{in} is essentially the same as E_a and E_b since the amplifiers are followers; but I_{in} is substantially reduced because the voltage across R and C is 0.0002 E_a/0.95—approximately one five-thousandth of the total input signal voltage. The new input impedance is then about $5000 \cdot R$, and C 5000: $5 \cdot 10^{17}$ ohms and 0.002 μμf.

Voltage Follows Accurately

The input voltage needed to support a signal of E_a and the E_a terminal (the voltmeter's high accuracy terminal) is the sum

Electrical Characteristics of Precision Unity Gain Amplifiers in High Impedance Voltmeter

	$PUGA_1$	$PUGA_2$	$PUGA_3$
Input R	10^{14} ohms	$5 \cdot 10^{7}$ ohms	$5 \cdot 10^{5}$ ohms
Input C	10 μμf	20 μμf	20 μμf
Volt Gain Dc	0.95	0.9998	0.9998
Output Z	100 ohms	100 ohms	10 ohms

How It Works *(Cont.)*

of the voltage across the input and common of $PUGA_1$ plus the output voltage of $PUGA_2$. The two voltages are 0.00021 E_o and 0.9998 E_o, a total of 1.00001 E_o. The ratio of output to input is therefore $E_o/1.00001\ E_o$: 0.99999.

Low output impedance for the instrument is obtained by connecting two separate amplifiers as one, as in Fig. 3. The two amplifiers, $PUGA_{3a}$ and $PUGA_{3b}$ each have an input impedance of $5 \cdot 10^5$ ohms, voltage gains of 0.99 and 0.98 respectively and 100 ohms and one K (R_b of Fig. 3). R_b is brought out externally for analysis; it is the output impedance of $PUGA_{3b}$.

The voltage E_c is about 1.02 ($E_o + I_oR_b$) since the gain of $PUGA_{3b}$ is 0.98. The signal into $PUGA_{3b}$ is ($E_o - E_c$), which is $-0.02\ E_o - 1.02\ I_oR_b$. The output of $PUGA_{3b}$ is 0.99 of the input signal. Suitable derivation shows E_b equal to $1.0002\ E_o + 0.0102\ I_oR_b$.

Since output impedance is the relative change in output voltage with a change in output current, $Z_o = E_o/I_o$, which equals $0.0102\ R_b$—about 10 ohms. The voltage following accuracy is 1/1.0002, or 0.9998 unloaded.

In practice, the Halex 301E's final stage circuit is not identical to the one in Fig. 3, though the principle is the same; and the true output impedance appears to be about 0.2 ohms. To be safe, the company calls it "less than ten ohms."

The voltmeter is so sensitive that cur-

Plugboard Logic Computer

Logic rewiring is done quickly and easily by changing interconnections on plugboard. Ordinarily board is removed from machine, but due to low voltages (16 v max) it is safe to rewire while computer is operating.

DESIGNED for designers, a small digital computer gives the engineer an opportunity to test out computer logic designs with maximum ease. Boolean equations can be realized by wiring up a plugboard, slipping the board into the computer and turning the "on" switch. If the logic design proves faulty no breadboarding time or component expense is lost. The computer cannot be damaged by miswiring the plugboard.

Manufactured by Computer Control Co., Inc., 2251 Barry Ave., Los Angeles 64, Calif., the SPEC (Stored Program Educational Computer) Mark III is so organized as to permit its use as a general purpose computer or as a digital differential analyzer. Prewired A-MP, Inc., plugboards are used to interconnect the same logical elements in different ways—"rewiring" of the internal logic, rather than simple program insertion.

SPEC contains the basic features of larger computers—adders, counters, comparison circuits, operation code and memory selection matrices, memory storage and one mc clocking. It is designed to simulate a big machine on a small (about $25,000) scale.

As a DDA (with a prewired plugboard supplied by the manufacturers) the computer contains 20 integrators with a maximum word length of 20 bits. Maximum accuracy is one part in 524,000, iteratio

rent flow along a glass rod can easily be measured. Mr. Dimon demonstrated this set up. He attached a 100-v source to both ends of a 4-in. long, 1/8-in. diam glass rod, grounded one end. The 301E was grounded at one end and a stiff metal wire inserted in the input jack. By touching the wire to the glass rod and moving it along its length, the meter was made to vary between zero and 100 v. Nothing but the conductance of the glass and surface leakage served to pass the current.

By using the short length of wire as an antenna, the potential difference between the meter and a glass rod rubbed with a piece of silk registered from three or four feet away. The meter needle faithfully followed the motion of the rod as it was moved from the voltmeter.

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rate 2380 iterations per sec per integrator. Interconnections are set up by the inserted stored program. Any integrator output may be used as an independent variable input; and any three integrator outputs may be summed into each integrator output.

The octal keyboard is used to program information and to set up scaling and initial conditions for the integrators. Digital to analog conversion of outputs from any two integrators is provided so outputs can be displayed on a scope or x-y plotter.

SPEC's magnetostrictive memory is a plug-in package consisting of three sections: driver circuit, nickel-iron magnetostrictive delay line and amplifier circuit. Each unit will store 32 words in a circulating loop at a one mc pulse repetition rate. Total capacity per circulating line is 416 bits.

For logic design, the engineer can wire an empty plugboard in any way he wants, with perfect assurance that even if his equations are wrong no damage to the machine will result. Due to all-transistor circuitry, there are no voltages higher than 16 v in the unit. The computer should prove valuable for teaching engineers logical design and implementing the designs of more experienced designers.

For further information on this plugboard computer turn to the Reader-Service Card and circle **104.**

NEW PRODUCTS

Covering all new products that might generally be specified by an electronics engineer engaged in the design of original equipment.

Bandpass Filters Cover 300 to 100 Mc Range

Operating in the frequency range of 300 to 1000 mc, the HFF(C) series of bandpass filters are designed and packaged to operate under military environmental conditions. The filters operate from a 50-ohm and into a 50-ohm impedance and have a selectivity ratio of less than 3 to 1. Typical of the units is one for operation at 332 mc with a 3 db bandwidth of 24 mc. It weighs 20 oz. Dimensions of the case are 5-1/8 x 1-11/16 x 3-1/4 in. Packaging of the units can be tailored to customer requirements.

Applied Research Inc., Dept. ED, 76 S. Bayles Ave., Port Washington, N. Y.

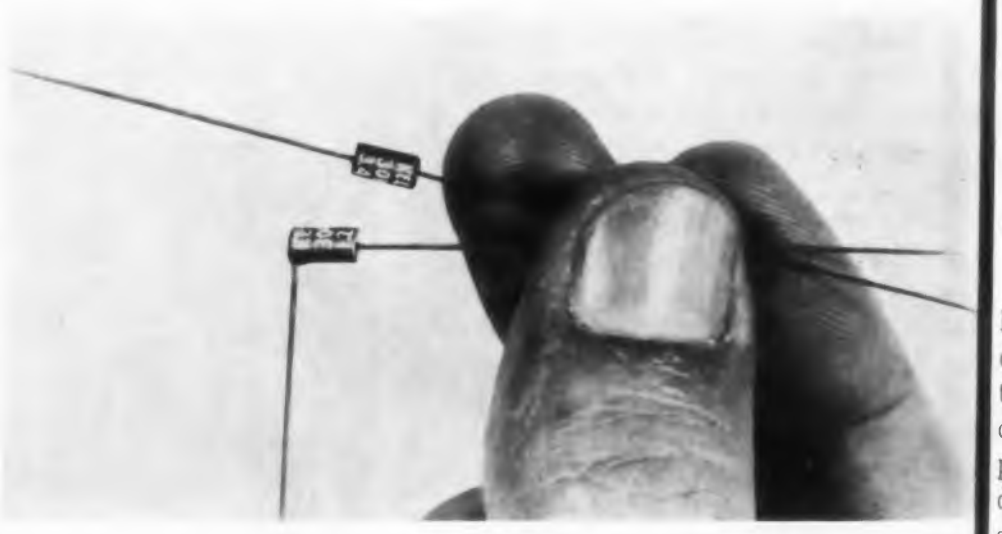
CIRCLE 67 ON READER-SERVICE CARD

Analog Computer Solves Seventh Order Differential Equations

The model 3500, 23-lb analog computer can be used to study almost any physical system that can be described by linear differential equations. The 10-amplifier unit will solve up to a seventh order differential equation or a ninth degree Laplace transform. It performs accurately with 1% or 0.1% computing components. It measures 5.25 x 19 x 10.25 in. and the problem board tilts up for rack mounting. For solving complex problems, up to three units can be slaved together for 10, 20 or 30 amplifier operation.

Donner Scientific Co., Dept. ED, Concord, Calif.

CIRCLE 68 ON READER-SERVICE CARD



Noninductive Wirewound Resistors Measure 1/8 x 1/4 in.

Type 301-P precision, noninductive wirewound resistors measure 1/8 x 1/4 in. long, with axial or axial/radial leads. They are encapsulated to withstand humidity, mechanical shock and a temperature range of −65 to +125 C. Their temperature coefficient is ±0.002% per deg C; wattage rating is 0.1 w. The units come with resistance ratings of 10 ohms min to 100 K max.

Kelvin Electric Co., Dept. ED, 5907 Noble Ave., Van Nuys, Calif.

CIRCLE 69 ON READER-SERVICE CARD

Relay Magnetic Preamplifier Has Power Gains Above 100,000

This relay magnetic preamplifier, model 761, gives power gains of more than 100,000 in a single stage. It delivers 0.3 w from dc control signals of less than 3 μw. It permits driving small power relays from thermistor bridges, photocells, null detectors, and similar low energy dc signals. The unit requires 0.6 w of 26 v, 60 cps supply power. It can be used in both industrial and military applications.

Acromag, Inc., Dept. ED, 22519 Telegraph Rd., Southfield (Detroit), Mich.

CIRCLE 70 ON READER-SERVICE CARD

Analog To Digital Converters Accommodate Any DC Input

Designed for both airborne and ground support data systems, the SBI-401 series of analog to digital converters uses self-balancing potentiometer circuitry. They can accommodate any dc signal input and can thus be used with pressure transducers, strain gages, accelerometers, thermocouples and any other transducer that represents a variable as a dc voltage. Standard units are normally supplied with brush type encoders, but they are also available with magnetic or optical encoding assemblies. They measure 7 x 3 in. in their basic configuration and provide a full scale sensitivity of 10 mv and a response time, also for full scale, of 2 sec. Shaft angle accuracy is ±0.5%. They operate from 115 v, 400 cps power.

North Atlantic Industries, Inc., Instrumentation Div., Dept. ED, 603 Main St., Westbury, N. Y.

CIRCLE 71 ON READER-SERVICE CARD

NEW PRODUCTS

Insulation Testers

With audible signals

These insulation breakdown testers have audible signals which sound at preset leakage current values. The units have an ac test potential up to 6000 v. Series 4003 testers have visual as well as audible leakage indicators and have a standard adjustment range from 300 μa to 300 ma; ranges extending to 10 ma are available on special order.

Associated Research Inc., Dept. ED, 3777 W. Belmont Ave., Chicago 18, Ill.

CIRCLE 74 ON READER-SERVICE CARD

Temperature Potentiometers

Error is ±0.2% of range

Having an error limit of ±0.2% of range span, these portable temperature potentiometers have 20 temperature ranges and four millivolt ranges which are all interchangeable. Both provide an output in millivolts equivalent to the temperature setting of the instrument for use in checking similar potentiometers, recorders, and controllers. The maximum external resistance is 50 ohms. Type 8692 single-range unit is calibrated for one type of thermocouple for temperature measurements or for millivolt measurements using one of the four ranges. Double range type 8693, shown here, can be supplied with one or different types of ranges for the same thermocouples. One range can measure temperature and the other, millivolts.

Leeds and Northrup Co., Dept. ED, 4932 Stenton Ave., Philadelphia, Pa.

CIRCLE 75 ON READER-SERVICE CARD

DC Power Supply

Total output is 5.8 kw

Able to furnish 17 different closely regulated and unregulated levels of power for all types of electrical data processing and computing machines, this transistorized power supply has a total output of 5.8 kw. A built-in transistor test circuit allows for quick detection of failure of any of the 200 power transistors without shutting down the supply. The complete unit weighs 1490 lb, measures 5 x 5 x 1-3/4 ft, and consists of 17 easily replaced plug-in components. It is made for military as well as commercial use.

Bogue Electric Mfg. Co., Dept. ED, 52 Iowa Ave., Patterson 3, N.J.

CIRCLE 77 ON READER-SERVICE CARD

Broadband Rotating Joints

Cover the range of 2.6 to 40 kmc

These broadband rotating joints cover the range of 2.6 to 40 kmc with a minimum vswr. The joints can be pressure sealed to 30 psi. The design allows for continuous rotation in either direction with negligible rotational variation. Units are suitable for fast or slow operation through small angles or for continuous rotation. Mechanical stability is provided by means of double ball-bearing mountings; bearings are isolated from rf. Four configurations can be supplied. All combinations of 90 deg and colinear arms are available, both on the fixed and movable side.

DeMornay-Bonardi, Dept. ED, 780 S. Arroyo Parkway, Pasadena, Calif.

CIRCLE 78 ON READER-SERVICE CARD

CIRCLE 79 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Variable Attenuator

Adjustable range is 0 to 40 db

Having an adjustable range of 0 to 40 db, model RDA-5811 variable attenuator is furnished in a waveguide measuring 2 x 1 in. Attenuation is accurate to 0.3 db at 4.8 kmc calibration frequency. The unit incorporates an anti-backlash gear train for holding original calibration over long periods of time. The insertion loss is 0.5 db and the maximum vswr is 1.15. All moving parts are housed in a sealed casting.

Radar Design Corp., Dept. ED, Picard Dr., Syracuse 11, N.Y.

CIRCLE 81 ON READER-SERVICE CARD

Transformer

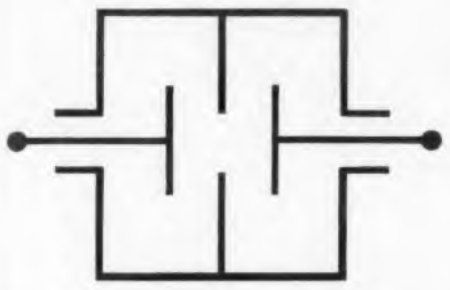
Handles 235 w

Series 882 Thin-Tran transformer handles 235 w, mounts in an area measuring 1-29/64 x 2-29/64 x 3 in., and operates over the ambient temperature range of −55 to +100 C. Primary voltage on the standard unit is 115 v 400 cps; secondary voltages are available from 5 to 2000 cps. The terminals are arranged in rows of five pins: one for primary, three for secondaries, and one for use as a center tap on secondary windings. Regulation is 5% max, no load to full load. The unit weighs 1.44 lb and provides a power-to-weight ratio of 155 w per lb. Life expectancy is 10,000 hr. Fully encapsulated and hermetically sealed in a steel container, the transformer meets MIL-E-5272B and MIL-T-27A, class S.

Arnold Magnetics Corp., Dept. ED, 4613 W. Jefferson Blvd., Los Angeles, Calif.

CIRCLE 82 ON READER-SERVICE CARD

MATCH WITS
with the
CRANKY CAPACITOR!



As soon as you're through the door at the NEREM show, grab a sharp pencil and head for Booth 928. You can win yourself a Wayne Kerr B-521 Component Bridge (3-terminal), and a reputation as the sharpest electronic wizard in the place.

All you have to do is estimate the magnitude of a 3-terminal capacitor set up in the Wayne Kerr booth. As per the schematic above, the device is made up of two circular discs, separated by a rectangular metal neutral plate. A circular hole is cut out of the center of the plate.

Capacitance is determined entirely by the aperture. Magnitude is established by the area of the opening and the spacing between the two active discs. In short, you'll be working with a direct application of the 3-terminal capacitor principle.

The challenge is to see how close you can come to the actual magnitude, as measured by the Wayne Kerr B-221 Universal Bridge (3-terminal, accurate to 0.1%).

NEREM show opens Tuesday, November 17 at 1 P.M. and closes the 19th at 6 P.M. Be there, at the Commonwealth Armory in Boston, Booth 928, and may the best man win. We hope it's you.

OTHER INSTRUMENTS: Audio to VHF Bridges; Oscillators; Attenuators; Microwave Equipment; Vibration and Distance Meters; Waveform Analyzer.

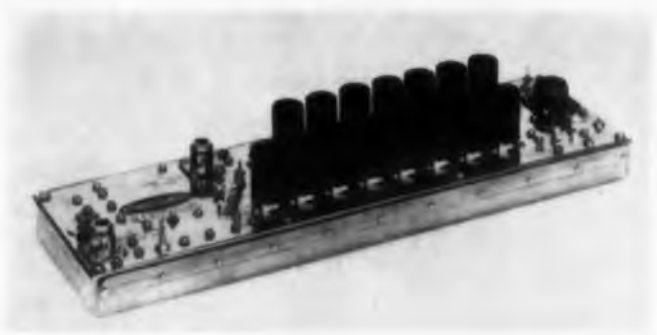
Send for complete W-K-02 catalog showing other instruments.

WAYNE KERR
CORPORATION
1633 Race St., Philadelphia 3, Pa.

Electronics for Measurement and Control
Sales, Stock and Service Facilities

CIRCLE 84 ON READER-SERVICE CARD

Amplifiers
For broadband use



Available in three standard models, these broadband amplifiers operate at impedance levels which permit convenient cascading of several amplifiers with standard 93-ohm interconnecting cables. Model 2220 has a voltage gain of 20 db; model 2230, shown here, has a 1-w power output. Both have a band pass of 100 kc to 300 mc with a 93-ohm input and output impedance. Model 2210 has a noise figure of 6 db over the same bandwidth. They can be furnished as separate units or rack mounted with integral power supplies. Modifications of the standard models can be supplied to cover different bandpass and gain requirements. Distributed and wideband amplifiers to meet Mil specs are also available.

RS Electronics Corp., Dept. ED, P. O. Box 368, Station A, Palo Alto, Calif.

CIRCLE 85 ON READER-SERVICE CARD

DC Null Detector
Input impedance is 40,000 ohms

For use with guarded and unguarded potentiometers and bridges in production testing and laboratory applications, type 9834 dc null detector has an input impedance of 40,000 ohms and will provide high sensitivities with source resistances up to 100,000 ohms. It has four degrees of sensitivity over the range of 1000 to 1 and has a noise level of less than ±0.1 mv. It is housed in a metal case with vinyl finish and carrying handle. Panel mounting models are also available.

Leeds and Northrup Co., Dept. ED, 4934 Stenton Ave., Philadelphia, Pa.

CIRCLE 86 ON READER-SERVICE CARD

Not a worry | in the world...

THIS IS ONE SNAP-IN CONTACT THAT WON'T PULL OUT!

...the Deutsch snap-in contact, of course – guaranteed to withstand 25 pounds pull. In Deutsch DS miniature connectors, each pin and socket is locked in place by an exclusive, patented spring mechanism.

WHAT'S MORE...Deutsch-designed tools whip the problem of fast, reliable crimping (hand or automatic) – insertion and removal.

And...just glance at these specs:

- Deutsch-designed crimp, stronger than the wire itself (AN #18 wire and smaller)
- 7 shell sizes, with alternate clocking and insert arrangements
- exclusive Deutsch ball-lock coupling
- superior interfacial seal
- silicone inserts; no shrinkage, bonding or reversion
- temperature range –67° to in excess of 300° F
- seal before electrical contact
- interchangeable with existing Deutsch DM (MS) miniatures and hermetics
- meet all applicable requirements of MIL-C-26482

So why worry? For details on completely reliable snap-in type connectors, contact your local Deutsch representative or write for data file C-11.

The Deutsch Company
ELECTRONIC COMPONENTS DIVISION
Municipal Airport • Banning, California

CIRCLE 87 ON READER-SERVICE CARD

NEW PRODUCTS

Transducers

Linear and rotary motion

These linear and rotary motion transducers, called Transipot, have ac input and ac or dc output. Rated for operation to 125 C, they can be used for telemetry, indication, data reduction, and as transmitters or receivers for detecting any combination of linear or rotary motion as part of a feedback control system. The specifications for a typical unit, the size 15 linear motion ac-ac transducer, include: input range, 20, 50, or 100 mils; sensitivity, 1 v rms per mil; input linearity, 0.5%; and frequency range, 300 to 3000 cps. All units are brushless and use modular construction with a standard servo-mounting.

Arnoux Corp., Dept. ED, 11924 W. Washington Blvd., Los Angeles 66, Calif.

CIRCLE 89 ON READER-SERVICE CARD

Turn Indicating Dials

For use with potentiometers

These ten-turn indicating dials provide readings of potentiometer full turns. The turn number stays in view while the dial registers partial turns in increments of 1/100. No gearing mechanisms are used and no disassembly or panel holes are required for mounting. Model 10 is a 1-in. unit and model 20 is 1-13/16 in. to fit 0.25 in. diam shafts. For 0.125-in. shafts, an adapter bushing can be supplied.

Spectrol Electronics Corp., Dept. ED, 1704 S. Del Mar Ave., San Gabriel, Calif.

CIRCLE 90 ON READER-SERVICE CARD

Volt Potentiometer

Ranges are 0 to 1.601 v and 0 to 0.1601 v

Type 8687 portable volt potentiometer has two operating ranges: 0 to 1.601 v and 0 to 0.1601 v. The instrument has limits of error of ±0.05% -|- 30 μv for the high range and ±0.05% + 3 μv for the low range. Typical laboratory applications of this compact, three-dial potentiometer include measurements of temperature, contact potentials, plus calibration of dc ammeters, voltmeters, and other instruments. In industrial use, it can calibrate thermal converters, and strain gages. It is housed in a metal case with a removable lid.

Leeds and Northrup Co., Dept. ED, 4934 Stenton Ave., Philadelphia, Pa.

CIRCLE 92 ON READER-SERVICE CARD

Tape Reader Set

Is 5-7/8 x 7-1/2 x 9-1/2 in.

Including transmitter-distributor, motor, base, and cover, model 28 LXD punched-tape reader set measures 5-7/8 x 7-1/2 x 9-1/2 in. It provides for sequential output and 100 words per min transmission. Optional contacts are available for multi-wire output. Models are furnished to read five or six-level chadless or fully perforated tape. Applications include on-line data transmission over existing communications facilities and off-line control of tape-operated machines.

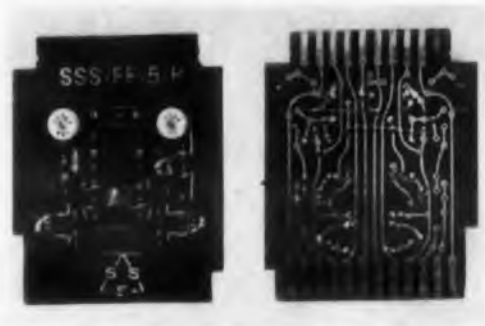
Teletype Corp., Dept. ED, 4100 Fullerton Ave., Chicago 39, Ill.

CIRCLE 93 ON READER-SERVICE CARD

NEW PRODUCTS

Control and Logic Modules

Plug-in design



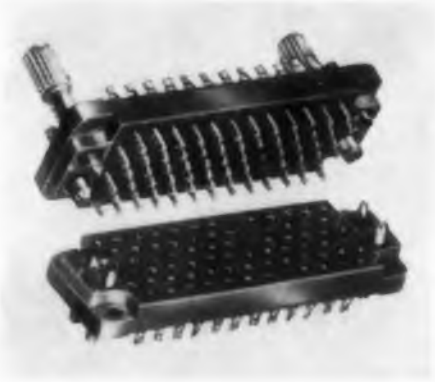
These transistorized, plug-in control and logic modules can be checked in place, without disturbing the normal operation of the circuit. Included in this line of compatible modules are flip-flops, gates, triggers, diode AND and OR logic units, power switching amplifiers, and devices for implementation of static control or computer systems accepting pulse repetition to 100,000 pulses per sec. The modules are 2-1/4 x 2-29/32 x 1/16 in. and fit 2 standard 12-terminal printed circuit connectors. All printed circuit conductors are hard gold alloy plated.

Solid State Systems, Inc., Dept. ED, 5716 Camille Ave., Culver City, Calif.

CIRCLE 97 ON READER-SERVICE CARD

Connectors

Have 20 and 75 contacts



For aircraft and instrumentation applications these 29 and 75-contact units have reversed guides or polarizing screwlocks. They have a current rating of 5 amp. Voltage breakdown at sea level is 1900 v rms and at 60,000 ft, 700 v rms. The minimum creepage path between contacts is 5/64 in. and the minimum air space between contacts is 3/64 in. Contacts measure 1/8 in. center-to-center, the pin diameter is 0.04 in., and the solder cup fits a No. 20 awg wire.

DeJur-Amsco Corp., Dept., ED, 45-01 Northern Blvd., Long Island City 1, N.Y.

CIRCLE 98 ON READER-SERVICE CARD

Wirewound Resistors

Temperature coefficient is ±20 ppm

Available in five styles, these miniature wirewound resistors have a standard temperature coefficient of ±20 ppm. They can be as small as 0.08 in. in diam and 0.375 in. long. The wattage rating starts at 0.05 w to 0.25 w at 125 C and is derated to zero at 150 C with accuracies to 0.025%. Designed to meet MIL-R-93B and MIL-R-9444, they can have axial wire terminals or dual wire terminals for printed circuit use. The units are encapsulated in epoxy.

Cinema Engineering Div., Dept. ED, 1100 Chestnut St., Burbank, Calif.

CIRCLE 108 ON READER-SERVICE CARD

Computer Diode

Recovery time is 4 mμsec max

These silicon mesa computer diodes have a maximum recovery time of 4 mμsec when switched from a forward bias with 10 ma current to a reverse bias of −5 v. Types 1N903, 1N904, and 1N905 have peak reverse voltage ratings at 25 C and 1 μa or at 100 c and 10 μa of 20, 30, and 40 v, respectively. The capacitance for all three types is 1 μμf and the forward voltage drop at 25 C and 10 ma is 1.1 v for type 1N903 and 1 v for 1N904 and 1N905. Also available, types 1N906, 1N907, and 1N908 have peak reverse voltages of 20, 30, and 40 v, respectively, a capacitance of 2.5 μμf, and a forward voltage drop of 1 v.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.

CIRCLE 109 ON READER-SERVICE CARD

CIRCLE 110 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Meter Relay

Accuracy is ±0.15% deviation

Designed to monitor per-cent deviation of voltages within predetermined limits over the range of 5 to 500 v, this meter relay has an accuracy of ±0.15% deviation at room temperature. Center scale voltage values may be programmed by switching external resistors. Contact closure will occur when the per-cent deviation of the programmed voltage exceeds the predetermined limits set on the movable contacts. Both ac and dc versions are available. Military units offer ±0.3% deviation accuracy from −55 to +71 C and meet vibration, shock, and humidity requirements of MIL-M-10304A. The ac meter relays maintain accuracy over the frequency range of 50 to 2000 cps. The relay contacts will give up to 10,000,000 make and break cycles without failure, and may be used to control corrective devices.

Voltron Products, Dept. ED, 1010 Mission St., S. Pasadena, Calif.

CIRCLE 111 ON READER-SERVICE CARD

Ultrasonic Cleaners

Efficiency is 90%

These ultrasonic cleaners have an efficiency rating of 90%. Cleaning power is increased by means of the transducer which consists of piezo-electric ceramic material compressed between two solid metal sections. Model DR 252 generator with the T3 tank provides an average output power of 250 w and a tank capacity of 3 gal, model DR 520 generator with the T5 tank provides an average output power of 500 w and a tank capacity of 5

◀ CIRCLE 112 ON READER-SERVICE CARD

gal, and model DR 1020 generator with the T10 tank provides 1000 w and a tank capacity of 10 gal. All models operate at 20 kc. They are used to clean gyros, differentials, relays, semiconductors, vacuum tube components, printed circuit boards, and other products.

Acoustica Associates, Inc., Dept. ED, Fairchild Court, Plainview, L.I., N.Y.

CIRCLE 113 ON READER-SERVICE CARD

Toroid Inductors

Inductances are 0.01 mh to 4 h

Series M50 toroid inductors provide a high Q from 1 kc to 2 mc with inductances from 0.01 mh to 4 h. They have printed circuit mountings and measure 43/64 in. OD and 13/32 in. high. The units are housed in metal cases.

Torotel, Inc., Dept. ED, 5512 E. 110th St., Kansas City, Mo.

CIRCLE 114 ON READER-SERVICE CARD

Drive Unit

Dual Speed

Type DSD-2 dual speed drive unit is a gear reducer for positioning and indicating with an accuracy of 6 min of arc or better. It has an inner dial for coarse positioning, an outer dial for fine positioning, plus in-line input and output shafts. Having no backlash, units are available with ratios to 72:1. A vernier is available for the ratios 20:1 and 36:1. A modified version, type DSD-3, has an accuracy of 12 min of arc. The units pass Air Force requirements of MIL-E-4970, a high temperature test at +200 F, a low temperature test at −80 F, and shock tests at 100 g.

Acton Labs, Inc., Dept. ED, 533 Main St., Acton, Mass.

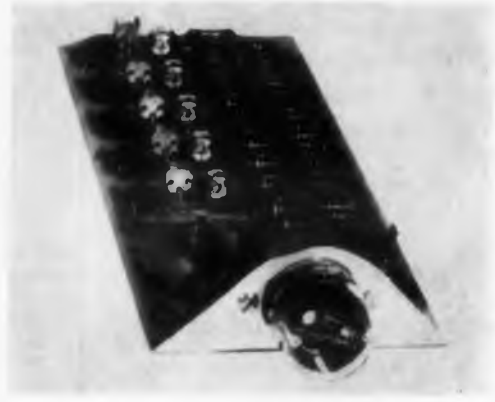
CIRCLE 115 ON READER-SERVICE CARD

CIRCLE 116 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Binary-to-Decimal Converter

For use with computers



Model 260 binary-to-decimal converter is for use with computers which require decimal display readout for any number of four-bit code inputs. Solid state techniques are used for conversion and memory functions. The converter activates a cold-cathode decimal display equal to a Nixie tube. The unit is available as a single plug-in module complete with illuminated display or as an assembly of a number of modules for rack mounting.

Hermes Electronics Co., Dept. ED, 75 Cambridge Parkway, Cambridge 42, Mass.

CIRCLE 118 ON READER-SERVICE CARD

Ultrasonic Cleaner

Tank is 9-1/4 x 5 x 6 in.

Model 100 ultrasonic cleaner has a tank measuring 9-1/4 x 5 x 6 in. with 25% of the tank bottom covered with driving elements. The radiating surface measures 12 sq. in. Made of heavy-gage stainless steel, the tank has rounded corners. A 115-v ac, 60-cps, single-phase generator, designed for continuous operation, delivers an average output of 60 w and a peak output of 240 w. The unit includes a one-tube oscillator, front panel switching which permits a choice of two transducers and three-wire ground protection.

National Ultrasonic Corp., Dept. ED, 111 Montgomery Ave., Irvington, N.J.

CIRCLE 119 ON READER-SERVICE CARD

Tee Circulator

Insertion loss is 0.4 db

Model CX400 three-port tee circulator has 15 db isolation and 0.4 db insertion loss over the frequency range of 9.1 to 9.9 kmc. In the band center the insertion loss is about 0.1 db. The unit is rated at 1 kw peak and 100 w avg. The temperature range is −55 to +71 C. The circulator is 3.1 in. long, weighs 3/4 lb, and is useful for maser and parametric amplifier applications.

Rantec Corp., Dept. ED, Calabasas, Calif.

CIRCLE 120 ON READER-SERVICE CARD

Complex Ratio Bridge

For in-phase and quadrature voltage ratios

This complex ratio bridge measures both in-phase and quadrature voltage ratios. The unit is used to test three- and four-terminal networks such as transformers, synchros, resolvers, gyros, and transducers. The instrument cancels quadrature effects and the bridge has an in-phase accuracy of 0.001%. Quadrature voltage ratios are read as rectangular coordinates, tangent of phase-shift angle, or magnitude of phase-shift angle, directly in degrees. A self-contained phase-sensitive detector provides good sensitivity with 2-v reference. Harmonics and noise are rejected by a band-pass filter. The magnitude of the transformation ratios of R + jX voltages are readable to six places. The bridge is available with a frequency range of 30 to 1000 cps or 50 to 3000 cps and in rack-mounting or cabinet models.

Gertsch Products, Inc., Dept. ED, 3211 S. La Cienega Blvd., Los Angeles 16, Calif.

CIRCLE 121 ON READER-SERVICE CARD

Distributed constant delay lines • Lumped-constant delay lines • Variable delay networks • Continuously variable delay lines • Pushbutton decade delay lines • Shift registers •

ESC EXTRA

Pulse transformers • Medium and low-power transformers • Filters of all types • Pulse-forming networks • Miniature plug-in encapsulated circuit assemblies

ESC DEVELOPS DELAY LINE WITH 170 to 1 DELAY TIME/RISE TIME RATIO

Model 61-34 Perfected For Specialized Communications Application

PALISADES PARK, N. J.—An entirely new Lumped-Constant Delay Line, with a proven 170 to 1 delay time/rise time ratio, has been announced by the ESC Corporation, Palisades Park, N. J. The new delay line, known as Model 61-34, was specifically designed for a specialized communications application calling for the exceptionally high delay time/rise time ratio.

ESC, the world's leading manufacturer of custom built and stock delay lines, is already widely recognized in the electronics industry for its exceptional engineering advances. In October, 1958, ESC broke through an existing design barrier and produced a delay line with a 145 to 1 delay time/rise time ratio. It had been thought, prior to the announcement of the Model 61-34, that ESC had reached the ultimate in this type of delay line.

SPECIFICATIONS OF NEW DELAY LINE MODEL 61-34

Delay time/rise time ratio: 170/1
Delay: 200 usec.
Rise time: 1.16 usec.
Attenuation: less than 2 db
Frequency response: 3 db = 325 KC
50 taps with an accuracy of ±0.2 usec. at each tap.

Complete technical data on the new unit can be obtained by writing to

ESC Corporation, 534 Bergen Boulevard, Palisades Park, New Jersey.

CIRCLE 122 ON READER-SERVICE CARD

NEW PRODUCTS

Modular DC Power Supplies

Outputs are 5 to 32 v

These transistorized dc power supply modules, designated models 22-211, 22-213, 22-214, and 22-217, have outputs of 5 to 7, 11 to 14, 14 to 17, and 25 to 32 v, respectively, and up to 6 amp. The input for all units is 105 to 125 v ac, 60 cps. Ripple is less than 2 mv rms, line regulation is 25 mv, and no-load regulation is 15 mv.

Dressen-Barnes Corp., Dept. ED, 250 N. Vinedo Ave., Pasadena, Calif.

CIRCLE 124 ON READER-SERVICE CARD

Current Governor

Line and load regulation is 0.05%

Designed for transistor and semiconductor measurements, type CS-111 current governor has a range of 10 μa to 500 ma from 0 to 200 v dc. Line and load regulation is better than 0.05%. Current is set to five places by decade knobs arranged to provide a digital inline readout. The current may be programmed or modulated by a remote signal. Transistor avalanche and Zener voltage measurements are easily made at controlled current. Dynamic measurements can be made by modulating the current. Other applications include measurement or testing of semiconductors, magnetic components, and other current sensitive devices.

North Hills Electric Co., Inc., Dept. ED, 402 Sagamore Ave., Mineola, N.Y.

CIRCLE 125 ON READER-SERVICE CARD

Metallized Mylar

Has many electronic applications

Metallized mylar, sealed against weather and chemical changes, will not scratch, tarnish, or deteriorate with age.

It is available with or without pressure sensitive adhesive, laminated to other types of materials for such use as heat sealing, or Mylar-vinyl extrusions. With or without embossing, it can be used for nameplates or dials.

Forest City Products, Inc., Dept. ED, Cleveland 15, Ohio.

CIRCLE 138 ON READER-SERVICE CARD

Pressure Switch

Actuating pressure range is 5 to 30 psia

Type RR-58 absolute air pressure switch is available in an actuating pressure range of 5 to 30 psia. It has an accuracy of ±0.5 psi from —85 to +185 F and ±1.5 psi from 185 to 400 F. Difference in pressure between the on and off positions is 2 psi.

The switch can be spst or spdt and is rated at 28 v dc or 110 v ac with 5 amp resistive load. It meets the environmental specifications of MIL-E-5272 including ±20 g shock and 75 to 500 cps at 10 g vibration. It weighs less than 1.8 oz and measures 1-27/32 in. in length and 7/8 in. in diam.

Suited to missile and aircraft applications, the switch can actuate at critical altitudes. It can actuate at critical pressures to prevent arc-over in high voltage equipment and to protect equipment in electronic assemblies.

Newark Controls Co., Dept. ED, 15 Ward St., Bloomfield, N.J.

CIRCLE 137 ON READER-SERVICE CARD

◀ CIRCLE 139 ON READER-SERVICE CARD

547, 548, 549 ON READER-SERVICE CARD ▶

INTERNATIONAL RECTIFIER CORPORATION

RECTIFIER NEWS

644 Zener Diode Types Offer Advantages to Every Voltage Regulator Circuit

As compared to other voltage reference elements, the silicon diode regulator has a longer life expectancy because of its mechanical ruggedness. It does not deteriorate under storage nor age during its operating life. Small size and light weight make its use in airborne or portable equipment especially desirable from many standpoints.

International Rectifier Corporation now offers an extensive line of zener types numbering 644 in seven basic styles. From the miniature type rated at 750 milliwatts to the precision 1N430 reference element types, all are manufactured to meet the most rigid military requirements. *See how these all-welded, hermetically sealed diodes can improve your circuit design. . . .*

CIRCLE 547 ON READER-SERVICE CARD

Miniature Voltage Reference Packs Maintain Voltage Regulation to within ± 0.01%!

REF-PAK MODEL 4RV8
Standard MIL Transformer Case

REF-PAK MODEL RV8-PC
Special Housing for insertion into printed circuit boards.

Designed around the highly stable 1N430 silicon reference element, these miniature reference supplies may be considered to be the solid state equivalent of the standard cell. A high degree of stability is attained by maintaining a precise constant current through the reference element, regardless of temperature or line voltage variations.

Ref-Paks will operate directly from an unregulated power source . . . maintain voltage regulation to within ± 0.01%! Output voltages of either 8.4 or 16.8 volts dc are available in 5 distinct types that allow operation from 28 or 115 volt dc, 400 and 60 cycle power supplies. Temperature coefficient of these devices is ± 0.001%/°C from −55° to +100°C.

For complete details ask for SR-401.

CIRCLE 548 ON READER-SERVICE CARD

ZENIAC Provides a Shortcut to the Application of Silicon Zener Diodes

A flip of the Zeniac selector switch quickly tells you the exact diode required in complex breadboard circuitry. This unique innovation — the first semiconductor substitution box in history — has been designed specifically to aid system design groups by saving valuable lab time in the application of zener diodes.

Two units are available, each housing 11 diodes in voltage steps from 3.9 thru 27 volts. Model A Zeniac is rated at 1-watt; Model B is rated at 10-watts. Both are now in stock at your Authorized Distributor. Ask for details on this time saver . . .

CIRCLE 549 ON READER-SERVICE CARD

Technical Service Provides XY Plot of Reverse Breakdown Characteristics of Each Diode in all Prototype Orders

To eliminate guesswork and tedious testing on your part, every zener diode sent on prototype orders will be accompanied by a specially plotted XY recording of its exact breakdown voltage point! This permanent record can come in mighty handy when it's time to match diodes or reorder to the same specs. This is just one of the many application engineering services we are prepared to extend to you at all times!

Write to the factory for Bulletin SR-250-A, a four page technical article describing the characteristics of zener diodes, how to select them, and application data with circuit schematics.

FOR SAME DAY SERVICE ON PRODUCT INFORMATION DESCRIBED ABOVE, SEND REQUEST ON YOUR COMPANY'S LETTERHEAD

EXECUTIVE OFFICES: EL SEGUNDO, CALIFORNIA • PHONE OREGON 8-6281 • CABLE RECTUSA
BRANCH OFFICES: NEW YORK CITY AREA OFFICE: 132 E. 70th St., TRafalgar 9-3330 • NEW YORK STATE AREA OFFICE: 2366 James St., Syracuse, N.Y., HOward 3-1441 • CHICAGO AREA OFFICE: 205 W. Wacker Dr., FRanklin 2-3888 • NEW ENGLAND AREA OFFICE: 17 Dunster St., Cambridge, Mass., UNiversity 4-6520 • PENNSYLVANIA AREA OFFICE: Suburban Square Bldg., Ardmore, Pa., Midway 9-1428 • MICHIGAN AREA OFFICE: 1799 Coolidge H'way, Berkley, Mich., Lincoln 9-1144 • IN CANADA: International Rectifier of Canada, Ltd., 158 Bank St., Ottawa, Ontario, Regent 3-6880

WORLD'S LARGEST SUPPLIER OF INDUSTRIAL METALLIC RECTIFIERS • SELENIUM • GERMANIUM • SILICON

Radiator Tube Clamp

Weighs 1 oz

For use with type 545, 554, 589, and 6339 external anode, miniature power diodes in air or oil cooled applications, this heat dissipating anode connector weighs 1 oz and occupies 1-1/8 cu in. Made of light weight aluminum, it maintains uniform anode contact to 300 C.

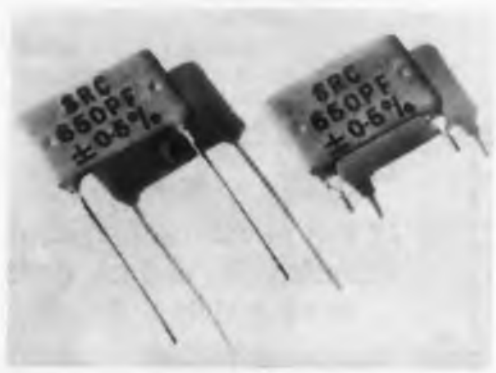
The requirements of MIL-C-5541 are met.

Trought Associates, Inc., Dept. ED, 116 Greylock Ave., Belleville 9, N.J.

CIRCLE 142 ON READER-SERVICE CARD

Capacitors

Range is 2 to 10,000 μμf



Having capacitances from 2 to 10,000 μμf, these cement-insulated silvered mica capacitors are less than 1/8 in. thick. They come in seven sizes and have conventional or printed circuit loads. Lead spacing is in modules of 0.1 in.

Tolerance is ±0.5% to ±10%. Temperature range is −60 to +100 C or to +135 C for encapsulated units.

Average temperature coefficient is ±25 ppm per deg C. The voltage rating is 500 wvdc and the long term stability is ±0.05%.

British Radio Electronics Ltd., Dept. ED, 1833 Jefferson Place, N.W., Washington 6, D.C.

CIRCLE 143 ON READER-SERVICE CARD

Frequency Generator

Output is 2.5 v, 300 to 4000 cps

Model 6261 frequency generator has an output of 2.5 v with frequencies of 300 to 4000 cps. Accuracies are 0.1% to 0.01%. The oscillator circuit uses types 2N334 and 2N335 silicon transistors, precision wire wound resistors, and metallized Mylar capacitors. A bimetallic tuning fork is employed. The tuning fork and the oscillator circuit are in a hermetically sealed can measuring 1-1/2 x 1-1/2 x 3-1/4 in. Required operating power is 28 v dc.

Varo Manufacturing Co., Inc., Dept. ED, 2201 Walnut St., Garland, Tex.

CIRCLE 145 ON READER-SERVICE CARD

Power Supplies

Both ac and dc types

These ac and dc power supplies have voltage ranges from between 0 and 30 v to between 0 and 120 v. Maximum current ranges are 1 to 12 amp. The ac output is variable; the dc output is well-filtered and can be obtained with a very low ripple. A voltmeter indicates output. All outputs are available from both the front and the rear of the units; all input connections are located at the rear. Protection against overload and short circuits is provided. The units are designed for panel mounting.

Nutron Manufacturing Co., Inc., Dept. ED, 67 Monroe Ave., Staten Island 1, N.Y.

CIRCLE 146 ON READER-SERVICE CARD

NEW PRODUCTS

Parametric Amplifiers

Two models available

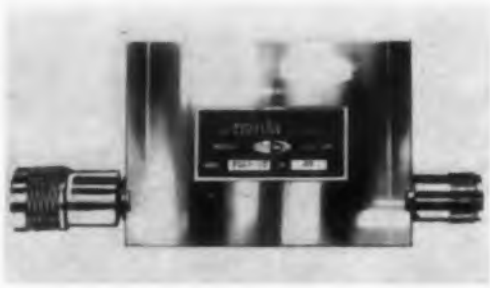
Model MA2-1000 parametric amplifier is used in the 950 to 1250 mc range and model MA2-1000L is used in radar receivers in the 1250 to 1350 mc range. Both models exhibit noise figures below 2 db with a bandwidth of 0.25%. The image rejection is better than 50 db down and the dynamic range is 80 db or better. The unit includes a Varactor diode, a low noise mixer, and a 1N21E or MA-412B diode for the down-converter stage. Complete amplifiers consist of the basic unit, a pump oscillator, a power supply, and waveguide accessories. The chassis is silver-plated brass and measures 6 x 3 x 2 in.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.

CIRCLE 140 ON READER-SERVICE CARD

Low-Pass Filters

Attenuation is 50 db



These low-pass filters are used in coaxial measurement set-ups to eliminate errors due to harmonics emitted by triode and klystron oscillators. They transmit frequencies up to the cut-off point of the filter. Attenuation is 50 db over most of the range, insertion loss is 1 db max, and vswr in the passband is 1.5 max. Units are available for frequencies of 500, 1000, 2100, and 4200 mc.

Narda Microwave Corp., Dept. ED, 118-160 Herricks Road, Mineola, N.Y.

CIRCLE 148 ON READER-SERVICE CARD

NEW PRODUCTS

Voltmeter

Measures 1 mv to 1000 v dc

For use in instrumentation, telemetering, and monitoring applications, type DVM digital voltmeter measures bipolar dc voltages from 1 mv to 100 v. Accuracy is ±0.1% and speed is 100 conversions per sec. The output is automatically displayed as a three-decimal digit readout plus an overflow digit, sign, and decimal point. Electrical outputs include parallel BDC coded voltages and a serial pulse train for single wire telemetry use. This completely solid state instrument can also be used to measure elapsed time, measure events per unit of time, scale inputs into engineering units, and provide zero suppression signal conditioning.

Epsco Inc., Dept. ED, 275 Massachusetts Ave., Cambridge, Mass.

CIRCLE 152 ON READER-SERVICE CARD

Thermoelectric Generator Elements

Made of lead telluride

Made of lead telluride, these thermoelectric generator elements can operate at junction temperatures of 1100 F for several years. Type TEG #2P positive and type TEG #2N negative elements are available in six standard sizes and have prefinished hot junction surfaces and pretinned cold junction surfaces. They can be assembled directly into test fixtures.

Minnesota Mining and Mfg. Co., Dept. ED, 900 Bush Ave., St. Paul 6, Minn.

CIRCLE 153 ON READER-SERVICE CARD

THERMOMETER.—Made of stainless steel, it is designed for both laboratory and production use. The thermometer can be reset and recalibrated by the user. It has a range of from 0 to 220 F. Stem length is 6 in. with a diameter of 1/4 in. The diameter of the dial is 2 in. and the overall diameter is 2-1 8 in. Designated as model 142, the thermometer is waterproof for intermittent immersion and for continuously humid atmospheres.

The Pacific Transducer Corp., Dept. ED, 11836 W. Pico Blvd., Los Angeles 64, Calif.

CIRCLE 154 ON READER-SERVICE CARD

SOCKET CAP SCREWS.—Are made of cold forged stainless steel. The screws can be re-applied many times because of their long length. They are available in numerous sizes in the new ASA 60 series or the old series.

Set Screw & Mfg. Co., Dept. ED, Bartlett, Ill.

CIRCLE 155 ON READER-SERVICE CARD

RELAY MISS TESTER.—Cycles relays for testing under dry-circuit conditions. The relay contacts are tested dynamically at open circuit voltages as low as 1 mv with closed circuit currents as low as 1 μa. An electronic gate is provided to eliminate erroneous miss indications.

Shasta Electronic Co., Dept. ED, P. O. Box 316, Palo Alto, Calif.

CIRCLE 156 ON READER-SERVICE CARD

AUTOMATIC MIXING DISPENSER.—Designed for flowable two-part compounds or adhesives, this unit is portable. Known as an Automatic Shot Meter, it is completely enclosed. It operates on 80 psi of airline pressure. It mixes and dispenses a uniform, air-free compound and is easily adjustable by means of a scale to any of fifty desired shot measurements from 2 to over 100 g.

Pyles Industries, Inc., Dept. ED, 20855 Telegraph Road, Detroit 41, Mich.

CIRCLE 157 ON READER-SERVICE CARD

TERMINAL BOXES.—Are built of cast iron or sheet steel with gasketed covers. The weatherproof multijunction thermocouple terminal boxes provide for the termination of from 6 to 100 thermocouple circuits. The cast iron boxes have either hinged or screw-down type covers, threaded openings for fittings, and external lugs for surface mounting.

Thermo Electric Co., Inc., Dept. ED, Saddle Brook, N. J.

CIRCLE 158 ON READER-SERVICE CARD

SERVO-MAGNETIC AMPLIFIERS.—This line is designed for 2-phase 400 cps servo motors. Voltage ratings are 26 and 115 v with power rating from 2.5 to 15 w. Weight of largest unit is under 2 lb.

Torotel, Inc., Dept. ED, 5512 E. 110th St., Kansas City, Mo.

CIRCLE 159 ON READER-SERVICE CARD

NEW PRODUCTS

Coaxial Attenuators

Ranges are 4 to 7 kmc and 7 to 11 kmc

This variable coaxial attenuator is available with bandwidths of 4 to 7 kmc and 7 to 11 kmc and produces a maximum of 40 db attenuation. Attenuation variation is less than 5%. The vswr on all settings is less than 1.5. The unit handles 4 w. Units producing to 100 db attenuation with flat attenuation versus frequency characteristics can also be provided.

Merrimac Research and Development, Inc., Dept. ED, 137-28 Northern Blvd., Flushing 54, N.Y.

CIRCLE 161 ON READER-SERVICE CARD

Pressure Switches

Pressure range is 10 to 4000 psi

The series 1590 pressure switch has a pressure range of 10 to 4000 psi and an ambient temperature range of —65 to +300 F. The complete unit weighs 2-1/2 oz, and is 3 in. long and 0.937 in. in diam. All moving parts are sealed in an aluminum and steel housing. The entire assembly is resistant to corrosion. Accuracy is within 0.5 psi. The applications include pneumatic, hydraulic, lubricating, fuel, chemical, and gas pressure systems.

Haydon Switch, Inc., Dept. ED, Waterbury 20, Conn.

CIRCLE 162 ON READER-SERVICE CARD

Transformer and Bobbin Winder

Permits fast wire change-over

This multiple transformer/bobbin winder permits fast change-over from one wire gage to another. The model 500-AM unit winds power, audio, and similar types of heavy duty transformer coils and all types of heavy duty field coils and bobbins.

The dial is calibrated in wire sizes from 10 to 31 AWG. Wire finer than 31 AWG can also be handled. Maximum coil OD is 16 in. and maximum winding stroke is 9 in. Loading distance for multiple winding is 24 in., max.

Winding width is adjusted by moving the slider on a calibrated scale to the desired winding width. The machine is furnished with an instant re-set automatic counter, a magnetic brake, and a motor and heavy duty tailstock. Winding speeds are up to 380 rpm.

Geo. Stevens Mfg. Co., Inc., Dept. ED, Pulaski Rd. at Peterson, Chicago 46, Ill.

CIRCLE 173 ON READER-SERVICE CARD

Indicator

For course, azimuth, and range

Combining the functions of a course indicator, an azimuth indicator, and a range indicator, this instrument, designated type 9814-02, measures 9-1/4 in. long and 3-1/8 in. in diameter and weighs 4-1/2 lb. The unit consists of three ac servo motors, four resolvers, one control transformer, one torque receiver, four potentiometers, and one servo amplifier.

The mechanical portion is hermetically sealed. A single indicator face presents compass information on a rotating compass card, distance information on a three-digit counter, and relative Tacan bearing information on a double-bar pointer. An auxiliary single bar pointer is provided for use with other navigational systems.

John Oster Mfg. Co., Avionic Div., Dept. ED, 1 Main St., Racine, Wis.

CIRCLE 174 ON READER-SERVICE CARD

CIRCLE 175 ON READER-SERVICE CARD ➤

CIRCLE 172 ON READER-SERVICE CARD

NEW PRODUCTS

One-hp Gearmotor

Has a 2-1/2 in. diam

This one-hp gearmotor, called model 70DC1R70, has a diameter of less than 2-1/2 in. The required input is 28 v dc at 65 amp. The output speed can be varied to meet customer specifications. The unit shown has an output shaft speed of 7000 rpm.

Western Gear Corp., Electro Products Div., Dept. ED, 132 W. Colorado Blvd., Pasadena, Calif.

CIRCLE 177 ON READER-SERVICE CARD

Epoxy Resin

Has low mix viscosity

ResinKast 709, a semi-rigid epoxy resin system has a two to four-day working life for a five gallon mass at 75 F. The mix viscosity is 4200 cps at 25 C. It is resistant to thermal and mechanical shock and is rated as class B electrical insulation material. The cure schedule is 16 hr at 175 F or 8 hr at 200 F.

Resin Formulators, Inc., Dept. ED, 8956 National Blvd., Los Angeles 34, Calif.

CIRCLE 178 ON READER-SERVICE CARD

DC Power Supply

Delivers 9 or 12 v

For the operation of transistorized equipment and for telephone systems, model TQ-4 dc power supply delivers 12 v at 500 ma or 9 v at 1 amp. The unit is fused, heavy filtering is provided, and a choke is used to obtain good regulation. It is enclosed in a heavy steel case and is supplied with cords.

Fisher Berkeley Corp., Dept. ED, 4224 Holden St., Emeryville 8, Calif.

CIRCLE 179 ON READER-SERVICE CARD

Zener Diodes

Rated at 3/4 w

These 3/4 w Zener diodes come in an axial-lead, flangeless package. They are available in ratings from 6.8 to 200 v. The flangeless package is suited for insertion by automatic equipment in printed circuit boards. Designed to meet or exceed mechanical and environmental requirements of military specifications, the units can be used in both ac and dc circuits.

Types 3/4M6.8Z through 3/4M-200Z can be used for applications such as regulation of vacuum tube filaments, protection of transistors against surge voltages, and in other circuits where it is necessary to provide proper voltage regulation.

Motorola Semiconductor Div., Dept. ED, 5005 E. McDowell Rd., Phoenix, Ariz.

CIRCLE 181 ON READER-SERVICE CARD

Seam Welding Machines

Two models available

The model VTW 500 seam welding machine can handle materials that vary in gage from 0.001 up to 0.01 in. or more. The machine can be used to weld stainless steel, nickel alloys, Kovar, and other new metal alloys.

A phase shift heat control circuit is used and it is adjustable to extremely low heat settings for delicate materials. The unit operates at full power output, 2.8 kva, on a continuous duty cycle. Welding speed is adjustable to either 60 or 120 spots per second. The model VTW 501 machine is identical to the VTW 500 except for an additional control that makes it suitable for spotwelds timed from 2 to 20 cycles.

Thickness range of the VTW 501 is 0.0005 in. to 0.035 in. Both welders have: inputs of 220 or 440 v, 300 w input-standby power, and a power load of 30 amp max at 240 v.

Hughes Aircraft Co., Vacuum Tube Products Div., Dept. ED, International Airport Station, Los Angeles 45, Calif.

CIRCLE 182 ON READER-SERVICE CARD

CIRCLE 183 ON READER-SERVICE CARD ➤

Trimpot® Makes Reliability a Reality

General Purpose Wirewound Trimpot — Model 200. Operates at 105°C/L,S,P terminals/¼ watt/10 ohms to 100K. Available as rheostat, Model 201.

CIRCLE 736 ON READER-SERVICE CARD

High-Resistance Wirewound Hi-R® Trimpot — Model 207. Operates at 175°C/L terminal/2 watts/100 ohms to 100K. Available as rheostat, Model 208 Hi-R Trim R®.

CIRCLE 737 ON READER-SERVICE CARD

Dual-Element Wirewound Twinpot® — Model 209. Operates at 105°C/L terminal/¼ watt/ 10 ohms to 20K. Two potentiometer outputs with one adjustment shaft.

CIRCLE 738 ON READER-SERVICE CARD

General-Purpose Carbon Trimpot — Model 215. Operates at 125°C/L,S,P terminals/¼ watt/ 20K to 1 Meg. Available as Mil-Spec humidity-proof unit, Model 235 (1K to 10 Meg).

CIRCLE 739 ON READER-SERVICE CARD

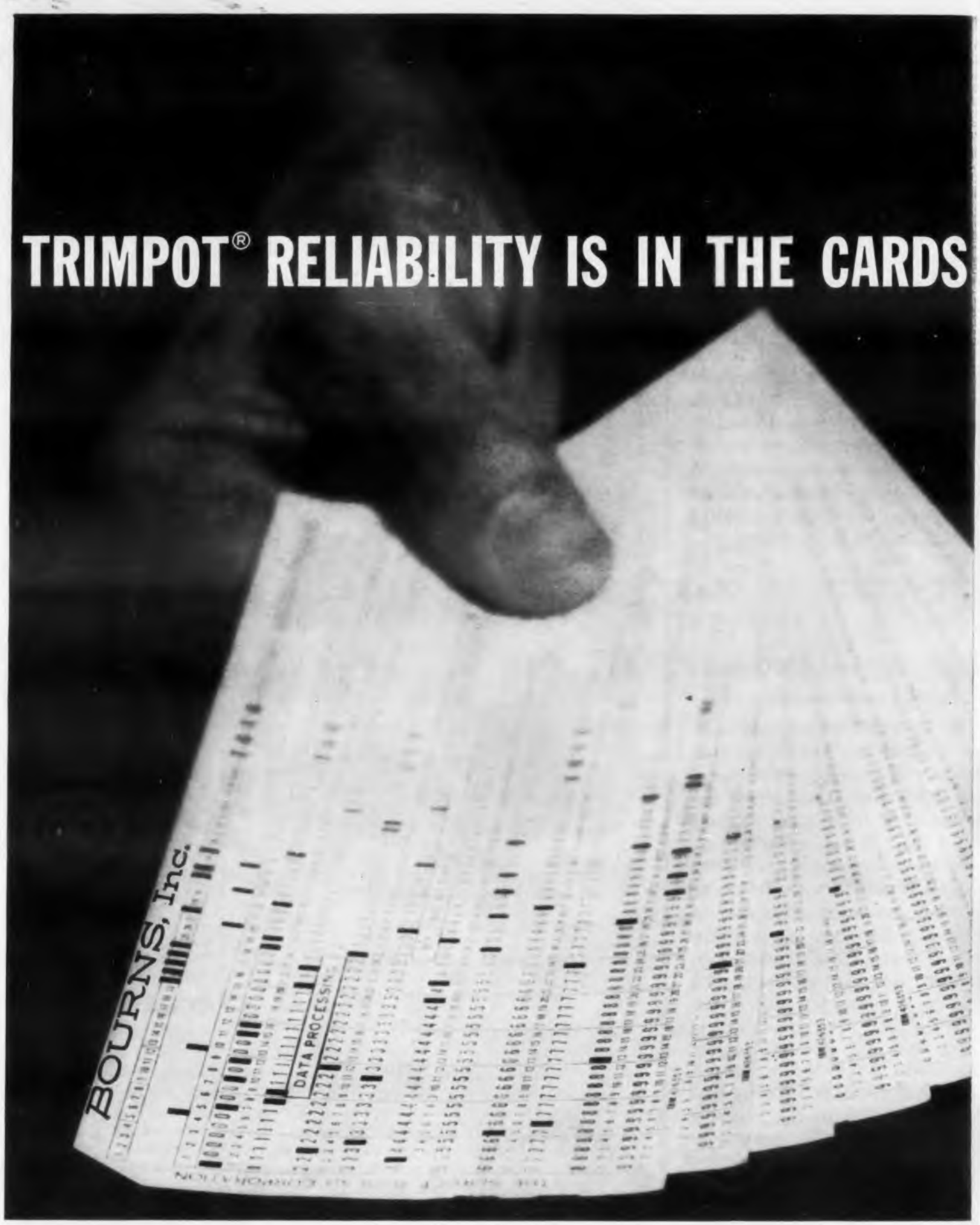
Subminiature Wirewound Trimpot—Model 220. Operates at 175°C / L & W terminals / 1 watt / 100 ohms to 20K. Meets Mil-Specs for humidity.

CIRCLE 740 ON READER-SERVICE CARD

High-Temperature, Humidity-Proof Wirewound Trimpot—Model 224. Operates at 175°C/L,S,P terminals/1 watt/100 ohms to 100K. Meets Mil-Specs for humidity.

CIRCLE 741 ON READER-SERVICE CARD

Choose from among four terminal types: L—insulated stranded Leads; S—Solder lugs; P—printed circuit Pins; W—uninsulated Wire. Full range of standard resistances from 10 ohms to 1 megohm. Other resistances available.



Test information punched in these cards can provide detailed performance reliability statistics on Trimpot production. The cards summarize extensive environmental tests which Bourns regularly conducts above and beyond regular quality control. In Bourns' own Reliability Assurance Laboratory, monthly samples are taken at random from factory stocks and completely tested for conformance to all environmental and electrical specifications on Trimpot catalog sheets. Results can then be fed into IBM computers which analyze performance data with corrective action taken immediately, if required!

This program is the only one of its kind in the industry. Only Trimpot potentiometers are tested so thoroughly, so frequently. In short, Trimpot reliability is a fact—one you can put in your next circuit.

PUNCHED CARDS ARE USED TO TABULATE BOURNS RELIABILITY DATA FROM –

Complete Quality Control Like This...

Trimpot reliability starts at the beginning. Here an incoming lot of potentiometer lead-screws undergoes a dimensional check.

From the time the element is wound until the lid of the potentiometer is installed, in-process inspection monitors quality.

100% final inspection is made possible by this exclusive high-speed system developed by Bourns to test all major electrical characteristics. Critical dimensions of each unit are also checked.

And Reliability Assurance Tests Like These...

This vibrator for measuring conformance to Mil-Specs is an important part of the extensive equipment in Bourns Reliability Assurance Laboratory.

This chamber subjects potentiometers to standard military tests for humidity, provides important feedback on product performance.

1000-hour load life testing per Mil-R-19A takes place in ovens like this, which hold temperatures at desired levels at full rated power.

When tests are completed and the results tabulated, Bourns engineers plot frequency distribution curves from the steady flow of test results. Analysis of these curves and other data from testing provides a continuing check on all models to see that they meet the most exacting standards of performance. This analysis and the constant flow of information between the Testing and Production departments is your assurance that the Trimpot potentiometers you specify and purchase will meet specifications.

Write for the new 8-page folder describing the Bourns Reliability Assurance Program and a copy of the Trimpot Summary Brochure.

BOURNS Inc.

P.O. Box 2112R, Riverside, Calif.
Plants: Riverside, California
and Ames, Iowa

Exclusive manufacturers of TRIMPOT®, TRIMIT®. Pioneers in potentiometer transducers for position, pressure and acceleration.

CIRCLE 735 ON READER-SERVICE CARD

Trimpot® Makes Reliability a Reality

Humidity-Proof Wirewound Trimpot – Model 236. Operates at 135°C/L,S,P terminals/0.8 watt/10 ohms to 100K. Meets Mil-Specs for humidity.

CIRCLE 742 ON READER-SERVICE CARD

High-Temperature Wirewound Trimpot—Model 260. Operates at 175°C/L,S,P terminals/1 watt /10 ohms to 100K.

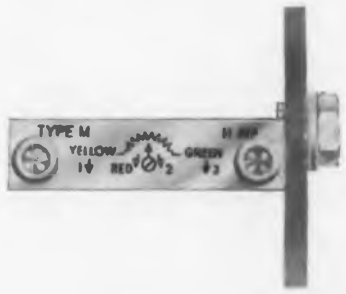
CIRCLE 743 ON READER-SERVICE CARD

High-Quality Commercial Wirewound Trimit® —Models 271, 273, 275. Operates at 85°C / L,S,P terminals/¼ watt/100 ohms to 10K.

CIRCLE 744 ON READER-SERVICE CARD

High-Quality Commercial Carbon Trimit – Models 272, 274, 276. Operates at 85°C/L,S,P terminals/0.2 watt/20K to 1 Meg.

CIRCLE 745 ON READER-SERVICE CARD



Panel-Mount Trimpot
All models are now available with the added convenience of panel mounting. Unique design permits quick factory attachment of rugged panel-mount assembly to standard "on-the-shelf" Trimpot potentiometers. The Panel Mount Trimpot takes as little as 1/12 sq. inch of panel space, meets Mil-Specs for vibration, shock, salt spray, etc. Recessed head prevents accidental changes of setting. Silicon rubber O-ring and Teflon washer provide moisture barrier.

CIRCLE 746 ON READER-SERVICE CARD

Choose from among four terminal types: L—insulated stranded Leads; S—Solder lugs; P—printed circuit Pins; W—uninsulated Wire. Full range of standard resistances from 10 ohms to 1 megohm. Other resistances available.

NEW PRODUCTS

Trimmer Potentiometer

Case is 0.89 x 0.21 x 0.312 in.

Having a resistance range of 10 to 100,000 ohms with ±5% standard tolerance, type W-5 trimmer potentiometer has a case size of 0.89 x 0.21 x 0.312 in. and 0.75 mounting hole centers. The unit dissipates 2 w at 70 C, derating linearly to zero at 200 C. Extreme environmental conditions are provided for. The unit is available with side-mounted printed circuit configurations, flexible wire leads, solder-lugs or panel-mounting hardware.

Atohm Electronics, Dept. ED, 7648 San Fernando Rd., Sun Valley, Calif.

CIRCLE 185 ON READER-SERVICE CARD

Radiant Energy Standard

Source temperature kept within ±1 deg Kelvin

This radiant energy standard is comprised of model 403 black body and model 100 temperature controller. Designed to emit black body radiation over the temperature range of 500 to 1000 Kelvin, the unit maintains its radiation source temperature within 1 deg Kelvin despite changes in ambient temperature, line voltage variations, transients, and tube aging. The selected temperature is maintained by a combination of vacuum-tube amplifier and thyratron circuitry.

Infrared Standards Lab., Dept. ED, 10555 Magnolia Ave., Riverside, Calif.

CIRCLE 186 ON READER-SERVICE CARD

Power Supply

Provides to 60 v dc

Model ME 60-1M transistorized power supply is rated at 0 to 60 v dc at 0 to 1 amp continuously variable over the entire range. It has no external

circuit breaker handle or fuses but can be operated at 120% of rated current. Under short circuit conditions the unit can be operated for long periods with 1/3 of the dissipation in the power transistors that occurs at normal full load. The current is cut off automatically when the output exceeds a preselected point, which is continuously variable from 20% to 120% of rated current. The output voltage may be regulated to 0.1% or 0.01%. Recovery time is less than 50 μsec and overshoot is less than 1%. Ripple is 0.01% max. The unit mounts on a standard 19 in. rack with panel height of 5-1/4 in., or can be furnished in a portable bench-top housing.

Mid-Eastern Electronics, Inc., Dept. ED, 32 Commerce St., Springfield, N.J.

CIRCLE 188 ON READER-SERVICE CARD

Tester

For synchro torque receivers

Model RF-2 receiver test fixture automatically tests for dynamic error in accordance with BuOrd Spec MIL-S-20708A. It can be used with aircraft indicators having sealed-in torque receivers. By pressing a button the indicator is driven with a three-wire electrical signal at the rate of 1 rpm. The variation in this signal is converted into a direct angular error indication without the aid of transducers. Specifications include frequency of 400 cps and synchro excitation of 10 to 115 v. The unit measures 21-3/4 x 9-3/4 x 4-3/4 in.

Theta Instrument Corp., Dept. ED, 20 Victor St., Saddle Brook, N.J.

CIRCLE 189 ON READER-SERVICE CARD

Multiplexers

Miniature type

The S series of miniature electromechanical telemetering multiplexers are available in all standard channel configurations and sampling rates for PAM and PDM applications. Containing no vacuum tubes, the amplifier is stabilized against zero drift during the master pulse interval by stabilizing segments on the mechanical commutator. The common mode rejection ratio is better than 100,000:1.

General Devices, Inc., Dept. ED, P.O. Box 253, Princeton, N.J.

CIRCLE 190 ON READER-SERVICE CARD

NEW PRODUCTS

Temperature Control

For refrigeration or heating equipment

Designed for exterior use to control either refrigeration or heating equipment, model GWS, non-indicating, single-point temperature control, is resistant to weather conditions and to shock and vibration. Functioning as a limit control, it stops the flow of the refrigeration medium or of steam, oil, gas or electricity for heating applications. Dials can be calibrated or uncalibrated. The unit can have a normal sensitivity of 1% of scale range or a close sensitivity of 0.5% of scale range.

Partlow Corp., Dept. ED, 530 Campion Rd., New Hartford (Utica), N.Y.

CIRCLE 193 ON READER-SERVICE CARD

Pulse Transformer

Subminiature

This subminiature pulse transformer, called the Micro-Stat, has a hermetically sealed metal casing that is 0.57-in. long with a diameter of 0.51 in. It is also available with an epoxy casing that is 0.41-in. long with a diameter of 0.3 in. All applicable military specifications are met by the unit that comes in over 50 designs. The unit is constructed on an armite form for precise winding geometry to control leakage inductance and distributed capacity. Each unit has a polished gap which represents 1/2 mil of effective gap. Improved voltage breakdown and insulation resistance is claimed through use of core-gapped construction.

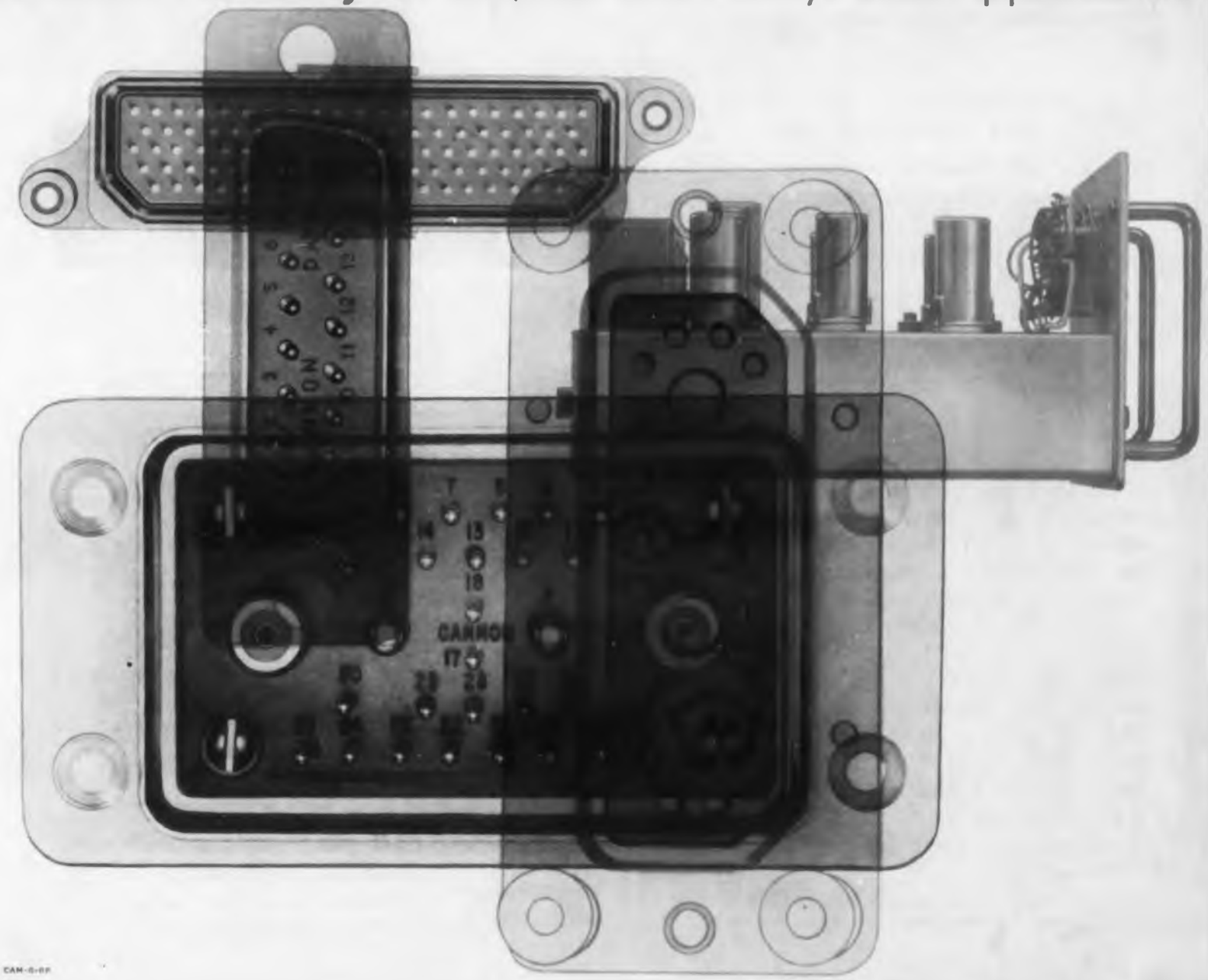
Pulse Engineering, Inc., Dept. ED, 560 Robert Ave., Santa Clara, Calif.

CIRCLE 194 ON READER-SERVICE CARD

CANNON PLUGS

The assembling of highly-flexible electronic systems and subsystems into a modular package . . . for fast inspection, testing, service, and replacement of components . . . calls for standardized-type plugs throughout the system. Reliability and optimum flexibility in shell designs and types of layouts are the design criteria for the more than 18 different basic Cannon Modular and Rack/Panel Plug Series. This Series is available in standard, miniature, or subminiature sizes . . . for standard or printed circuitry. Up to 180 contacts and a varied combination of contacts for control, audio, thermocouple, co-ax, twin-ax, and pneumatic connections. Single or double-gang. With or without shells. The Rack/Panel Series ranges from the tiny "D" subminiature to the heavy-duty DPD Rack/Panel Plug. For further information on Cannon Modular and Rack/Panel Plugs write for Cannon DP Catalog, Cannon Electric Co., 3208 Humboldt St., Los Angeles 31. Please refer to Dept. 438 Factories in Los Angeles, Santa Ana, Salem, Toronto, London, Paris, Melbourne, Tokyo. Distributors and Representatives in the principal cities of the world.

Maximum Flexibility for Modular and Rack/Panel Applications



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CANNON PLUGS

Schweber

FOR IMMEDIATE LARGE QUANTITY DELIVERY AT FACTORY PRICES

2500

Yes! You can now order up to 2500 each of such popular Cannon Connector types as Miniature D, KO, DPD, DPA, DPX, etc. Immediate shipment at factory prices.

Schweber ELECTRONICS

RICKS ROAD, MINEOLA, L.I., N.Y.
R 6-6520 TWX G-CY-NY-580
CIRCLE 196 ON READER-SERVICE CARD

CIRCLE 197 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Blowers

Corrosion-resistant

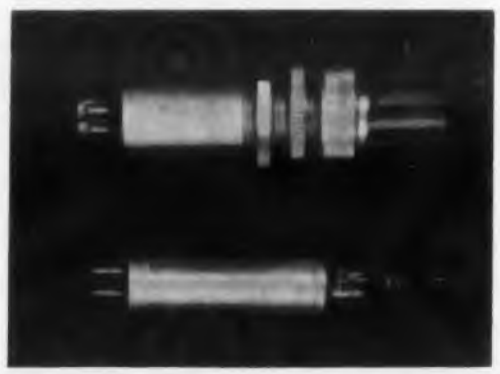
Series PVC direct-drive, corrosion-resistant utility blowers come with 1/3, 3/4, or 1 hp motors and capacities of 399 to 2000 cfm. Constructed of rigid unplasticized polyvinyl chloride, they can be used in such applications as laboratory hood exhaust systems. They withstand temperatures to 140 F at the blower inlet.

Industrial Plastic Fabricators, Inc., Dept. ED, Endicott St., Norwood, Mass.

CIRCLE 198 ON READER-SERVICE CARD

Gas Triode Indicator

For transistor monitoring



This gas triode indicator is a subminiature grid-controlled unit designed for transistor monitoring service. The 1GT7 with a plug-in KP-145A tube can be operated as a conventional thyratron and used in relay control circuits. Or it can be applied in circuits requiring electrical memory combined with visual readout. In typical ac operation the anode voltage is 120 v ac, the anode series resistance is 120 K, and the grid triggering voltage is from 1.5 to −6 v. In typical dc operation, the anode voltage is 85 ±15 v dc, the anode series resistance is 120 K, and the grid triggering voltage is from 0 to −4.5 v.

Eldema Corp., Dept. ED, 1805 Belcroft Ave., El Monte, Calif.

CIRCLE 199 ON READER-SERVICE CARD

The Metal Pots

Spectrol offers four 3-turn and four 10-turn models. All feature anodized aluminum cases with 3/16-inch thick walls. These 8 precision wire-wound pots absorb no moisture—dissipate heat fast and stay dimensionally stable. They operate from −55°C to +125°C and withstand relative humidity of 95%.

You can choose diameters of 7/8, 1, 1-5/16 and 1-13/16 inches in both 3 and 10-turn models. Resistance ranges to 1,000,000 ohms with standard linearity tolerances of ±0.25% (0.020% on special order). Like Sir Spectrol, the new multi-turns will take a respectable jolt. They function to 20g vibration from 55 to 2,000 cps and withstand 30g shocks.

SPECIFICATIONS

MODEL	540	530	580	560	780	790	880	840
No. of coil turns	10	3	10	3	10	3	10	3
Diameter (inches max.)	⅞	⅞	1	1	1 5/16	1 5/16	1 13/16	1 13/16
Standard resistance range in ohms (±3%)	25-125K	10-36K	25-150K	10-40K	30-300K	10-90K	50-400K	20-120K
Special resistance to	250K	75K	250K	75K	750K	240K	1 meg	330K

SPECIAL POTS

Spectrol can design and deliver the pot you need when you need it. Recent custom designs include pots for airborne computers, pots designed to be immersed in fuel, pots for high temperature application, pots with non-linear functions, and many others. Let us know your requirements.

STANDARD POTS

Popular single and multi-turn models and turns counting multi-dials are stocked in 30 electronics supply houses in the U. S. and Canada. Ten resistance ranges from 100 ohms to 200 k ohms with standard linearity tolerances of ±0.3% are available.

Please write for literature, or consult the yellow pages of your phone book for your Spectrol engineering sales representative.

SPECTROL ELECTRONICS CORPORATION
1704 SOUTH DEL MAR AVENUE • SAN GABRIEL, CALIFORNIA

17

CIRCLE 202 ON READER-SERVICE CARD

MINIATURE THERMAL MAGNETIC CIRCUIT BREAKER

With Alarm Circuits
SERIES 44-000.00

CURRENT: 50 milliamp (min) to 10 amp (max)
VOLTAGE: 250 V A.C. 65 V D.C.
CASE SIZE: 1.653 x 1.614 x 0.433 inches

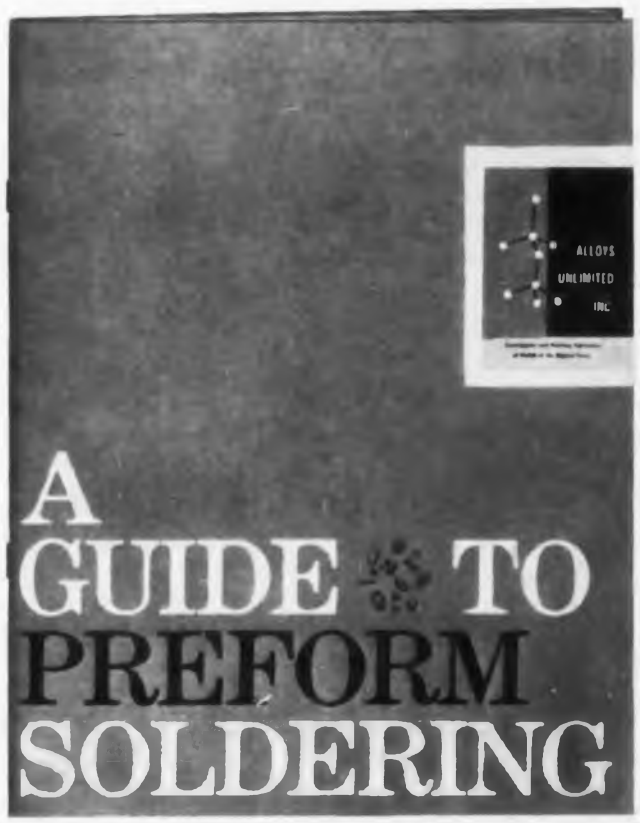
Ideal as a dependable sensitive protection in communication equipment, telephone systems, electronic and electrical equipment. Available with auxiliary circuits to signal "Make" and "Break" position; features manual release for occasional disconnection of equipment from line.

Why not replace bothersome fuses with modern E-T-A circuit breakers!!!

Call or write

E-T-A PRODUCTS CO. OF AMERICA
6284 No. Cicero Ave., Chicago 46, Ill.
Telephone: KIldare 5-1554

CIRCLE 203 ON READER-SERVICE CARD



FREE! NEW 8 PAGE GUIDE

Complete information on solder preforms, their selection and use. Technical diagrams. Send for your copy today.

21-01 43rd AVENUE, LONG ISLAND CITY 1, N.Y. ALLOYS UNLIMITED INC

CIRCLE 204 ON READER-SERVICE CARD

Terminal Blocks

With many types of terminals

These terminal blocks are supplied with either stud or turret terminals or a combination of both, as well as with screw type terminals. Possible configurations include threaded stud terminals on top of block so that two or more leads can be attached to a common terminal, and solder turret terminals on top of the block. Taper-pin terminals are also available. On double-row terminal blocks, a combination of terminal types can be used for the two rows and bus plates can be supplied to connect the two rows at any point between the barriers.

Kulka Electric Corp., Dept. ED, 633-643 S. Fulton Ave., Mt. Vernon, N.Y.

CIRCLE 205 ON READER-SERVICE CARD

Microwave Filter

Range is 3000 to 36,000 mc

Originally designed for C-band operation, this microwave filter can operate with any waveguide size or at any frequency from 3000 to 36,000 mc, and with larger or smaller pass and stop bands. Typical characteristics at the C-band are: 0.3 db maximum insertion loss in the pass band, 1.4 max vswr in the pass band, 30 db minimum rejection in the stop band, and a power capacity of 0.5 mw cw.

Litton Industries, Dept. ED, 336 N. Foothill Rd., Beverly Hills, Calif.

CIRCLE 206 ON READER-SERVICE CARD

NEW PRODUCTS

Potentiometer

Wirewound type

Having a 3/4 in. diam, this wirewound potentiometer is especially designed for environmental conditions found in military applications. It has from 25 to 50,000 ohms resistance. The applicable parts of MIL-R-19A, MIL-E-5272A, MIL-R-19518, MIL-R-12934B, and NAS 710 are met. The unit has sealed-type construction for encapsulation.

Maurey Instrument Corp., Dept. ED, 7924 S. Exchange Ave., Chicago 17, Ill.

CIRCLE 207 ON READER-SERVICE CARD

Wavemeters

Can be read directly to 0.0001 in.

These secondary-standard, broadband wavemeters can be read directly to 0.0001 in. Large micrometer heads are used, eliminating the need for verniers. The line ranges from 2.6 to 140 kmc in 12 models, each covering the entire waveguide bandwidth. The units have high Q values, which are maintained by the sealed construction and inert gas pressurization. Changes in humidity, altitude, and barometric pressure are provided for. Each unit is individually calibrated and is supplied with a calibration chart.

DeMornay-Bonardi, Dept. ED, 780 S. Arroyo Parkway, Pasadena, Calif.

CIRCLE 208 ON READER-SERVICE CARD

Pulse Generator

Repetition rate is 2 mc

The model 3450C pulse generator is constructed entirely of plug-in wiring modules that allow extension to multiple pulse requirements and provide maximum accessibility for maintenance. Fast rise time pulses at repetition rates to 2 mc are provided. Features include: wide range variable pulse delay and duration, high resolution controls, and automatic overload protection. The output amplitude is stabilized by power regulators and pulse output is presented dc coupled with base line at chassis ground.

Electro-Pulse, Inc., Dept. ED, 11861 Teale St., Culver City, Calif.

CIRCLE 211 ON READER-SERVICE CARD

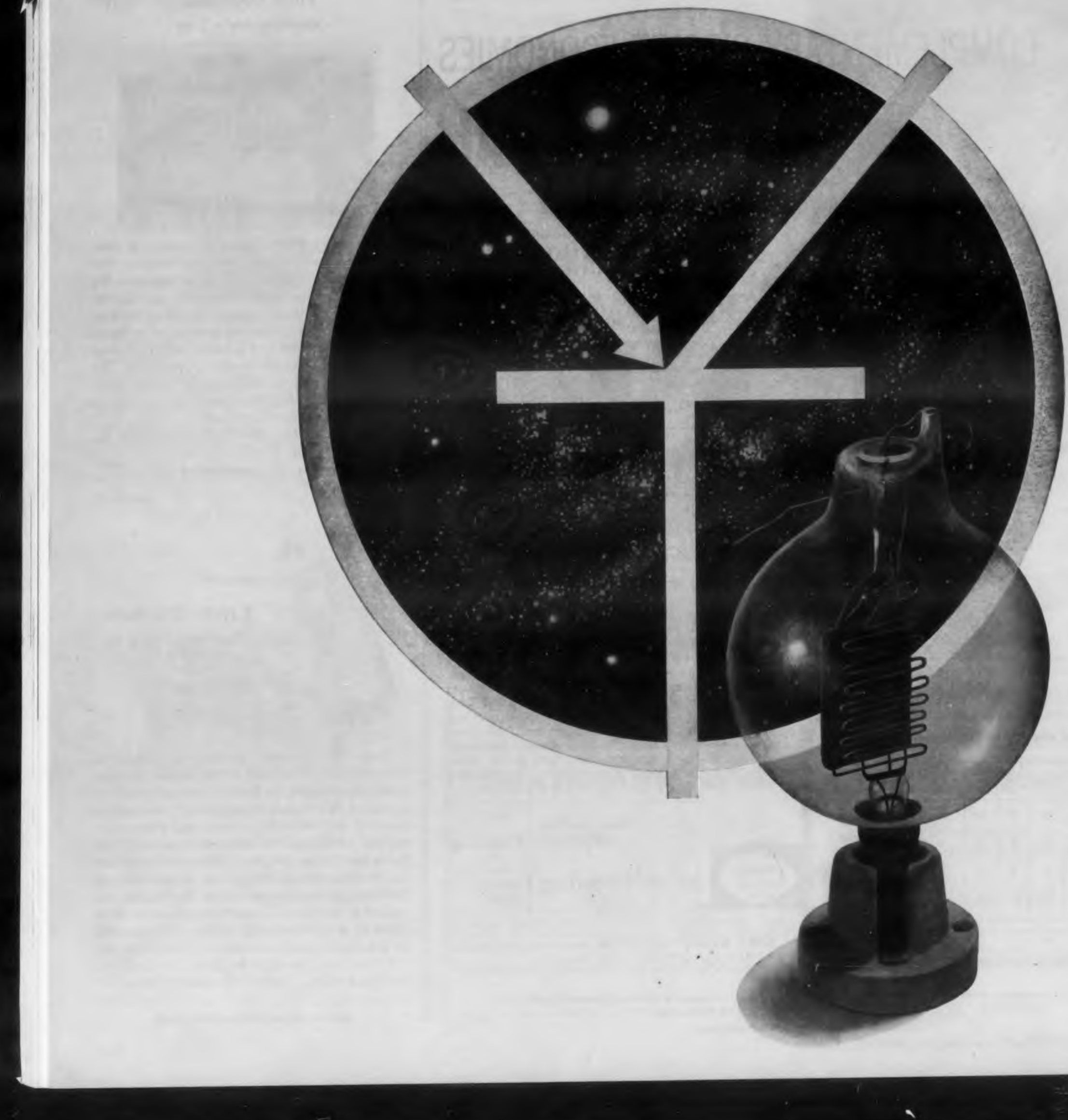
Crystal Oscillator

Stability is 0.001% to 0.0001%

Type DFO-12 crystal oscillator is available at any frequency from 10 kc to 100 mc and provides a stability of 0.001% to 0.0001%, depending on frequency. The standard operating temperature range is −55 to +75 C; special units for operation to +105 C are available. An input of 20 v or more provides an output of 100 mv into a 50-ohm load with corresponding power outputs into impedances as high as 500 ohms. The current required is 3 to 5 ma. Heater voltage may be dc or from 6.3 to 115 v ac with 4 w avg. Encapsulated in Silastic, the unit measures 1-1/4 in. diam and 3-1/2 in. long. It weighs 3-1/2 oz.

Delta-f, Inc., Dept. ED, 113 E. State St., Geneva, Ill.

CIRCLE 212 ON READER-SERVICE CARD



ELECTRONICS

EXPANDING

THE FRONTIERS OF

SPACE

TECHNOLOGY

ELECTRONICS: In the half century since the invention of the original audion tube by De Forest, the art of electronics has expanded to a fourteen billion dollar industry that is contributing in hundreds of ways to our knowledge of the universe and our understanding of life itself. At Lockheed, for example, over half the technical staff is engaged in electronics research and development.

Significant contributions to the advancement of the state of the art in electronics have been made by Lockheed engineers and scientists in such areas as: computer development; telemetry; radar and data link; transducers and instrumentation; microwave devices; antennas and electromagnetic propagation and radiation; ferrite and MASER research; solid state electronics, including devices, electrochemistry, infrared and optics; and data reduction and analysis.

Over one-fifth of the nation's missile-borne telemetering equipment was produced by Lockheed last year. Its PAM/FM miniaturized system provides increased efficiency at one-fourth the weight of FM/FM missile-borne systems.

Advanced development work in high-energy batteries and fuel cells has resulted in a method for converting chemical energy directly into electrical power that promises a fuel utilization of almost 100% and an energy conversion efficiency of 70% or better.

Areas of special capability in computer development include the design of large scale data handling systems; development of special purpose digital computing and analog-digital conversion devices; development of high-speed input-output equipment; and advanced research in computer technology, pattern recognition, self-organizing machines, and information retrieval.

Other major developments are: a digital flight data recorder able to record each of 24 channels every few seconds; digital telemetry conversion equipment to reduce telemetered test data to plotted form rapidly and inexpensively; advancements in the theory of sequential machines; and a high-speed digital plotter that can handle some four thousand points per second with the finished plot programmed into the data tape as a continuous curve.

Lockheed Missiles and Space Division is engaged in all fields of the art — from concept to operation. Its programs reach far into the future and deal with unknown environments. It is a rewarding future which scientists and engineers of outstanding talent and inquiring mind are invited to share. Write: Research and Development Staff, Dept. K-21, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship required.

Lockheed

MISSILES AND SPACE DIVISION

Systems Manager for Navy POLARIS FBM; DISCOVERER, MIDAS and SAMOS; Army KINGFISHER; Air Force Q-5 and X-7.

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NEW PRODUCTS

Power Supplies

Provide 110 to 325 v dc

The 300 series of transistorized power supplies furnishes 110 to 325 v dc variable output at 200, 400, 800, and 1500 ma with 0.1% load and 0.1% line regulation. The 200, 400, and 800-ma units require only convection cooling and occupy 3-1/2 in. of panel space. The 1500-ma power supply has a 5-1/4 in. panel height and uses forced air cooling. Remote programming is provided on all units.

Trygon Electronics, Inc., Dept. ED, Pleasant Ave., Roosevelt, L.I., N.Y.

CIRCLE 214 ON READER-SERVICE CARD

DC Signal Sources

For digital programming

Made for digital programming, these dc signal sources accept input signals from such program devices as paper tape recorders and keyboards. Typical uses are in automatic checkout equipment and precision testing applications. Standard units are for three binary-coded decimal digits; other codes can be supplied. The three digits may be fed serially or simultaneously. External contacts must remain closed for 3 sec to register. The unit has a clock closure circuit. The output voltage stability is 0.05% under these conditions: no load to full load, ±10 deg C temperature change, and ± 10% variation in line voltage. Recovery time for a 20% load change is 100 μsec. The voltage is adjustable with an accuracy of ±0.1% and the output ripple is under 0.05%. The unit requires 8-3/4 in. of rack space.

Consolidated Avionics Corp., Dept. ED, 880 Canal St., Stamford, Conn.

CIRCLE 215 ON READER-SERVICE CARD

Voltage Divider

Six-decade type

Model VDR-106A six-decade voltage divider can be set to any one of 1,000,000 voltage divider ratios from 0.000001 to 1 with an absolute accuracy of 0.0002% of the input voltage from dc to 4000 cps. At 10 kc the absolute accuracy is better than 0.0005%. The resolution is 0.0001% and the over-all resistance of the divider is 10,000 ohms. The rated accuracy is maintained from 15 to 35 C. Suitable for rack mounting, the unit measures 19-1/2 x 14 in. A unit for bench use is also available.

Julie Research Labs., Inc., Dept. ED, 556 W. 168th St., New York 32, N.Y.

CIRCLE 253 ON READER-SERVICE CARD

Mercury Relays

Two- and three-pole types

These double- and triple-pole mercury relays, called Phaertltron, have Teflon bearing surfaces, heavy tungsten contacts, and mercury-to-mercury make and break. The plunger units are hermetically-sealed in glass. There is no exposed arc. Contacts are rated at 35 and 60 amp at 115 v ac. The triple-pole model measures 5-9/16 x 4-3/4 x 2-5/16 in.; the double-pole model is 4-1/8 in. wide.

Mack Electric Devices, Inc., Dept. ED, Wyncote, Pa.

CIRCLE 254 ON READER-SERVICE CARD

Magnetic Switch

Has plastic shell

Contained in a plastic shell, type MH-2-P magnetic switch is for mounting in areas of limited access and has a quick disconnect plug. A minimum magnetic field transient time of 8 msec is needed to activate the switch. The operating life is in excess of 1,000,000,000 operations.

Post Machinery Co., Dept. ED, 875 Eliot St., Beverly, Mass.

CIRCLE 255 ON READER-SERVICE CARD
CIRCLE 218 ON READER-SERVICE CARD ➤

NEW FAIRCHILD 2N706 provides

TRANSISTOR LOGIC OF MAXIMUM

Saturating high-speed silicon logic ends the need to sacrifice one requirement in favor of another. The Fairchild 2N706 diffused silicon mesa transistor is as fast as the fastest germanium – and in addition has the inherent advantages of silicon. This combination fulfills all these logic-circuit design objectives:

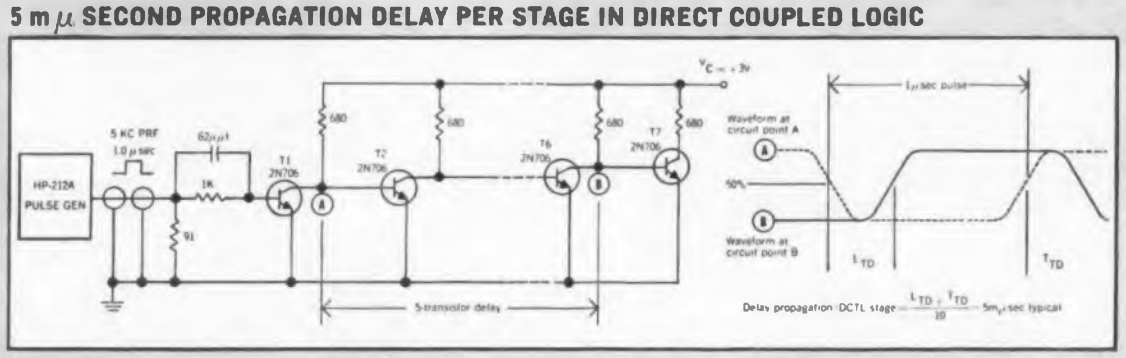
SPEED	**10 megapulse operation saturated**
	25 megapulse operation nonsaturated
	Guaranteed low storage
RELIABILITY	**Large power reserve: 150 mW dissipation at 100° C ambient (no heat sink)**
	300° C stabilization of all units
	Rugged mesa construction
CIRCUIT SIMPLICITY	**Saturating logic with fewer components**
	3 to 5 milliampere current level
	Small JEDEC TO-18 outline

Fairchild's 2N706 provides optimum performance in the most-used logic circuit configurations and has a broad current and power range that covers many alternate approaches. It is ideally suited for high-density modular equipment because of its small size and its high performance in simple, low-power saturated circuits. The 10 megapulse speed is conservative, applying specifically to saturating logic and a 3 to 5 milliampere current level.

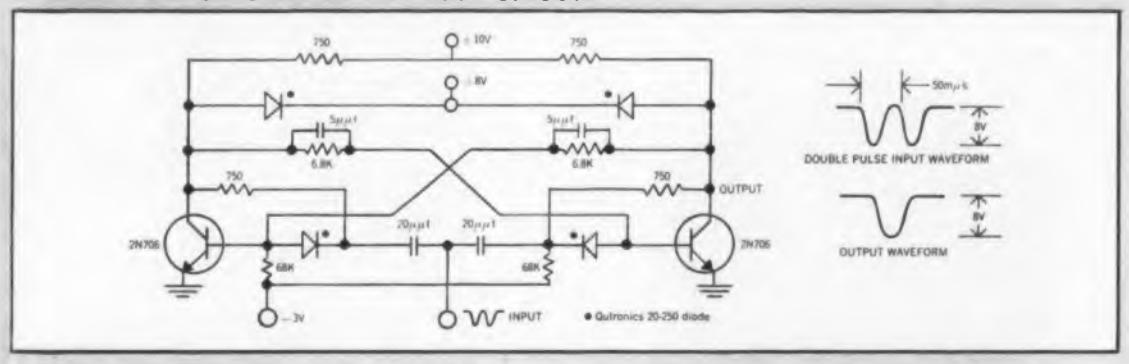
CIRCLE 219 ON READER-SERVICE CARD

IUMPEED, RELIABILITY, SIMPLICITY

5 m μ SECOND PROPAGATION DELAY PER STAGE IN DIRECT COUPLED LOGIC



20 MEGACYCLE SATURATING FLIP-FLOP CIRCUIT



RATINGS AND CHARACTERISTICS (25° C) — 2N706 NPN DIFFUSED SILICON TRANSISTOR

Symbol	Characteristics	Rating	Min.	Typ.	Max.	Test Conditions	
V_{CBO}	Collector to base voltage	25 v					
V_{EBO}	Emitter to base voltage	3 v					
	Total dissipation, 100° C free air ambient	150 mw					
h_{FE}	D.C. pulse current gain		15			$I_C = 10mA$	$V_C = 10v$
$V_{BE(SAT)}$	Base saturation voltage				0.9	$I_C = 10mA$	$I_B = 1mA$
$V_{CE(SAT)}$	Collector saturation voltage			0.3	0.6	$I_C = 10mA$	$I_B = 1mA$
h_{fe}	Small signal current gain at f = 100 mc			4		$I_C = 20mA$	$V_C = 10v$
C_{ob}	Collector capacitance (140Kc)			3.5 pf	6 pf	$I_E = 0mA$	$V_C = 10v$

For specification sheets, write Dept. B-11-11

FAIRCHILD SEMICONDUCTOR CORPORATION

545 WHISMAN ROAD • MOUNTAIN VIEW, CALIFORNIA
YORKSHIRE 8-8161 • TWX: MOUNTAIN VIEW CAL 122

REGIONAL SALES OFFICES: Philadelphia area: 100 Old York Road, Jenkintown, Pa.. TUrner 6-6623 and 6624, TWX: Jenkintown Pa 1056 • Los Angeles area: 8833 Sunset Blvd., Los Angeles 46, Calif., OLeander 5-6058 and 6059, TWX: BV 7085

CIRCLE 220 ON READER-SERVICE CARD

FAIRCHILD SEMICONDUCTOR CORPORATION

The following Fairchild transistors are available from stock for same day shipment in quantities up to

1000

pieces per type.

Standard NPN: 2N696, 2N697. High Voltage NPN: 2N699. High Beta NPN: 2N1420. Low Storage NPN: 2N1252, 2N1253. Standard PNP: 2N1131, 2N1132. Mesa: 2N706.

At factory prices of course!

Schweber ELECTRONICS

CIRCLE 221 ON READER-SERVICE CARD

NEW PRODUCTS

Recording Systems

Four, six, and eight-channel types

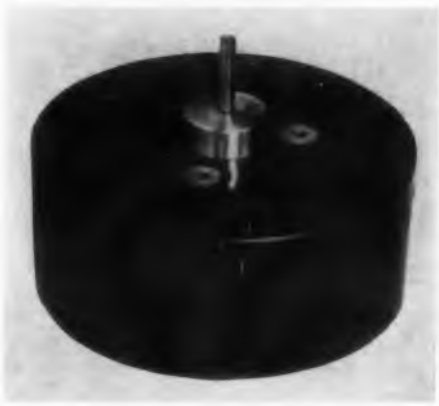
Available in four, six, and eight-channel types with a choice of five interchangeable preamplifiers, these modular graphic recording systems produce traces on standard roll chart or Z-fold paper. The basic unit consists of the recorder, master power panel, power supplies, and driver amplifiers; they are contained in a standard 19 in. relay rack which is mounted on casters.

Epsco Worchester, Div. of Epsco, Inc., Dept. ED, 588 Commonwealth Ave., Boston 15, Mass.

CIRCLE 223 ON READER-SERVICE CARD

Hysteresis Motors

Synchronous



These hysteresis synchronous electric motors are for use in ambient temperatures from −32 to +135 C. The motor-induced flutter will not exceed 0.1 rms at 1200 rpm or 0.15 rms at 360 rpm. The stray external magnetic field is −47 dbm. Typical applications include tape transports, turnable drives, missile and aircraft instrumentation, computer drum drives, viscometers, flow meters, and dynamometers.

Telecomputing Corp., Hysyn Electromotive, Dept. ED, 915 N. Citrus Ave., Los Angeles 38, Calif.

CIRCLE 224 ON READER-SERVICE CARD

HERMETIC CONNECTORS.—The DM5600 miniature series and the DHO2 AN series have eyelet or solder pot contacts fused into a single piece of white glass. They stand mechanical shock of 100 g, thermal shock from —100 to +500 F, operate at pressures to 1000 psi, and have a potential of over 2000 v. The DH series mates with MS and MS-E plugs from size 10SL to 32 AN; the DM5000 series mates with rack and panel, standard, and snap-in contact miniature plugs.

The Deutsch Co., Electronic Components Div., Dept. ED, Banning, Calif.

CIRCLE 227 ON READER-SERVICE CARD

DRAFTING EQUIPMENT.—Set No. 70,242 includes a French curve, an engineer's 6-in. scalemaster, an architect's 6-in. scalemaster, a 6-in. slide rule, a 30 to 60 deg triangle, a 45 to 90 deg triangle, a ruler, a T-square, and protractor calibrated in 1/2 degrees.

Edmund Scientific Co., Dept. ED, Barrington, N.J.

CIRCLE 228 ON READER-SERVICE CARD

ANALOG TO DIGITAL CONVERTER.—Type 161 provides a punch paper tape processed in binary coded decimal form for use with special purpose digital computers. It measures from 3 mv to 1000 v dc with an accuracy of ±0.05%. Recording speed is 10 per sec.

Systron Corp., Dept. ED, 950 Galindo St., Concord, Calif.

CIRCLE 229 ON READER-SERVICE CARD

ADHESIVE.—Called Epox-Cement, it cures at room temperature and has a bond strength of 3000 lb per sq in. on metals, ceramics, plastics, and other materials. It is claimed to have excellent dielectric properties.

G-C Electronics Co., Div. of Textron Inc., Dept. ED, 400 S. Wyman St., Rockford, Ill.

CIRCLE 230 ON READER-SERVICE CARD

MOTOR-STARTING CAPACITORS.—Model 5992 is rated at 1 μf, 400 cps, and operates from —65 to +400 F. The unit has a 1-1/4 in. ID with 1/4 to 3/8 in. thickness, depending on the temperature range, and is 1/2 in. long.

Double E Products Co., Dept. ED, 208 Standard St., El Segundo, Calif.

CIRCLE 231 ON READER-SERVICE CARD

PLUG.—Type PR-300 is for easy insertion and withdrawal in Press-Fit jacks. The in-line plug takes the stripped wire end to the tip of the probe where it is soldered without interfering with the ready insertion or withdrawal.

Sealectro Corp., Dept. ED, 139 Hoyt St., Mamaroneck, N.Y.

CIRCLE 232 ON READER-SERVICE CARD

INSULATION SLEEVE.—Is designed to slip on and snap in place to prevent interference of the sleeve with the insertion of ground tap leads. This design also allows for maximum visibility during insertion.

Amp Inc., Dept. ED, Harrisburg, Pa.

CIRCLE 233 ON READER-SERVICE CARD

NEW PRODUCTS

Thermoelectric Transducers

Outputs are 0 to 5 v

Using a minimum of modular elements and replaceable, humidityproof sensing elements, these transducers have outputs from 0 to 5 v and ranges from −320 to +1000 F. Fluid-immersion types with 4500 psi to 100 F and gas-immersion types with 4500 psi at 77 F and 2000 psi at 1200 F are available. The sensing elements may be nickel-iron, platinum or thermistor, semiconductor oxides. The resistance tolerance is to 0.5%. Mounting permits variation in tube length or changing the element while the fitting is locked. Solder terminals are used.

Arnoux Corp., Dept. ED, 11924 W. Washington Blvd., Los Angeles 66, Calif.

CIRCLE 236 ON READER-SERVICE CARD

Telemetering Commutator

For airborne applications

For missile, rocket, and other airborne applications, type 500602 PDM telemetering commutator is a two-pole 45 break-before-make channel, 20 rps type. Weighing 1.8 lb, the unit provides 500 hr noise-free service. One pole is used to sample single-ended transducer data of 0 to 30 mv dc or 0 to 5 v dc signal levels at 900 samples per sec. Transducer loading is less than 1 ohm and interchannel isolation is over 100 meg. The second pole is for timing according to IRIG. The sampling system is enclosed in a hermetically-sealed case. The switch withstands 20 g vibration at 20 to 2000 cps.

Instrument Development Labs., Inc., Dept. ED, 67 Mechanic St., Attleboro, Mass.

CIRCLE 237 ON READER-SERVICE CARD

NEUMATIC CRIMPING TOOL.—Loads 100 or ore contacts, pins or sockets at once. They are tomatically fed, one at a time, into the jaws of e tool and are fixed to the wire by pressing a utton.

The Deutch Co., Electronic Components Div., ept. ED, Banning, Calif.

CIRCLE 239 ON READER-SERVICE CARD

NSULATED SOLDERLESS TERMINALS.—This t includes a type 1930 bolt cutter and crimping tool us an assortment of terminals.

Vaco Products Co., Dept. ED, 317 E. Ontario St., hicago 11, Ill.

CIRCLE 240 ON READER-SERVICE CARD

RESSURE CALIBRATOR SYSTEM.—Measures d regulates pressure in a reservoir using a fre- ency comparator. The comparator indicates the gnitude and direction of the difference in fre- encies. The accuracy is 0.05% full scale.

Wiancko Engineering Co., Dept. ED, 255 Hal- ad, Pasadena, Calif.

CIRCLE 241 ON READER-SERVICE CARD

RAFTING EQUIPMENT.—Includes a portable fting machine, a holemeter with diameters of to 1/2 in., and a protractor as well as vertical and rizontal scales calibrated in 1/32 in. increments. e brief case type holder permits drawing in a flat ition or, by snapping the case together, provides 8-deg inclined surface.

Charles W. Thrift Co., Dept. ED, 3312 W. Ver- Ave., Los Angeles, Calif.

CIRCLE 242 ON READER-SERVICE CARD

AFTING PEN.—Model 3065 has interchangeable nt sections that provide these line widths: 00, 0, 2, 2-1/2, 3, and 4. Each point section has its own cartridge.

Koh-I-Noor Pencil Co., Dept. ED, Bloomsbury, J.

CIRCLE 243 ON READER-SERVICE CARD

RNACE.—Molybdenum heated, permits tempera- s of 3400 F in a hydrogen atmosphere. Heating ontrolled by a saturable reactor and radiation ometer controls. Cooling is controlled by refrac- -lined water-cooled zones. The applications in- e aircraft, missile, ceramic, and metallurgical stries.

V. P. Keith Co., Dept. ED, 9128 S. Norwalk l., Santa Fe Springs, Calif.

CIRCLE 244 ON READER-SERVICE CARD

CHOR NUTS.—Self-locking type, have high ten- strength. Type F19270 is made of A286 stainless l for use to 1200 F. Type F19271 is made of 2 stainless steel for use to 1400 F.

aynar Manufacturing Co., Inc., Dept. ED, Kay- Div., Box 2001, Terminal Annex, Los Angeles Calif.

CIRCLE 245 ON READER-SERVICE CARD

NEW PRODUCTS

Terminal Boards

Taper pin type

Designed for use in computer and data process programming and multi-channel communications systems, these single row terminal boards have 10 or 20 feedthrough type taper receptacles with single and double feedthrough connections. They have nesting projections and recesses to aid stacking. Elongated holes facilitate mounting and barriers across both faces increase creepage path. Receptacles are silver-plated and gold-flushed. With standard solderless taper pins minimum pull out is 14 lb. The molding compound conforms to MIL-M-14E. The terminal boards pass the shock requirement of MIL-S-901B.

General Products Corp., Dept. ED, Union Springs, N.Y.

CIRCLE 250 ON READER-SERVICE CARD

Transducer

For radiation tracking

Type XY20 solid state radiation tracking transducer detects the position of visible to near infrared light sources. A linear functioning semiconductor device, this single element detects the angular position of the source. Having microsecond response characteristics, it can be used in tracking, instrumentation, automatic control, and computers. Detection occurs by means of a lateral photoeffect in a silicon pn junction.

Electro-Optical Systems, Inc., Dept. ED, 170 N. Daisy Ave., Pasadena, Calif.

CIRCLE 251 ON READER-SERVICE CARD

Telemetering System

Video type

Designed for missile applications, model 701 video telemetering system withstands 40 g shock for 11 μsec in three planes and 45 g acceleration. It has 525 lines and a 30-frame fully interlaced picture. The circuitry is transistorized and the EIA synchronization is crystal-controlled. The entire system occupies 118.8 cu in. and weighs 5.9 lb.

Lockheed Electronics and Avionics Div., Dept. ED, 6201 E. Randolph St., Los Angeles 22, Calif.

CIRCLE 263 ON READER-SERVICE CARD

Micro-Gage

Measures 0.5 micron or less

Designated the Dyna-Micro-Gage, this photoelectric instrument is capable of dynamic measurements down to 0.5 micron or less. Uses of the instrument include continuous gaging for diameter of wire and for width of sheets, measurement of small hole sizes and of variation in roundness in wire or thread. It can also be used as a strain gage to measure very small deflections. The output voltage can operate a meter, actuate a relay or be recorded to give a graphical record of variations.

Lindly & Co., Inc., Dept. ED, 248 Herricks Rd., Mineola, N.Y.

CIRCLE 264 ON READER-SERVICE CARD

Interference Filters

For ground support equipment

Made for military ground support equipment and conforming to MIL-F-15733C, these radio interference filters are hermetically-sealed and have stud type terminals for standard connectors. Ground terminals are provided on each side for grounding neutral power leads and harness shielding. The product line includes single and three-phase 120 and 240 v, 60 and 400 cps units with a current rating of 5 to 100 amp. Single and dual units for 28 v dc power lines are rated at 100 v dc and at 5 to 300 amp.

Genistron, Inc., Dept. ED, 2301 Federal Ave., Los Angeles 64, Calif.

CIRCLE 265 ON READER-SERVICE CARD

Tension Control

Spools fine gage wire

Called Auto-Tension Control No. 510-A-116, this unit spools and unspools fine gage wire and provides automatic control of tension. It is used for wire in the winding of electron tube grids, resistors, solenoids, potentiometers, and transformers.

The unit is comprised of an ac motor, controls, a sensing device, and an automatic brake. Controllable tension range is 1.5 to 140 g with winding speeds to 1000 ft per min for a spool with a 2 in. OD. Spool sizes to 4-1/2 in. OD can be accommodated. The unit is housed in a 12-3/4 x 4-13/16 x 8-11/16 in. anodized aluminum cabinet, is rated at 5 to 10 w, and operates from a 115 v ac, 60 cps, single-phase line.

Diehl Manufacturing Co., Dept. ED, Somerville, N.J.

CIRCLE 267 ON READER-SERVICE CARD

Function Generator

Has a 34-chord accuracy

Operating as an adjustable nonlinear potentiometer, the Vernistat-adjustable function generator produces any empirical or mathematical curve with a 34-chord accuracy. The function adjusting assembly is a 34-pole, 101-position printed circuit switch. An integral voltage divider provides voltages to the switch positions in 1% increments. The 34 poles are sliding contacts which are used to select the voltage levels to ±0.5% of any desired value.

The interpolating unit accepts the selected voltages and performs linear interpolation between the voltages appearing at adjacent sliding contacts. Applications include ballistic wind computers, differential analyzers, air data computers, and environmental controllers.

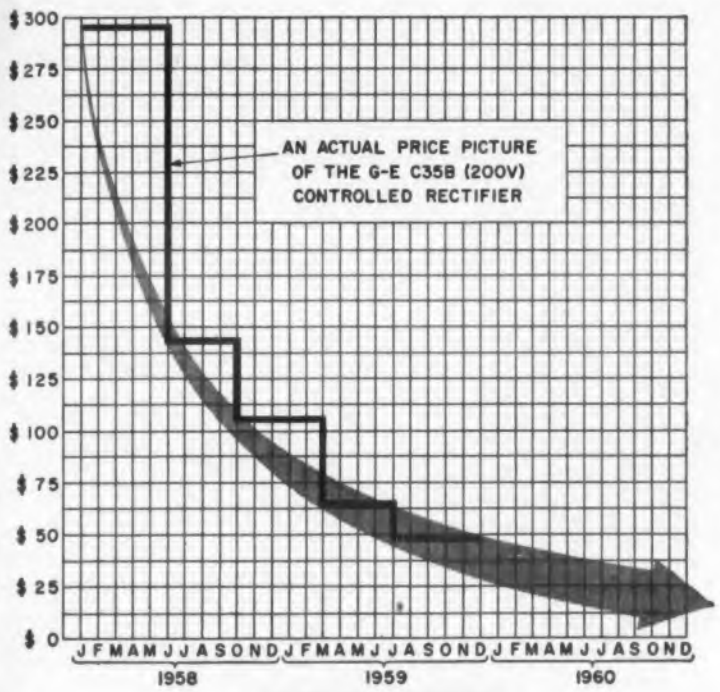
Perkin-Elmer Corp., Dept. ED, Norwalk, Conn.

CIRCLE 268 ON READER-SERVICE CARD

silicon controlled rectifier

Prices again reduced, new circuits developed, customer designs move into manufacturing stage

Prices again have been reduced an average of twenty percent on General Electric's Silicon Controlled Rectifier, providing greater values to users. These new prices have been made possible through expanding production and lower manufacturing costs.



GENERAL ELECTRIC
CONTROLLED RECTIFIER PRICE TREND

TESTS AND FIELD REPORTS PROVE RELIABILITY

Reliability of General Electric SCR's has been steadily improved over two years of manufacturing experience. Typical test results point to the reliability achieved to date.

98% survival after 1000 hours of storage at 125°.

97% survival after 1000 hours of operation at maximum ratings at 125°C.

No thermal fatigue failures after 30,000 cycles from 20°C to 135°C and return.

Less than one percent failures experienced by customers (many of which were traced to misapplication).

SCR NOW BEING USED BY MANY COMPANIES

The evaluation stage is passing rapidly into the application stage. Many products incorporating the SCR are being marketed, for the applications are proved, circuits refined and quantity production is a reality. These are just a few of the many cases where an SCR is now doing a job more efficiently, less expensively, faster or more reliably than previous designs:

Power supplies incorporating transient voltage protection (for computers).
Radar modulator.
Static switch to replace mechanical relay for aircraft.
Three phase inverter.
Stage lighting lamp dimming.
Regulated power supply.
Battery charging regulator.
Constant current supply for a magnetic yoke.

SEND FOR DESIGN INFORMATION

Detailed application notes and article reprints are available for the guidance of designers. Your General Electric Semiconductor Sales Representative will be pleased to provide you with complete details. Or write to Section **S23109**, Semiconductor Products Dept., General Electric Company, Electronics Park, Syracuse, New York. Many local G-E Semiconductor Distributors also stock General Electric SCR units for fast delivery at factory-low prices.

MAXIMUM ALLOWABLE RATINGS (Resistive or Inductive Load)

	C35U	C35F	C35A	C35G	C35B	C35H	C35C	C35D
Continuous Peak Inverse Voltage (PIV)	25	50	100	150	200	250	300	400 volts
Transient Peak Inverse Voltage (Non-Recurrent<5 millisec.)	35	75	150	225	300	350	400	500 volts
RMS Voltage (V_{RMS}), Sinusoidal	17.5	35	70	105	140	175	210	280 volts
Average Forward Current (I_F)	Up to 16 amperes							
Peak One Cycle Surge Current (I_{surge})	150 amperes							
Peak Gate Power	5 watts							
Average Gate Power	0.5 watts							
Peak Gate Current (I_G)	2 amperes							
Peak Gate Voltage (V_G) (forward)	10 volts							
Storage Temperature	−65°C to +150°C							
Operating Temperature	−65°C to +125°C							

CHARACTERISTICS (At Maximum Ratings)	C35U	C35F	C35A	C35G	C35B	C35H	C35C	C35D
Minimum Forward Breakover Voltage (V_{BO})	25	50	100	150	200	250	300	400 volts
Maximum Reverse (I_R) or Forward (I_S) Leakage Current (Full Cycle Average)	6.5	6.5	6.5	6.5	6.0	5.5	5.0	4.0 ma
Maximum Forward Voltage ($V_{F\ AVG}$)	0.86 volts (Full Cycle Average)							
Maximum Gate Current To Fire (I_{GF})	25 ma							
Maximum Gate Voltage To Fire (V_{GF})	3 volts							
Typical Gate Current To Fire (I_{GF})	10 ma at +1.5 volts (Gate to Cathode Voltage)							

C-35 Series—lower cost series with ratings similar to above, but for use up to 100°C maximum, with forward current ratings up to 10 amperes.
ZJ-50 Series—a high-current series now in development, and available on a prototype-sample basis.

GENERAL ELECTRIC

Semiconductor Products Department

CIRCLE 269 ON READER-SERVICE CARD

Tape Reader

Reads to 48 lines simultaneously

For standard 1-in. 5 to 8-hole paper or Mylar tapes, the series TR tape block reader can read a fixed block of information of up to 48 lines or 384 bits simultaneously. Output terminals are available for all bits through special alloy triple-wire brush contacts. The device is useful for numerically controlled systems, automatic programming, and automatic testing.

Wang Laboratories, Inc., Dept. ED, 12 Huron Dr., Natick, Mass.

CIRCLE 270 ON READER-SERVICE CARD

Resistors

Molded-carbon deposited type

Type CPM molded-carbon deposited resistors are encapsulated in moisture and heat resistant plastic. Called Carbomold, they are supplied in ranges of 10 ohms to 5 meg in the 0.5-w size, 10 ohms to 10 meg in the 1-w size, and 30 ohms to 20 meg in the 2-w size. Tolerance is ±1%. Designed for full load at 70 C and derated to zero at 150 C, they exceed the insulation resistance requirements of MIL-R-1059C.

Aerovox Corp., H-Q Div., Dept. ED, Olean, N.Y.

CIRCLE 271 ON READER-SERVICE CARD

Spectrum Analyzers

Range is 1 to 200 cps

These real-time spectrum analyzers, called Simoramic, synthesize the equivalent of thousands of bandpass filters by means of a single delay line in a closed loop. The frequency location, impulsive response, and gain of all the synthesized filters are determined by the same network elements in the closed loop. The outputs are presented sequentially. Model 4A covers the band of 1 to 200 cps with about 1 cps resolution.

Federal Scientific Corp., Dept. ED, 615 W. 131 St., New York 27, N.Y.

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Spools fine gage wire

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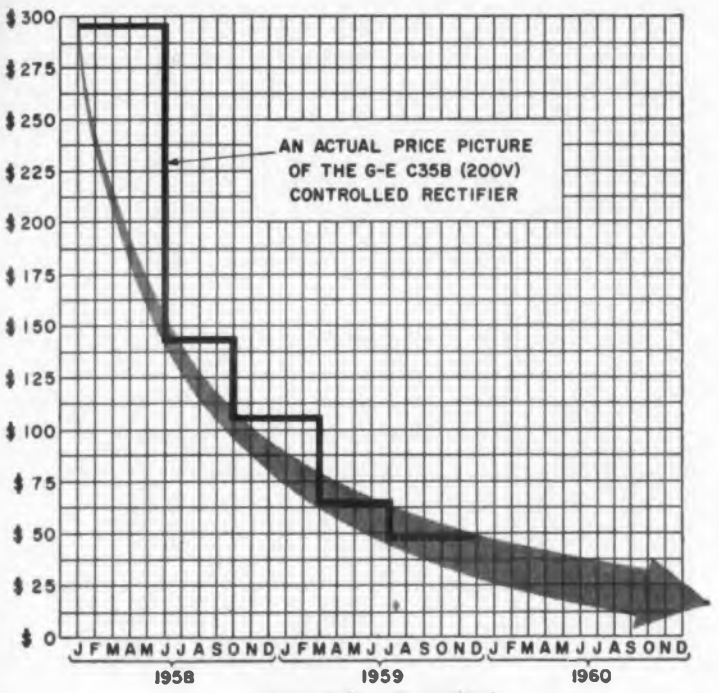

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- Three phase inverter.
- Stage lighting lamp dimming.
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- Constant current supply for a magnetic yoke.

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GENERAL ELECTRIC

Semiconductor Products Department

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Aerovox Corp., H-Q Div., Dept. ED, Olean, N.Y.

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Federal Scientific Corp., Dept. ED, 615 W. 131 St., New York 27, N.Y.

CIRCLE 272 ON READER-SERVICE CARD

NEW PRODUCTS

INSULATED SOLDERLESS TERMINALS.—Included in this line are 13 ring tongue terminals with hole diameters from 9/64 to 13/32 in., five spade tongue terminals with hole diameters from 9/64 to 13/64 in., and three butt connectors for wire sizes 22-16, 16-14, and 12-10 gages. They are color-coded for size.

Vaco Products Co., Dept. ED, 317 E. Ontario St., Chicago 11, Ill.

CIRCLE 274 ON READER-SERVICE CARD

FASTENERS.—One-piece, right-angle, type are available in many configurations for lengths to 3 in. of instrument panels, shock-mounting of equipment in 0.02-in. increments. For such uses as attachment in package containers, tubing and wiring harnesses, they have been vibration tested to 43 g with amplitudes to 0.375 in., and at frequencies to 80 cps.

Western Sky Industries, Dept. ED, 21301 Cloud Way, Hayward, Calif.

CIRCLE 275 ON READER-SERVICE CARD

ALUMINUM NUTS.—Are self-locking type and have a stainless steel wire form. They meet the requirements of MIL-C-25027 for 550 F operation.

Waltham Precision Instrument Co., Dept. ED, 221 Crescent St., Waltham 54, Mass.

CIRCLE 276 ON READER-SERVICE CARD

LATITUDE COUNTER.—Reads directly in degrees and minutes. The characters are 0.125 x 0.075 in. and are furnished in standard or fluorescent enamels. The unit measures 1.725 x 0.5 x 0.75 in. The ball-bearing mounted shaft may be operated at 500 rpm constant or up to 1500 rpm intermittent. Mil specs for aircraft are met.

Veeder-Root Inc., Dept. ED, Hartford 2, Conn.

CIRCLE 277 ON READER-SERVICE CARD

ELECTRONIC ASSEMBLY AND MAINTENANCE TOOLS.—Set 5343-ET-B has special alloy steel tools that are heat treated. Screwdrivers for compact assemblies, pliers, diagonal cutters, drivers, and a pencil-type soldering iron are included in this set of 43 tools.

Snap-on Tools Corp., Dept. ED, 28th Ave., Kenosha, Wis.

CIRCLE 278 ON READER-SERVICE CARD

VIDEO MONITORS.—Have a resolution of 600 lines, 2% max nonlinearity, and an 8-mc frequency response. The modules are plug-in type and the aluminized picture tube has a nonglare face plate. The following picture tube sizes are available: type V-36 is 14 in., V-96 is 17 in., V-98 is 21 in., and V-92 is 24 in. They may be either cabinet or rack design.

Foto-Video Labs., Inc., Dept. ED, 36 Commerce Rd., Cedar Grove, N. J.

CIRCLE 279 ON READER-SERVICE CARD

Variable Resistors

Wirewound

These preset wirewound variable resistors have a resistance range of 1/2 to 5000 ohms and measure 3/4 in. in diameter. Positive contact with the resistance winding at every point of rotation is provided by a spring contactor. Continuous contact between contactor, rotor, and cover is also provided. Rotational torque is 2 to 8 oz-in., stop torque is 12 lb-in., and the angle of rotation is 240 ±5 deg without fixed resistor stop. Type 110 has straight or snap-in mounting tabs and terminals for printed circuits and type 112 has a flange type cover for eyelet or rivet mounting.

Chicago Telephone Supply Corp., Dept. ED, Elkhart, Ind.

CIRCLE 280 ON READER-SERVICE CARD

Leak Detector

Detects 1 x 10^{-13} cc per sec

Model 700A leak detector is sensitive to a leak rate of 1 x 10^{-13} cc of air per sec. The attenuation settings are 1, 3, 10, 30, 100, 300, and 1000. The required input is 115 v, 60 cps, single-phase. Model 700B includes a pumping system in addition to the basic instrument. The over-all dimensions of these units are 52 x 45-1/2 x 25-1/2 in.

Crosby-Teletronics Corp., Vacuum Research Div., Dept. ED, 54 Kinkel St., Westbury 4, L.I., N.Y.

CIRCLE 281 ON READER-SERVICE CARD

Silicon Transistors

Saturation resistance under 5 ohms at 10 μa

These symmetrical pnp silicon transistors have a saturation resistance of less than 5 ohms at 10 μa. Leakage currents are held below 0.005 μa. Like relay contacts, the transistors can switch current in both directions. They are used in choppers, demodulators, bilateral applications, and conventional switching circuits.

Crystalonics, Inc., Dept. ED, 249 Fifth St., Cambridge, Mass.

CIRCLE 282 ON READER-SERVICE CARD

CIRCLE 283 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Neon Indicator Unit

Mounts in 3/8-in. hole

This low-voltage neon indicator unit generates its own ignition voltage from any applied dc voltage of four or more volts. It mounts in a 3/8-in. hole and is available in a variety of lens shapes and colors. Called a Tec-Lite, and designated the LVN-Series, it may be operated directly from the source voltage. Or it may be additionally controlled by a low voltage, high impedance input signal. It is designed for portable, battery-operated equipment.

Transistor Electronics Corp., Dept. ED, 3357 Republic Ave., Minneapolis 26, Minn.

CIRCLE 285 ON READER-SERVICE CARD

Circulator Tee

Frequency range is 9 to 9.16 kmc

For missile applications, transponders, beacons, and other airborne radar systems, model 380864-1A three-port circulator tee has a frequency range of 9 to 9.16 kmc with isolation at 16 db min. The insertion loss from the transmitter to the antenna is 0.4 db max, and from the antenna to the receiver, 0.2 db max. The input vswr is 1.5 max, peak power is 50 kw, and average power is 50 w.

Kearfott Co. Inc., Microwave Div., Dept. ED, 14844 Oxnard St., Van Nuys, Calif.

CIRCLE 286 ON READER-SERVICE CARD

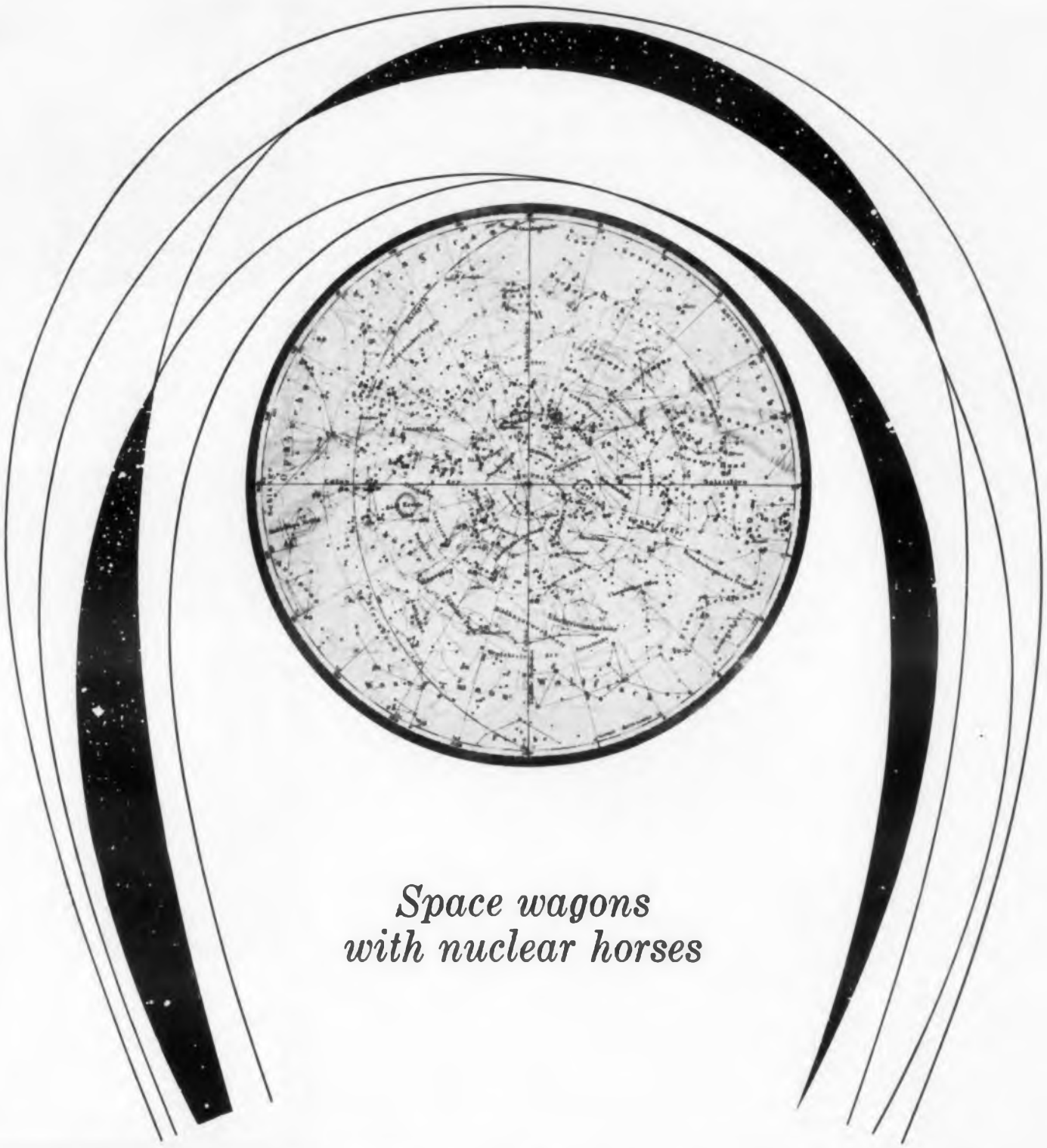
Picture Tube

Needs no safety plate

Type 23KP4 square-cornered picture tube needs no safety plate, and has 114 deg deflection using standard 110 deg sweep components. The tube is 23 in. wide and uses a dark safety glass, called Ultra-Vision,, which increases picture contrast and cuts reflected light.

General Electric Co., TV Receiver Dept., Dept. ED, Electronics Park, Syracuse, N.Y.

CIRCLE 287 ON READER-SERVICE CARD



Space wagons with nuclear horses

Space exploration will really come of age when manned rockets can leave earth, accomplish their missions and return without disposing of parts of themselves en route. This breakthrough depends on the rapid development of both nuclear rocket engines and the space vehicles capable of using them. Douglas is putting forth a major research effort in the area of manned nuclear space ships. Every environmental, propulsion, guidance and structural problem is being thoroughly explored. Results are so promising that even if the nuclear engine breakthrough comes within the next five years, Douglas will be ready to produce the vehicles to utilize this tremendous new source of space power! Douglas is seeking qualified scientists and engineers for this and other vital programs.

Elmer Wheaton, Engineering Vice President, Missiles and Space Systems, goes over new space objectives that will be made possible by nuclear propulsion with Arthur E. Raymond, Senior Engineering Vice President of DOUGLAS

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- Strength Testing
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- Mathematical Analysis

For full information
write to:

Mr. C. C. LaVene
Box 601-E
Douglas Aircraft Company, Inc.
Santa Monica, Calif.

NEW PRODUCTS

Wire Tubing

For high temperature use

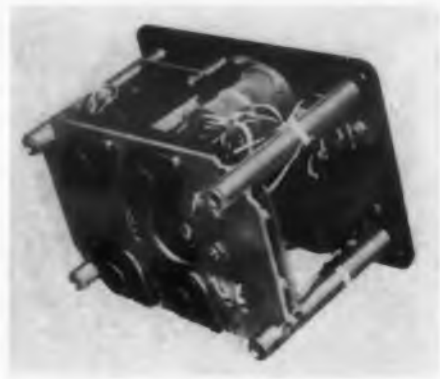
This aluminized, silicone-rubber impregnated glass cloth, called Zippertubing, is for use on wires and cables in high temperature areas. It has good chemical resistance and can be used on aircraft cables which are in contact with hydraulic fluids such as Skydrol. It is designed for easy installation.

Zippertubing Co., Dept. ED, 752 S. San Pedro St., Los Angeles 14, Calif.

CIRCLE 290 ON READER-SERVICE CARD

Servo Amplifier

Operates dc plus 2 and 3-phase motors



Designed to respond to 400 cps control signals obtained from synchro, induction-potentiometer, or resistance-potentiometer follow ups, model D-3320 servo amplifier operates dc, two-phase, and three-phase motors. The temperature range is −65 to +160 F. Positioning time is as low as 5 sec from travel stop-to-stop. The unit withstands 10 g vibration at frequencies to 2000 cps and 15 g shock. Solid state electronics are used. The unit is adaptable to aircraft, missile, ordnance, marine, and industrial applications.

Hoover Electric Co., Dept. ED, Hanger Two, Port Columbus Airport, Columbus 19, Ohio.

CIRCLE 291 ON READER-SERVICE CARD

Wire Cutter

Automatic

For short run productions, model AB-4 wire cutter can be operated by inexperienced personnel. Wire may be cut in lengths from 2-1/2 to 25 in. The counter, which determines the number of pieces to be cut, may be set from 0 to 500. Hook-up wire and sleeving is cut at the rate of 1000 ft per hr.

Electronic Industries, Dept. ED, 2624 Perliter St., N. Las Vegas, Nev.

CIRCLE 292 ON READER-SERVICE CARD

SILICON MONOCRYSTALS.—Semiconductor grade, are doped to customer specifications. The boron level is less than 1/2 ppb. Undoped monocrystals have resistivities of 800 ohm-cm or higher and lifetimes in excess of 200 μsec. Polycrystalline rods are also available.

Grace Electronic Chemicals, Inc., Dept. ED, 101 N. Charles St., Baltimore 1, Md.

CIRCLE 294 ON READER-SERVICE CARD

SILICON DIODES.—For very fast computer switching applications, types RD2121 and RD2124 recover to 200 K in 0.2 μsec. Typical capacitance is 1.5 μμf. Mil specs are met.

Rheem Semiconductor Corp., Dept. ED, 327 Moffett Blvd., Mountain View, Calif.

CIRCLE 295 ON READER-SERVICE CARD

JAR BATHS.—Called Magni-Whirl, are for ASTM kinematic viscosity tests and general laboratory use. Automatic pulsation of the agitator plate maintains temperatures constant to ±0.1 deg C. The temperature range can be 70 C or to 100 C. The design allows for full visibility.

Blue M Electric Co., Dept. ED, 138th and Chatham St., Blue Island, Ill.

CIRCLE 296 ON READER-SERVICE CARD

SOLDERING TIP CLEANER.—Type 149 has brushes treated to withstand heat. Certified not to cause corrosion of solder joints, it is used in laboratories, industrial applications, and workshops.

Dickinson's Electronics, Dept. ED, Sacramento 24, Calif.

CIRCLE 297 ON READER-SERVICE CARD

SHIPPING CONTAINER.—Gives complete protection to electronic equipment and conforms to the Air Transportation Association category 1 standards. They are made in customer-specified sizes and are re-usable.

William Bal Corp., Dept. ED, 947 Newark Ave., Elizabeth, N. J.

CIRCLE 298 ON READER-SERVICE CARD

LAMP SHIELDS.—Spring-type brass, cadmium-plated, they fit directly on the glass part of the T-3 1/4 lamp. They come in straight or flared design.

Amatom Electronic Hardware Co., Inc., Dept. ED, 88 Drake Ave., New Rochelle, N. Y.

CIRCLE 299 ON READER-SERVICE CARD

BATTERY CHARGE CONTROL.—Type MP-3 automatically controls the battery charging equipment as it brings the battery to a full state of charge, and then automatically terminates the charge. Designed to control both regular daily charges and weekly equalizing charges, it requires no attendance or resetting. For controlling modified-constant potential battery charging, units are available for 6- to 60-cell batteries. Dimensions are 6-1/4 x 8-1/8 x 4-1/8 in.

The Electric Storage Battery Co., Exide Div., Dept. ED, Rising Sun and Adams Aves., Philadelphia 20, Pa.

CIRCLE 300 ON READER-SERVICE CARD

NEW PRODUCTS

Potentiometer

Resistance range is 10 ohms to 100 K

Model 224 Trimpot potentiometer has a resistance range of 10 ohms to 100 K, a temperature range of −65 to +175 C, and a power rating of 1 w at 70 C. The resolution is as low as 0.17%. Three terminal configurations are available: insulated stranded leads, solder lugs, and printed circuit pins. The unit weighs 0.1 oz and measures 0.19 x 1.25 x 0.32 in. It meets MIL-STD-202A.

Bourns, Inc., Dept. ED, P.O. Box 2112. Riverside, Calif.

CIRCLE 303 ON READER-SERVICE CARD

Frequency Signal Source

Delivers 40 to 4000 cps

For aircraft, missile, and ground control equipment, model MJXO frequency signal source delivers from 400 to 4000 cps. The unit is available with accuracies of ±0.05%, ±0.02%, and ±0.01% for continuous operation from −55 to +85 C. Operating from a 28 v dc, 20 ma, it furnishes a 0.23 rms min sine wave into equal or more than 2 K load, or 6 v peak-to-peak min clipped sine wave into equal or more than 7.5 K load. The unit is potted in silicone rubber and is hermetically sealed. Variations in waveform, output, and input are available.

Philamon Laboratories, Inc., Dept. ED, 90 Hopper St., Westbury, N.Y.

CIRCLE 304 ON READER-SERVICE CARD

Active Cathode Alloy

For vacuum tubes

Type X-3012 active cathode alloy is available in the form of seamless, Weldrawn, disc, lock-seam, and lapseam cathodes for vacuum tube. Having a high emission rate and a low sublimation rate, this material is made by adding 0.1% zirconium and 2% tungsten to the nickel base. Cathodes made from it can be fired at 700 C without undue softening.

Superior Tube Co., Dept. ED, 1521 Germantown Ave., Norristown, Pa.

CIRCLE 305 ON READER-SERVICE CARD

CLINCH NUTS.—Types NKCFM are used in miniature components in aircraft, missiles, and industrial applications. They are effective to 350 F. The integral nylon cap seals pressures to 80 psi past the bolt threads. The installation may be by hand or by using a riveting or spinning technique. Shank lengths are 0.04 to 0.06 in. and minimum thickness is 0.03 in. Available in thread sizes 4-40 through 10-32, they are made of steel, cadmium plated, and stainless steel, plain finish. They meet AN-N-10 and MIL-N-25027 requirements.

Elastic Stop Nut Corp. of America, Dept. ED, 2330 Vauxhall Rd., Union, N. J.

CIRCLE 307 ON READER-SERVICE CARD

STRAIGHTENER AND ORIENTER.—Type H-100 straightens diode leads and feeds packages into test equipment, taping machines, and marking machines. Typical operating speed is 3600 diodes per hr. Power required is 115 v ac.

Carman Labs., Inc., Dept. ED, 10 Carman Rd., Bedford, Mass.

CIRCLE 308 ON READER-SERVICE CARD

CASES.—For housing components or assemblies which must be easily accessible, three sizes of Minislides are available. They are made of aluminum.

Bud Radio, Inc., Dept. ED, 2118 E. 55th St., Cleveland 3, Ohio.

CIRCLE 309 ON READER-SERVICE CARD

CASES.—Designed for installation of more components than is possible with other cases of the same size, they have both snap lock and screw type fastening and are made of steel or aluminum. Called Miniboxes, they come in 18 sizes.

Bud Radio, Inc., Dept. ED, 2118 E. 55th St., Cleveland 3, Ohio.

CIRCLE 310 ON READER-SERVICE CARD

WIRE STRIPPERS.—Called Luco, they can strip plastic, polyethylene insulation, and Teflon. Several models are available for either hand or foot pedal operation. The model LT 4 can be modified for solenoid operation, mounted on work tables.

Electronic Applications, Inc., Dept. ED, 194 Richmond Hill Ave., Stamford, Conn.

CIRCLE 311 ON READER-SERVICE CARD

WIRE STRIPPER.—Strips wire larger than No. 12 AWG and smaller than No. 36 AWG as well as coaxial cable. Called model F, it can be used with Teflon, vinyl, nylon, mylar, rayon, and polyethylene.

Western Electronic Products Co., Dept. ED, 655 Colman St., Altadena, Calif.

CIRCLE 312 ON READER-SERVICE CARD

SILICON DIODES.—Types RD1356 through RD1359 have a resistance to 50,000 meg at 25 C. Forward conductance is 100 ma at +1 v and breakdown voltages range is to 200 v. Mil requirements are met.

Rheem Semiconductor Corp., Dept. ED, 327 Moffett Blvd., Mountain View, Calif.

CIRCLE 313 ON READER-SERVICE CARD

GRID.—For drafting printed circuits, has a tolerance of ±0.001 in. over a 36-in. dimension. The material used is Mylar.

Flexigraph Co., Inc., Dept. ED, 998 Farmington Ave., W. Hartford, Conn.

CIRCLE 481 ON READER-SERVICE CARD

RECORDING THERMOMETER.—Uses a dry stylus and will record in any position. Temperature ranges are +20 to +220 F or −40 to +160 F; time ranges are either 24 hr or 7 days. The unit weighs 14 oz and measures 3-15/16 x 2-7/8 x 3-3/8 in.

Pacific Transducer Corp., Dept. ED, 11836 W. Pico Blvd., Los Angeles 64, Calif.

CIRCLE 482 ON READER-SERVICE CARD

FREQUENCY CALIBRATOR.—For fm-fm telemetering systems model 520 has a calibration time of 30 sec per channel. External metering is provided and operation may be effected by inexperienced personnel.

Fenske, Fedrick & Miller, Inc., Dept. ED, 12820 Panama St., Los Angeles 66, Calif.

CIRCLE 483 ON READER-SERVICE CARD

NEW PRODUCTS

Phase Shifter

Produces 90 deg phase shift

Model 400 phase shift unit produces a 90 deg phase shift with a precision of 0.05 deg. The unit has a low phase gradient with respect to frequency, unity gain, low output impedance, and stable operation. Calibration adjustments are provided for. For operation at 400 cps, the unit has applications in tachometer testing, generating two-phase signals, and phase angle generation. It can be supplied in either full panel or half-panel sizes.

Dytronics, Dept. ED, P.O. Box 3676, Columbus 14, Ohio.

CIRCLE 316 ON READER-SERVICE CARD

Thermostat

Rated at 5.5 amp on 110 to 120 v ac

Type B thermostat operates on the principle of current flowing through the bimetal and generating heat which actuates the bimetal, breaking the circuit. As the device cools, the bimetal returns to the normal position and recloses the contacts. The blade and bimetal are supplied to give any desired performance. The unit is normally rated at 5.5 amp on 110 to 120 v ac. Both screw and quick disconnect terminals are standard; other types are available on special order. Adjustable and non-adjustable types can be furnished.

Clark and Bobertz, Inc., Hickok-Donnelley Div., Dept. ED, 1900 Euclid Ave., Cleveland 15, Ohio.

CIRCLE 317 ON READER-SERVICE CARD

SILICON MESA TRANSISTORS.—Are npn, double-diffused type with a switching time of 25 mμsec. Saturation resistance is 5 ohms. They conform to Mil specs and to JEDEC TO-5.

Rheem Semiconductor Corp., Dept. ED, 327 Moffett Blvd., Mountain View, Calif.

CIRCLE 320 ON READER-SERVICE CARD

NAME PLATES.—Are made from color-fast, anodized aluminum. They can be used for marking and decorating electrical equipment such as relays, transformers, regulators, and dial faces. Wiring and circuit diagrams can also be placed on them. They are custom-made in all sizes, designs, and in one or more colors. The name plates can be supplied with various types of adhesives and are resistant to organic solvents and extreme weather conditions.

Allied Decals, Inc., Dept. ED, 8100-35 Hough Ave., Cleveland, Ohio.

CIRCLE 321 ON READER-SERVICE CARD

MILLIWATTMETER.—Type U-381 is a portable, resistive film, bolometer wattmeter for the measurement of microwave power. It measures power in the 1 to 100 mw range with an accuracy of ±3% over the frequency band of 12 to 18 kmc. The unit has terminals provided for calibrating it against dc power. A micrometer adjustment permits a short-circuiting termination to be set for a vswr near unity at any frequency within the specified range.

Wayne Kerr Corp., Dept. ED, 1633 Race St., Philadelphia 3, Pa.

CIRCLE 322 ON READER-SERVICE CARD

TRAVELING WAVE TUBE.—Designed for microwave relay service. These tubes are available in models which cover frequency bands spanning 800 to 4800 mc.

International Telephone and Telegraph Co., Dept. ED, 67 Broad St., New York 4, N. Y.

CIRCLE 323 ON READER-SERVICE CARD

STEPPING RELAY.—Operates at a step rate of 8 per sec. It is a 12-position unit. Three of these relays have operated for more than 60 million revolutions with no indication of impending failure in life tests.

International Telephone and Telegraph Corp., Dept. ED, 67 Broad St., New York 4, N. Y.

CIRCLE 324 ON READER-SERVICE CARD

DPDT CHOPPER.—Model C1430-1 is a 9-pin plug-in unit with make-before-break-after action. Excitation frequency is 260 to 440 cps. The unit operates in temperatures from —65 to +125 C and will take 30 g of shock. The case measures 1/4 x 1-3/8 in. Model C1430 is a 9-pin general purpose unit that also has an excitation frequency of 360 to 440 cps. Other specifications are the same as for the C1430-1.

The Bristol Co., Aircraft Equipment Div., Dept. ED, Waterbury 20, Conn.

CIRCLE 325 ON READER-SERVICE CARD

NEW PRODUCTS

Wavemeters

Absorption type

This series of absorption wavemeters offers the following frequency ranges: model RDW-5R, 1 to 2 kmc; model RDW-6R, 2 to 4 kmc; and model RDW-7R, 4 to 8 kmc. All models have a built-in crystal detector and a micrometer movement which is readable to 0.0001 in. The off-resonance insertion loss is less than 1 db and the insertion loss at resonance is about 2 db. The vswr is below 1.5; the loaded Q is greater than 2000. Each unit is furnished with a calibrated chart activated to 0.1%. Electrical foreshortening results in a maximum length of 14 in. for the largest unit.

Radar Design Corp., Dept. ED, Pickard Drive, Syracuse 11, N.Y.

CIRCLE 327 ON READER-SERVICE CARD

Frequency Generator

Provides 60 to 4000 cps

Model TFGX frequency generator, incorporating a tuning fork oscillator, provides from 60 to 4000 cps and a variety of output waveforms and voltages. It operates from 28 v dc to furnish 6 v peak-to-peak square wave or pulse into equal or more than 7.5 K load, or alternately a 1 rms filtered sine wave into equal or more than 10 K with less than 1% distortion. Binary frequency dividers offer lower frequencies with over-all accuracy and stability ranges from 0.001% to 0.05%. The unit is potted in silicone rubber and hermetically sealed.

Philamon Laboratories, Inc., Dept. ED, 90 Hopper St., Westbury, N.Y.

CIRCLE 328 ON READER-SERVICE CARD

Microammeter

Range is 0 to 50 μa

This recording type dc microammeter has a range of 0 to 50 μa with an input resistance of about 200 ohms. Ranges of 0 to 10, 50 and 200 mv dc are also included. A magnetic amplifier, powered by 120 v, 60 cps, is combined with a permanent-magnet moving-coil movement. Accuracy is within 2% of full scale. The instrument can be used in series with or as a substitute for indicating instruments that give only instantaneous readings. Chart speeds are 3/4 in. per hr through 12 in. per min. Portable or mounting type models with motor or spring driven chart drives are offered.

Esterline-Angus Co., Dept. ED, Indianapolis 6, Ind.

CIRCLE 329 ON READER-SERVICE CARD

Solenoids

Coils are encapsulated

Series 801 double-T solenoids have a layer of epoxy resin for protection from moisture, water, machine oils, diluted acids, and harmful alkalies. The double-T design provides almost level pull characteristics throughout the plunger stroke. As the plunger decreases, the gap in the frame is bridged by the extra T-section on the plunger, providing additional pull and preventing a drop in power. Type 801 has a maximum stroke of 5/8 in., a formed pull-bar, and a 1/2-in. stack. Type 812 has a maximum stroke of 1-1/16 in., a straight pull-bar with reinforced slugs, and a 3/4 or 1-in. stack. Type 821 has a maximum stroke of 1-3/8 in., a formed pull-bar, and a 1-in. stack. Each is available for either constant or intermittent duty at 110 or 220 v, 60 cps. Units for dc may be ordered.

Controls Co. of America, Industrial and Commercial Controls Div., Dept. ED, 9555 Soreng Ave., Schiller Park, Ill.

CIRCLE 330 ON READER-SERVICE CARD

CIRCLE 331 ON READER-SERVICE CARD ➤

NEW PRODUCTS

DC Motors

Have constant speed

These constant speed dc motors are for such uses as controlling circuits from a battery. With operating voltages from 3 to 110 v dc and from 0.06 to 2 w input power, up to 150 oz-in. of torque can be produced at 1 rpm. Speeds from 900 rpm to 1 revolution in 24 hr can be provided. Severe environmental conditions, including vibration, gravity, and temperature, are provided for.

Amglo Corp., Dept. ED, 4325 N. Ravenswood Ave., Chicago 13, Ill.

CIRCLE 332 ON READER-SERVICE CARD

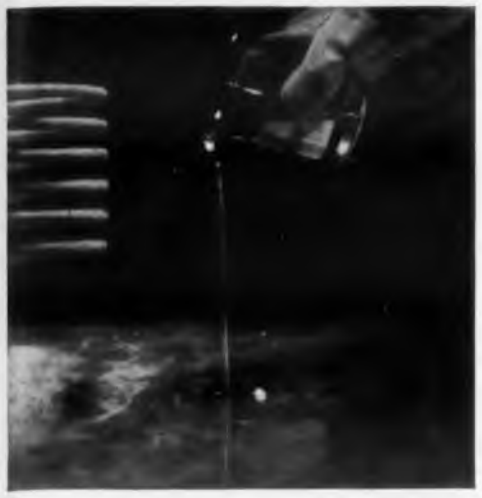
Counter

Has selectable digital time base

Equipped with a highly variable counting interval, model 5311 counter provides indications of flow, pressure, and speed in units such as psi, rpm, and gal per sec. The counting interval may be varied in steps of 10 μsec from 10 μsec to 1 sec. The frequency counting range is 10 cps to 200 kc. The counter makes period measurements by timing the duration of 1 to 100,000 cycles in 10-μsec units. It is possible to produce a percentage indication of deviation from any given frequency by timing the number of input cycles. The internal time standard has a stability of 3 parts in 10^7 per day at a constant temperature. The ambient temperature range is −5 to +150 F.

Beckman Instruments, Inc., Berkeley Div., Dept. ED, 2200 Wright Ave., Richmond 3, Calif.

CIRCLE 333 ON READER-SERVICE CARD



3M FLUOROCHEMICAL FC 75 pours at −148°F. It has a wide liquid range of −148°F. to 212°F. at atmospheric pressure, with low viscosity. In addition, it offers these useful properties: high dielectric strength of 37KV; self-healing, maintaining dielectric strength after repeated high voltage arcing. Compatible with most materials used in high temperature equipment. Thermally stable in excess of 800°F., it prevents development of hot spots in equipment. Prevents sludge formation due to hydrolysis or oxidation.

or at 800° F.

For free literature, write on your company letterhead, specifying product interest to 3M Chemical Division, Dept. KAP-119, St. Paul 6, Minn.

3M CHEMICAL DIVISION, MANUFACTURERS OF:
Acids • Resins • Elastomers • Plastics • Oils, Waxes and Greases • Dispersion Coatings • Functional Fluorochemicals • Inert Liquids and Surfactants

COATING.—For spray coating of metal parts to provide anti-stick properties or for corrosion resistance or electrical insulation. The coating is made from Teflon and Kel-F. Custom coatings of from one to 20 mils in thickness can be applied to specification.

R. S. Hughes Co., Inc., Dept ED, 4515 Alger St, Los Angeles 39, Calif.

CIRCLE 335 ON READER-SERVICE CARD

INSERT.—Meets fastener requirements in electronic equipment. The S110 insert requires hole drilling only and can be used in open or blind applications. The insert provides load bearing, wear resistant, self-locking threads for holes in materials such as plate or cast aluminum, magnesium and cast iron. It can be used to temperatures as high as 450 F.

Rivet Tool Co., Dept. ED, 2600 W. 247th St., Torrance, Calif.

CIRCLE 336 ON READER-SERVICE CARD

CRADLE HEAD.—Permits tilting and panning television cameras by remote control. This makes possible positioning of cameras in inaccessible and dangerous locations. The control cradle head is powered by two separate motors which tilt the camera 30 deg up and 38 deg down and rotate it 370 deg. They are housed in soundproof housings for silent operation. Manual operation is also possible.

Houston Fearless Corp., Dept. ED, 11849 W. Olympic Blvd., Los Angeles 64, Calif.

CIRCLE 337 ON READER-SERVICE CARD

PROTECTIVE COMPOUND.—For protecting electric motor stator windings against moisture, dirt, abrasives, chemicals and other contaminants. Called Hysol 10-55, it is a two-component system which is mixed 1 to 1 by volume. The usual curing oven temperatures are used for preheating the motor and for curing the compound.

Houghton Laboratories Inc., Dept. ED, Olean, N. Y.

CIRCLE 338 ON READER-SERVICE CARD

POTTING COMPOUND—For power transformers, the B-1317 material has a coefficient of shrinkage of 0.0002 in. per in. It offers adhesion to metal and a +265 F cold flow resistance. Good pour characteristics are obtained at +330 to +350 C.

Biwax Corp., Dept. ED, 3445 Howard St., Skokie, Ill.

CIRCLE 339 ON READER-SERVICE CARD

POWER SUPPLIES.—Chopper stabilization is now available as an optional accessory on Regatron power supplies. The chopper stabilizer raises the stability and regulation fixtures for the Regatron units by a factor of from 10 to 50.

Electronic Measurements Co. Inc., Dept. ED, Eatontown, N. J.

CIRCLE 340 ON READER-SERVICE CARD

NEW PRODUCTS

Wirewound Potentiometer

Rating is 4 w at 40 C

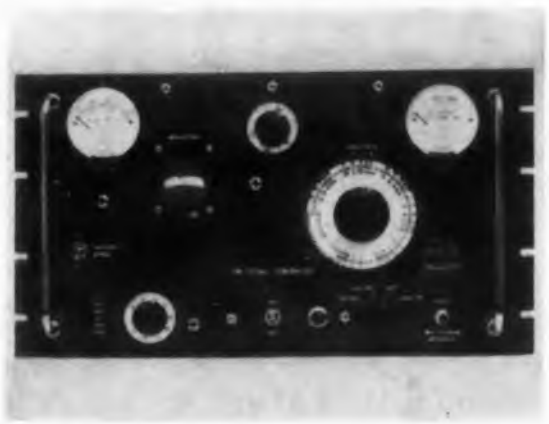
Type 45 wirewound potentiometer has a power rating of 4 w at 40 c, derated to zero at 135 C. The unit has a 1-1/8 in. diam. The resistance range is from 1 ohm to 10 K, linear; resistance tolerances are ±10% or closer. It is available with one tap at 50% ±2% resistance, at any position electrically. Series 45M, made to meet Mil specs, can also be supplied. Mechanical and electrical rotation is 300 deg, 280 deg effective. Torque is 1.2 to 6 oz-in.

Clarostat Manufacturing Co., Inc., Dept. ED, Dover, N.H.

CIRCLE 342 ON READER-SERVICE CARD

Signal Generator

Covers 150 to 280 mc



Designed for telemetry applications, model 100 TM fm signal generator has a total range of 150 to 280 mc. It can be used with beating units to provide lower carrier frequencies. Its 300-kc deviation permits direct sweeping of if stages. Spurious outputs are harmonics of the oscillator only. The unit conforms to JCEC specs and meets all telemetry requirements for carrier frequency, deviation, and modulating frequency. It occupies 10-1/2 in. of panel space.

Waltham Electronics Corp., Dept. ED, Waltham, Mass.

CIRCLE 343 ON READER-SERVICE CARD

Recording System

For use with computers

This recording system, called Dacom, reads magnetic tape from a computer and records characters on microfilm. The unit operates at 16,500 characters per sec. As many as 66 lines of 130 characters can appear as a page; these are microfilmed at more than 2 frames per sec. A roll of 1000 ft of 16-mm film contains the decoded information from more than 35 reels of 2400-ft magnetic tape.

Eastman Kodak Co., Dept. ED, 343 State St., Rochester 4, N.Y.

CIRCLE 344 ON READER-SERVICE CARD

Oscillograph Recording System

Has eight channels

Model 958-1500 direct wiring oscillograph recording system accepts up to eight floating or grounded inputs. It has a maximum sensitivity of 10 μv per chart division. All circuitry is transistorized and features include up to eight channels of amplification, and a common power supply. Plug-in printed circuit units are used and the system can be adapted for use with other readout devices. The system has a linearity of ±0.4%. Frequency response is from 0 to 100 cps within 3 db at 10 divisions peak-to-peak amplitude. There is a choice of eight switch-selected sensitivities. The enclosed galvanometers have velocity feedback damping.

Sanborn Co., Industrial Div., Dept. ED, 175 Wyman St., Waltham 54, Mass.

CIRCLE 345 ON READER-SERVICE CARD

CIRCLE 346 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Epoxy Resin

Flame-proof, semi-flexible

Type XR-5019 Scotchcast semi-flexible epoxy resin meets and exceeds the flammability and thermal shock requirements of MIL-I-16923C and MIL-T-27A. It is a two part, thermosetting resin with a mixed pot life of 3 or 4 days at room temperature. The initial viscosity is 100 cps at 76 C, and the moisture absorption is 0.76% after 240 hr immersion. The electrical strength is 600 v per mil in 50-mil thickness. The dielectric constant is 7.24 at 1000 cps, —130 C. The dissipation factor is 0.199. Three cure cycles are recommended: 120 C for 2 to 3 hr, 95 C for 8 to 12 hr, and 75 C for 16 to 24 hr.

Minnesota Mining and Manufacturing Co., Dept. ED, 900 Bush Ave., St. Paul 6, Minn.

CIRCLE 349 ON READER-SERVICE CARD

High Voltage Tester

For automated production testing

Model 8514 high voltage tester, called Hypot, provides sensing and control circuits for automated production testing of motors, controls, capacitors, and transformers. It also makes breakdown tests of insulation in controls, cables, bushings, and other components. The unit has an automatic rate of rise on high voltage dc test potential and an adjustable automatic shutoff of voltage and leakage current meter. The timer shunts the leakage current microammeter for 0 to 5 min while capacitance loads draw to 10 ma for rapid charging. The unit provides automatic shorting of internal and external circuits upon release of high potential test voltage. A selector switch may be set for manual, semi-automatic, or fully automatic operation.

Associated Research, Inc., Dept. ED, 3777 W. Belmont Ave., Chicago 18, Ill.

CIRCLE 350 ON READER-SERVICE CARD

STOP CLOCKS.—Designed for ac and dc operation, the clocks measure time intervals over wide voltage and ambient temperature variations. The digital ac stop clocks may be used for 60 and 400 cps operation. The digital dc stop clocks are used for 20 to 30 v operation. Electrical reset permits local or remote control or automatic operation where successive time intervals must be measured. Series numbers for the ac units are L15100 and L15200. Series number for the dc units is L15300.

The A. W. Haydon Co., Dept ED, Waterbury 20, Conn.

CIRCLE 353 ON READER-SERVICE CARD

ETCHANT.—Provides a method for bonding Teflon to itself and to other materials. Called Tetra-Etch, it is an activated form of sodium in solution. It reacts with Teflon to form a carbonaceous film on the treated surface which serves as a means of anchoring adhesives. The compound has proved compatible with a variety of adhesives, including epoxies, phenol formaldehydes, and most of the rubber and silicone types.

W. L. Gore & Associates, Inc., Dept. ED, 487 Papermill Road, Newark, Del.

CIRCLE 354 ON READER-SERVICE CARD

SCREW COVER PULL BOXES.—For wiring installation, these units are available in two types. Type FC is for flush installations and type SC is for surface mounting. They are available in standard sizes ranging from 4 x 4 x 4 in. to 24 x 24 x 6 in. They are formed of heavy gage one-piece sheet steel with all corners folded in and welded. All standard stock boxes are furnished with or without standard knockouts. Standard finish is a corrosion-resistant gray baked enamel.

Keystone Manufacturing Co., Dept. ED, Warren, Mich.

CIRCLE 355 ON READER-SERVICE CARD

MIXER-PREAMPLIFIER.—This line of matched mixer-preamplifier units covers the 8.5 to 9.6 kmc range. It has a minimum gain of 25 db, a maximum noise figure of 7.5 db and a 50-ohm if output at 30 or 60 mc. Model MMX-2 is available with or without an integral variable attenuator in the LO arm.

Lel, Inc., Dept. ED, 380 Oak St., Copiague, L. I., N. Y.

CIRCLE 356 ON READER-SERVICE CARD

FASTENER.—Self-retained type, eliminates the possibility of screws falling into electronic circuitry. It mates with any standard internally threaded member and can be adjusted to panel thickness over an 1/8 in. range. No special tools are required for installation.

Illinois Tool Works, Calinoy Div., Dept. ED, 12917 Cerise Ave., Hawthorne, Calif.

CIRCLE 357 ON READER-SERVICE CARD

NEW PRODUCTS

Sweep Generators

Output is from 20 to 1000 mc

Model SP-103, SP-104, SP-105 and SP-106 cover center-frequency ranges of 20 to 100 mc, 100 to 250 mc, 250 to 500 mc and 500 to 1000 mc, respectively. Sweep widths are variable from near zero to over 20% of the center frequency. The two low frequency units use inductively tuned oscillators. The other two are designed with cavity-tuned oscillator circuits. All oscillators produce the specified output of over 15 v rms into 50 ohms, which is equivalent to 4 to 5 w. The output is held constant within ±5% over the maximum sweep width by use of agc circuits controlling the oscillator's B+ voltage. For load isolation, a 3 db pad is provided between the oscillator and the ouput jack. There is a vernier attenuator with a range of about 0 to 10 db. Display linearity is better than 1.2 to 1. Source vswr for the instruments is normally below 1.3 to 1.

Telonic Industries, Inc., Dept. ED, Beech Grove, Ind.

CIRCLE 360 ON READER-SERVICE CARD

Audio-Video Amplifier

Range is to 20 mc

Called the Transifier, this transistorized, wideband, audio-video amplifier has a gain that is 3 db down at 20 mc in the 10 db position. The gain is down 3 db at 15 mc in the 20 db position. A voltage amplification of 30 and 100 is realized when two are used in series. The input impedance in the 10 db position is 15 μμf and 20,000 ohms; output impedance is about 75 ohms. In the 20 db position, the inherent noise is less than 10 mv. The maximum voltage output is 0.2 v rms in the 10 db position and 0.3 v in the 20 db position. The gain, in the 10 db position is no more than 3 db down at 15 cycles and, in the 20 db position, no more than 3 db down at 20 cycles. Dimensions are 2.25 x 1.15 x 4.5 in., and the weight is 15 oz.

Kay Electric Co., Dept. ED, Maple Ave., Pine Brook, N.J.

CIRCLE 361 ON READER-SERVICE CARD

Hi-Fi Tube

For 20 to 30 w range

For hi-fi equipment in the 20 to 30 w range, type 7355 octal-based beam pentode incorporates a five-ply bonded plate metal. With 18 w plate dissipation per tube, a pair of tubes is rated to deliver 28.5 w with 2% harmonic distortion without feedback in a class AB1 push-pull hi-fi amplifier. The maximum ratings include: plate, 440 v; screen, 400 v; screen dissipation, 2.5 w continuous and 5 w on speech and music peaks; and cathode current, 100 ma. The 6.3 heater draws 0.8 amp. In typical single-ended class A1 amplifier service at 250 plate v, transconductance is 7600 μmhos and maximum signal power output is 9 w.

General Electric Co., Receiving Tube Dept., Dept. ED, Owensboro, Ky.

CIRCLE 363 ON READER-SERVICE CARD

Cross-Guide Coupler

Covers 7 to 10 kmc

Model RDC-710 cross-guide coupler, having one arm terminated in a matched load, provides 20 and 30 db coupling with a frequency sensitivity of 1 db over the range of 7 to 10 kmc. The average coupling is a nominal ±0.5 db, directivity is 18 db min, and vswr is 1.05 max. The unit is also available with a fourth flange replacing the matched load. Applications include scaling high power to the level of ordinary instruments.

Radar Design Corp., Dept. ED, Pickard Drive, Syracuse 11, N.Y.

CIRCLE 364 ON READER-SERVICE CARD

CIRCLE 365 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Vibration Instrument

For testing accelerometers

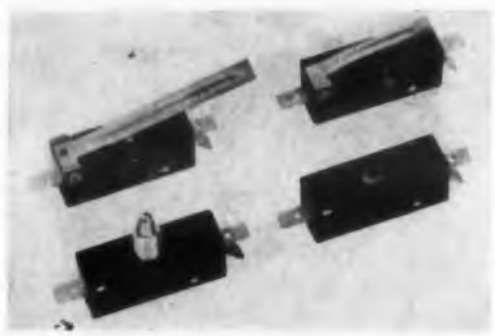
This accelerometer sensitivity standardizer, called Dial-a-gain, converts all accelerometer sensitivities to 1 v per g to allow direct reading of acceleration on any vtvm. The unit includes a cathode follower input and a precision amplifier with a continuously variable gain control dial, calibrated directly in accelerometer sensitivities.

Unholtz-Dickie Corp., Dept. ED, 2994 Whitney Ave., Hamden 18, Conn.

CIRCLE 367 ON READER-SERVICE CARD

Snap Action Switches

Come in three types



These three types of snap action switches have molded phenolic cases, brass switch blades, and 1/4-in. terminals with holes for soldering. Type 750-150 pin plunger switch is suited to applications requiring limited overtravel where the actuating device can be accurately controlled. It is designed for limit, safety interlocking, and control switch requirements. Types 750-250 and 750-251 lever action switches have a maximum travel of 1/4 and 3/4 in., respectively. Panel mounting type 750-350 is for use where the actuating motion cannot be accurately controlled. The switches have the following ratings: 15 amp, 125 v ac; 10 amp, 250 v ac; and 1/2 hp, 125 to 250 v ac.

Controls Co. of America, Industrial and Commercial Controls Div., Dept. ED, 9555 Soreng Ave., Schiller Park, Ill.

CIRCLE 368 ON READER-SERVICE CARD

RC-RL Curves and Nomograms — 1

Donald Moffat
Motorola, Inc.
Western Military Electronics Center
Phoenix, Ariz.

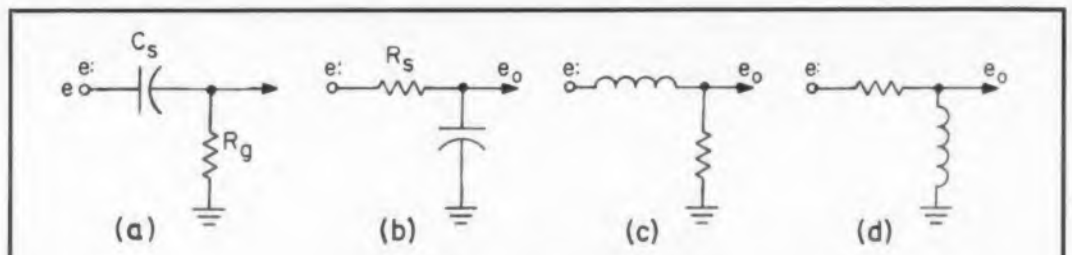


Fig. 1. Simple RC and RL circuits. Subscripts shown apply throughout article.

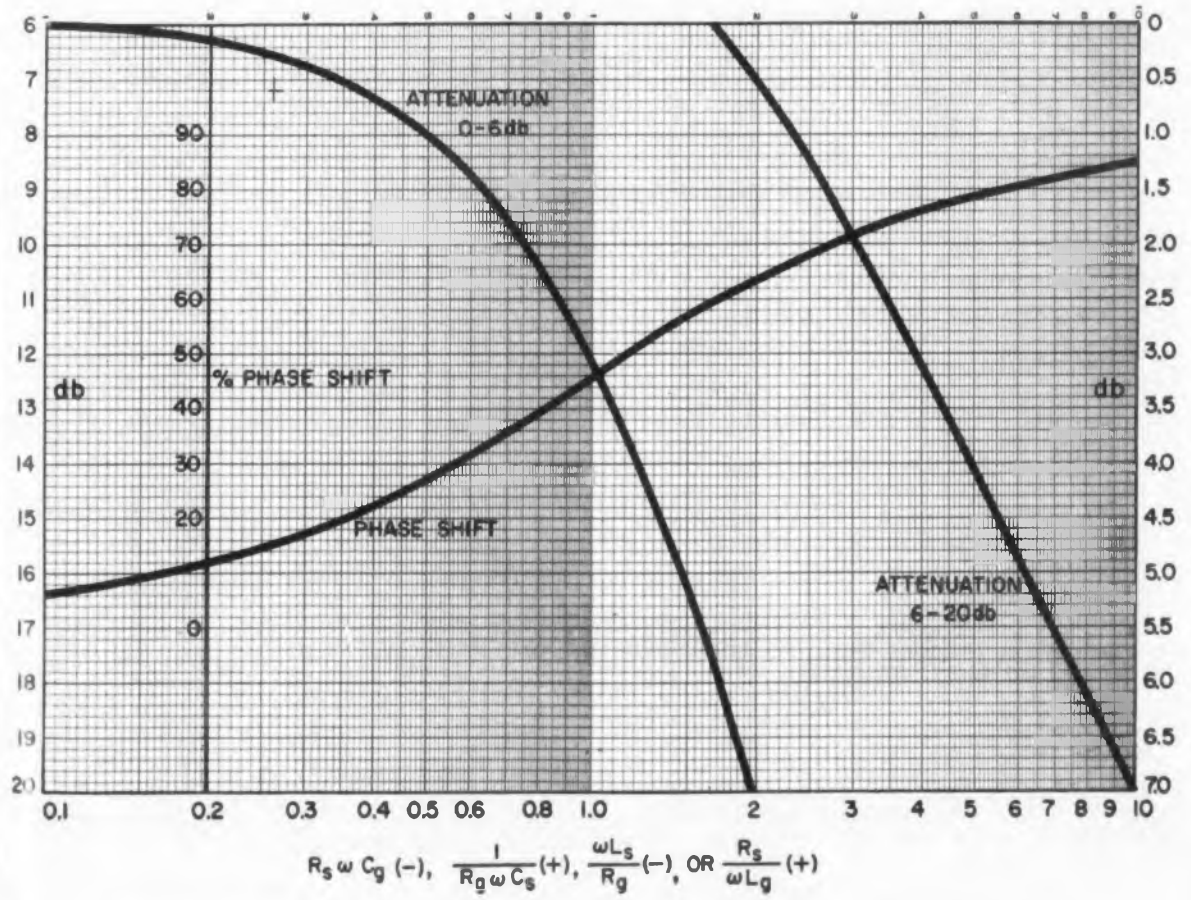


Fig. 2. Universal curve for the four single-section configurations shown in Fig. 1. Plus and minus signs on abscissa indicate the direction of phase shift (Abbreviations in abscissa: S, series element; G element to ground; Plus, e_o leads e_i; minus, e_o lags e_i).

CIRCLE 248 ON READER-SERVICE CARD

Calculating transfer functions for even simple RC and RL circuits can be time-consuming. To simplify the designer's task, Mr. Moffat has analyzed many of the most common circuits and here presents their transfer functions, curves and nomograms. Some discussion is included on the effects of loading, so that exact equations can be used where approximations are not valid.

In Part I an analysis of single sections is made. Part II, in a future issue of ELECTRONIC DESIGN, will discuss phase manipulation in single sections. Part III will analyze multiple sections and discuss the optimum number of sections for achieving a desired phase shift. RC differentiation, with nomograms, will be covered in the same part.

FOUR COMMON RC-RL circuits of interest are shown in Fig. 1. If loading is negligible, the transfer functions for the circuits are:

Fig. 1a

$$\frac{e_o}{e_i} = \frac{R_g}{R_g + \frac{1}{j\omega C_s}} = \frac{1 \angle \arctan \frac{1}{\omega R_g C_s}}{\sqrt{1 + \frac{1}{\omega^2 R_g^2 C_s^2}}} \quad (1)$$

Fig. 1b

$$\frac{e_o}{e_i} = \frac{\frac{1}{j\omega C_g}}{R_s + \frac{1}{j\omega C_g}} = \frac{1 \angle -\arctan \omega R_s C_g}{\sqrt{1 + \omega^2 R_s^2 C_g^2}} \quad (2)$$

Fig. 1c

$$\frac{e_o}{e_i} = \frac{R_g}{R_g + j\omega L_s} = \frac{1 \angle -\arctan \frac{\omega L_s}{R_g}}{\sqrt{1 + \frac{\omega^2 L_s^2}{R_g^2}}} \quad (3)$$

(*Continued on page 154*)

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(*Continued from page 153*)

Fig. 1d

$$\frac{e_o}{e_i} = \frac{j\omega L_g}{R_s + j\omega L_g} = \frac{1 \angle \arctan \dfrac{R_s}{\omega L_g}}{\sqrt{1 + \dfrac{R_s^2}{\omega^2 + L_g^2}}} \qquad (4)$$

Because these four simple circuits are so commonly used in all frequency bands, a universal curve is given in Fig. 2, where attenuation is expressed in decibels. The abscissa is normalized impedance ratio and is written in four ways; the applicable one can be determined by comparing the subscripts with those of Fig. 1. Whenever possible, the subscript s will be used to designate an element that is in series with the signal, and g will go with an element that is grounded. Plus and minus signs on the abscissa of Fig. 2 indicate the direction of phase shift.

Loading

The circuit of Fig. 1a is often seen in interstage coupling, with the output going to a tube. Under certain conditions there will then be a shunt capacitance across R_g that cannot be neglected. The equivalent circuit then is like that in Fig. 3a.

Analysis of this circuit shows that except at dc, there will always be more attenuation than there was with no loading. The fractional amount of difference—error—is

$$\delta = 1 - \sqrt{\frac{1 + 1/\omega^2 R_g^2 C_s^2}{(1 + C_o/C_s)^2 + 1/\omega^2 R_g^2 C_s^2}} \qquad (5)$$

Note that error is not constant, but is a function of both capacitance ratio and frequency, with any particular capacitance ratio having increasing error with increasing frequency. Eq. 5 is plotted

(*Continued on page 156*)

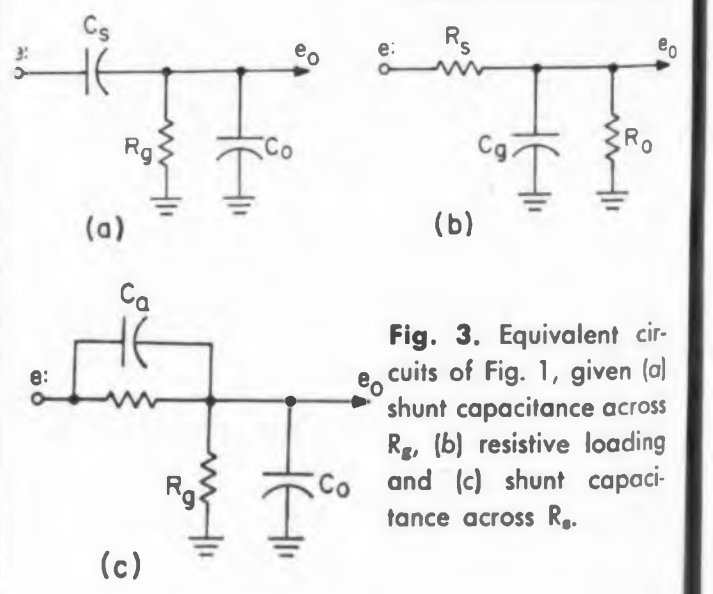


Fig. 3. Equivalent circuits of Fig. 1, given (a) shunt capacitance across R_g, (b) resistive loading and (c) shunt capacitance across R_s.

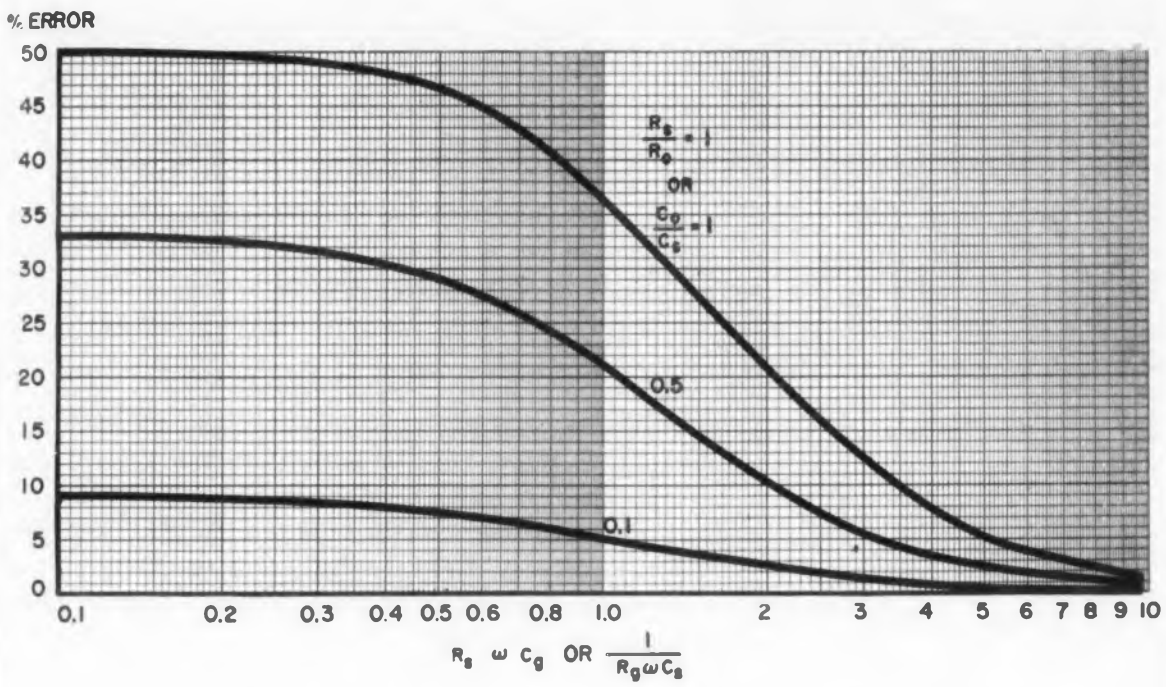
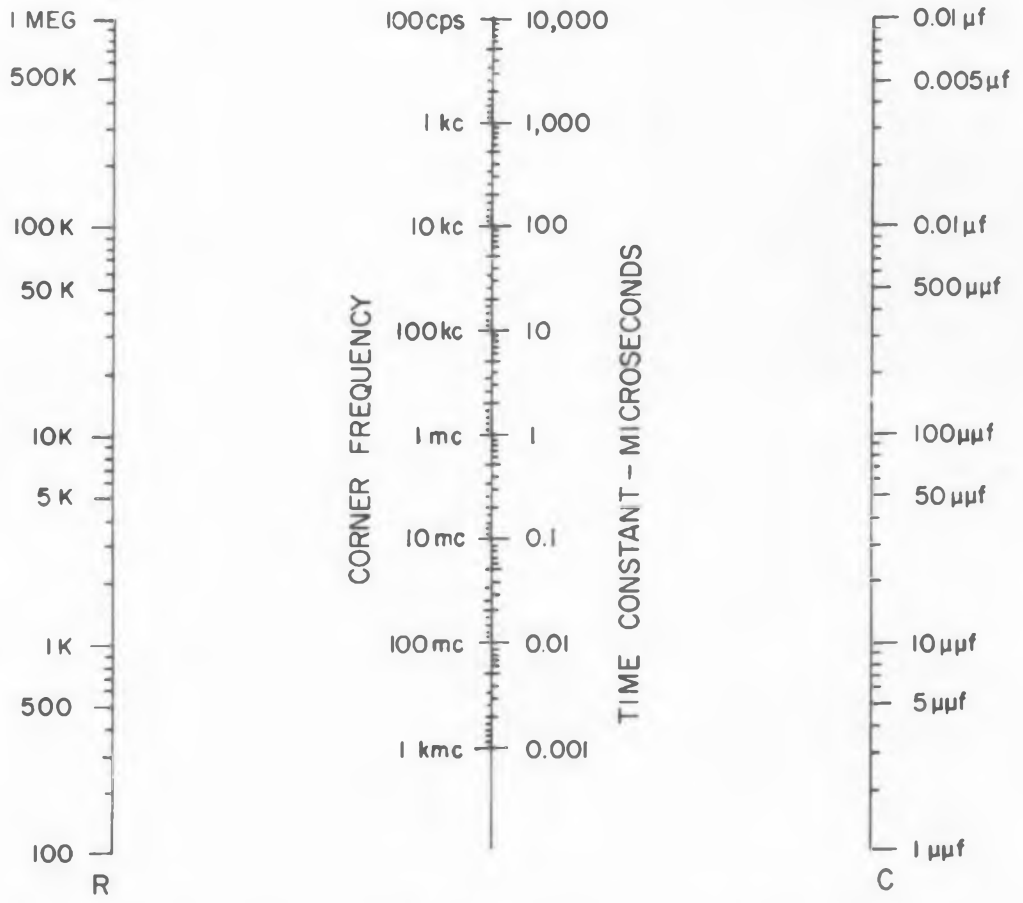


Fig. 4. Plot of error in circuit of Fig. 3(*a*). Error is a function of both capacitance ratio *and* frequency. Abscissa is normalized impedance ratio, and the parameter is capacitance ratio.



Nomogram of $R_s C_a = R_g C_o$. Both scales correspond to both sides of the equation.

ELECTRONIC DESIGN DATA

(*Continued from page 154*)

in Fig. 4, where the abscissa is again normalized impedance ratio, and the parameter is capacitance ratio.

Nomogram

To reduce the high-frequency discrimination of capacitive loading, the series resistor can be shunted with a capacitor, as in Fig. 3c. For best results, the time constants are made equal:

$$R_s C_a = R_g C_g \tag{6}$$

The nomogram is a convenient tool to work out Eq. 6. Note that no subscripts are used on the nomogram: both scales correspond to both sides of the equation. First use the $R_g C_s$ time constant and draw a line through the proper values on the R and C scales. Next use the point where this line crosses the *Turning Scale* as a pivot about which to rotate a straight edge. Every combination of R and C that the straight edge joins is a valid combination of R_s and C_a to compensate R_g and C_s.

The range of the scales can be extended by multiplying either of both scales by any order of magnitude before drawing the first line. After the first line is drawn, the scales can be changed for the second time by multiplying the R scale by any power of ten, and the C scale by the reciprocal of the same power of ten.

Resistive Error

The circuit of Fig. 1b is not subject to error through capacitive loading, because any shunt capacitance can be simply added to C_g. The circuit might, however, have undesirable resistive loading—such as a grid return resistor. In the region above tens of megacycles, the tube itself may present a resistive input as low as 1000 ohms.

The resultant equivalent circuit is shown in Fig. 3b, and the error is given by

$$\delta = 1 - \sqrt{\frac{1 + \omega^2 R_s^2 C_g^2}{(1 + R_s/R_g)^2 + \omega^2 R_s^2 C_g^2}} \tag{7}$$

Error is now a function of both resistance ratio and frequency, decreasing with increasing frequency. When R_g is much larger than R_s, Eq. 7 approaches zero and Eq. 2 can be used with negligible error. By using resistance ratio as the parameter, the designer can use Fig. 4 to evaluate Eq. 7.

Part II of this series will discuss manipulation of the phase response of a single section. Three nomograms will be included to find ϕ_{max}, a value of capacitance to place ϕ_{max} at a given frequency and to select values to locate the phase maximum at any given frequency for another circuit. ■ ■

NEW LITERATURE

Analog To Digital Processor 415

Details of MicroSadic, a high-speed analog to digital processor are presented in this illustrated, four-page bulletin, No. 3004. The machine acquires, digitizes, and stores data at a maximum rate of 10,000 samples per second. Operations, design details, and specifications are given. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

Amplifier Measurements

This booklet, entitled "Standard Methods of Measurement for Amplifiers" is the second of a series designed to establish comprehensive measurement standards for high fidelity components. The standard defines terms and test conditions and lists tests and ratings for amplifier output, sensitivity, frequency response, distortion, hum and noise, and damping factor. *Send $1.00 to Institute of High Fidelity Manufacturers, 125 E. 23rd St., New York, N.Y.*

Digital Subsystems 417

Functionally packaged digital subsystems are described in this four-page, illustrated folder. The folder describes the versatility of the units as elements of digital subsystems. Included are photographs and specifications of available digital modules, such as a: forward-backward counter, bistable multivibrator, exclusive OR gate, AND gate, Schmitt trigger, and monostable multivibrator. Servomechanisms, Inc., 12500 Aviation Blvd., Hawthorne, Calif.

Microwave Measurements 418

Measurement of impedance and its associated parameters in waveguide systems through use of a sliding termination with specific reflection characteristics is discussed in this report entitled "Waveguide Sliding Shorts, Sliding Terminations, and Standard Mismatches." Use of sliding shorts for precision measurement of impedance (scattering matrix), insertion loss, attenuation and propagation constants, dielectric constant, slotted section curves, wavelength, and frequency are also covered. The article covers ways in which standard mismatches can be employed as reference standards of reflection—and therefore, vswr—against which various microwave test components may be calibrated. Photographs are included in Vol. 6, No. 2 of "PRD Reports." Polytechnic Research & Development Co., Inc., 202 Tillary St., Brooklyn 1, N.Y.

NEW LITERATURE

Pulse Instrumentation 421

The 48-page, 1959-60 general catalog includes complete technical data on a broad range of pulse instrumentation, including general purpose pulse generators, word generators, time delay generators and electronic counters. Factors in instrument selection and application are covered in the catalog. Photographs of the equipment are provided. Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif.

Semiconductor Diodes 422

This replacement characteristics and guide for semiconductor diodes contains complete data on the firm's diodes as well as replacement information on all EIA registered diodes. A digital automatic tester and classifier is also described in the 12-page brochure. Sylvania Electric Products Inc., 1100 Main St., Buffalo 9, N.Y.

Capacitors 423

Bulletin GEA-7008, four pages, provides detailed information on wet-type, sintered porous-anode tantalum capacitors used where extremely high capacitance values are required in the smallest possible space. The bulletin explains performance characteristics and advantages of the units and includes four tables, five graphs, outline drawings and complete ratings and dimensions. Actual size photographs are included. General Electric Co., Schenectady 5, N.Y.

Accelerometers 424

Accelerometer methods and techniques are described in this 20-page, illustrated manual "Series 2200 Accelerometers." Application information, mounting techniques, fixtures, and use of piezoelectric accelerometers for shock measurements are included in this booklet. Endevco Corp., 161 E. California Blvd., Pasadena, Calif.

Digital Voltmeters 426

This 20-page illustrated bulletin describes the NLS series 30 digital voltmeters. Complete specifications, operating instructions, information on input and output accessories, and complete wiring diagrams to convert the instruments into data logging and measurements systems are included. Non-Linear Systems, Inc., Del Mar, Calif.

Microwave Instruments 427

Detailed information is given in this 120-page catalog on slotted lines and tapered reducers, automatic impedance plotters, coaxial switches, transmission line hybrids, instrument loads, adjustable matching networks and impedance standard lines. In addition to technical descriptions, pictures, outline dimensions, circuit diagrams, and electrical and mechanical characteristics, the catalog includes a summary of data on transmission line connectors, complete price lists and suggestions for ordering. Alford Manufacturing Co., 299 Atlantic Ave., Boston, Mass.

Miniaturization 428

This brochure describes the Miniaturization Awards Competition now in progress. The Award is presented annually to the individual or organization judged to have the greatest contribution to the field of miniaturization. The Award for 1959 will be presented in the Spring of 1960. Deadline for receiving entries is January 20, 1960. Sponsor for the Awards is Miniature Precision Bearings, Inc., Miniaturization Awards Committee, Box 604, Precision Park, Keene, N.H.

Components Catalog 429

The Fall issue of Helinews, eight pages, provides information on the firm's all-metal single-turn potentiometers, cermet trimming potentiometers, and includes test reports on ac voltmeters. Also mentioned is the technical information available from the firm. A zany glossary of German missile terms is given. Beckman Instruments, Inc., Helipot Information Service, 2500 Fullerton Road, Fullerton, Calif.

NEW LITERATURE

Indicators and Controls 433

A line of indicators and controllers is described in 10-page bulletin GEZ-2898. Instruments discussed are a dc millivoltmeter, bridge-type controllers, temperature scanner systems, and saturable reactor control systems. Typical measurement applications, principles of operation, control forms, and electrical specifications are given. General Electric Co., Schenectady 5, N.Y.

Magnetic Components 434

"Magnetic Components for Computers, Business Machines and Electronic Systems," 16 pages, describes the basic operating mechanism of magnetic cores used in logic, shift registers, and magnetic memories. Included is a section describing their use in typical applications such as computers, business machines, and data handling systems. Magnetics Research Co., Inc., 255 Grove St., White Plains, N.Y.

Resistors 435

The 1959-60 edition of the firm's catalog covers their complete line of resistors. Complete specifications on the units and other pertinent data are included. Tech-Ohm Resistor Corp., 36-11-33rd St., Long Island City 6, N.Y.

Slide Rule

This reactance computer slide rule permits designers to determine the resonant frequency of a circuit knowing inductance and capacitance. Or they can select various inductances and capacitances for a desired frequency. The slide rule also has provisions for computing inductive and capacitive reactances as well as inductances and capacitances of resonant circuits from 1 mc to 1000 mc. Constructed of plastic, the slide rule is 9.5 in. long. *Send $1.00 to JFD Electronics Corp., 6101 Sixteenth Ave., Brooklyn 4, N.Y.*

Ceramic Capacitors 437

This two-page bulletin describes the VK line of ceramic capacitors. These miniature units operate at 200 v dc and to 150 C without derating. Electrical and physical characteristics of the capacitors are described with accompanying charts and drawings that cover capacity values to 10,000 μμf. The line is also offered without cases for complete circuit assembly encapsulation. Vitramon Inc., Box 544, Bridgeport 1, Conn.

Zener Diode Slide Rule

This slide rule is designed to simplify the calculations that are necessary to design Zener diode circuits. Among the calculations that can be made are: value of the ballast resistor; maximum Zener dissipation; required thermal dissipator or heat sink area; and change in regulated voltage with ambient temperature. The various scales eliminate the need for using several curves. Design information such as basic regulator circuit, various relationships, and tabular design data have been included as part of the calculator. *Send $1.00 to Motorola, Inc., Dept. ED, Semiconductor Products Div., 5005 E. McDowell Rd., Phoenix, Ariz.*

Silicon Trigistors 438

Applications and circuit design notes for silicon trigistors appear in this 16-page booklet. Operation, trigistor biasing, a one shot multivibrator, a memory circuit, and a flip flop binary counter are discussed with the aid of diagrams. Solid State Products, Inc., 1 Pingree St., Salem, Mass.

Power Amplifier 439

A three-channel amplifier designed for driving recording oscillographs from low-level accelerometer signals is described in this two-page, illustrated bulletin. Features, operating specifications, operating curves, and circuit description are included. Columbia Research Labs, Mac-Dade Blvd. & Bullens Lane, Woodlyn, Pa.

NEW LITERATURE

Zener Diode Handbook

The basic theory, design characteristics and applications for Zener (voltage limiting) diodes are covered in this 130-page manual. Chapter headings include: Characteristics of Silicon Zener Diodes, Design Considerations, Regulated Power Supplies, Surge Protection, AC and DC Amplifiers, Temperature Compensation and Impedance Cancellation, New Approaches in Zener Diode Applications, and Specifications and Testing Methods. How the Zener diode can be used as a coupling device in ac to dc amplifiers and as a biasing element is discussed fully. The book contains numerous schematic drawings, tables and curves, all based on actual circuits that were designed and tested. References that have appeared in previous literature have been checked and incorporated into the manual. *Send $1.00 to Motorola, Inc., Semiconductor Products Div., Dept. ED, 5005 E. McDowell Rd., Phoenix, Ariz.*

Silver-Zinc Batteries 443

The performance features of secondary (rechargeable) silver-zinc batteries for electronic equipment, underwater apparatus, and industrial communications systems are explained in this four-page brochure. Battery discharge cycle capability, shelf life, reliability, weight, and output factors are covered in specification charts and dimensional tables. Photographs of various models are included. Cook Batteries, Subsidiary of Telecomputing Corp., 3850 Olive St., Denver 7, Colo.

Video Transformation Tube 444

The firm's video transformation tube, which accepts a radar (rho-theta) signal and converts it to a television (rectilinear) display, is described in this illustrated four-page catalog. Characteristics and diagrams for the reading gun and the writing gun are included. Intercontinental Electronics Corp., Mineola, N.Y.

Pulse Transformer Parameters 446

Bulletins PT-204, PT-205, and PT-206, each four pages, discuss blocking oscillator applications, interstage coupling applications, and specific applications where transformer parameters are known. In each bulletin a section is devoted to the characteristics of the pulse transformer which distinguish it from other circuit elements. An illustrated waveform of a typical pulse transformer output pulse showing two cases of damping is included. Transformer parameters are indicated on the waveform. Technitrol Engineering Co., 1952 E. Allegheny Ave., Philadelphia, Pa.

Decade Counters 447

Modular plug-in decade counters are featured in bulletin 826A, 12 pages. Each of the ten counters in the line is illustrated with photographs, outline drawings, and circuit diagrams. Circuits showing the units operating as variable scale and preset counters are included. Burroughs Corp., Electronic Tube Div., Plainfield, N.J.

Voltage Regulators 448

Features of automatic voltage regulators of the instantaneous electronic transistorized series are covered in this eight-page bulletin. In addition to dimensional diagrams, photos of the various types also appear. The Superior Electric Co., 83 Laurel St., Bristol, Conn.

Coil Form Chart 449

Information on ceramic, phenolic, shielded, and printed circuit coil forms is given on this 22 x 34 in. reference chart. Military specs and materials for coil forms are included; scale drawings give dimensions. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass.

Radio Remote Control Units 450

This data sheet provides specifications, applications and a description of radio remote control units. Diagrams of the transmitter and receiver are included. Regent Electronics Manufacturing Co., 15321 Rayen St., Sepulveda, Calif.

NEW LITERATURE

Transfer Switches 454

Relay control features of automatic transfer switches are discussed in four-page bulletin 07500-G. A narrow control center model is illustrated. Specifications and schematic diagrams also appear. Lake Shore Electric Corp., 205 Willis St., Bedford, Ohio.

Graphite Properties 455

"Graphite—How It Compares with Metals, Ceramics," is a four-page reprint of an article presented before the Electrochemical Society. Comparative data on electrical resistivity, tensile strength and modulus, strength-to-weight ratio and thermal conductivity are shown graphically. One table relates the properties of graphite with its industrial uses and its applications in the nuclear and missile fields. Another table lists the coefficients of thermal expansion. Speer Carbon Co., St. Marys, Pa.

Semiconductor Graphites 456

Graphite usage in semiconductor production is the subject of illustrated catalog SC-659. Sections cover unique semiconductor graphites, specialized graphite machining problems, methods of graphite quality control, means of planning, scheduling and expediting orders, typical physical properties of various grades of graphite, stock sizes and prices. United Carbon Products Co., P. O. Box 747, Bay City, Mich.

Hook-on Volt Ammeter 457

Descriptions, specifications and construction details of pocket-size, hook-on volt ammeters for testing ac voltages is given in Bulletin GEA-6292C, four pages. The bulletin lists applications, current ranges, accuracy percentage and operating instructions. Photographs are included. General Electric Co., Schenectady 5, N.Y.

Microwave Components 459

Resonance isolators, circulators, switches, tee circulators, phase shifters, and modulators are discussed in "Microwave Ferrite Components," a four-page catalog. Subgroups of coax and test equipment isolators, high power, miniature and microwave relay isolators, faraday rotators and differential phase shift circulators are also included. Ferrotec, Inc., 217 California St., Newton, Mass.

Time Delay Relays 460

Bulletin 5903, eight pages, describes and illustrates time delay relays. Manufacturing and assembly processes, standard and special type specifications, data on sizes, available mounting arrangements, weights and terminal styles, and a description of circuit design are included. Circuit application notes and a discussion of special types available for accuracies as good as 0.01 per cent also appear. Tempo Instrument Inc., P. O. Box 338, Hicksville, N.Y.

Inertial Guidance Platform 461

This eight-page bulletin illustrates and describes a gimbal platform which operates from −55 to +100 C. In addition to a description of the platform and associated electronic components, dip brazing fabrication features, configuration details of nine platform versions, and application information are included. General Electric Co., 600 Main St., Johnson City, N.J.

Precision Potentiometers 462

This catalog discusses box type and rotary trimmers, panel controls, precision servo type potentiometers, non-standard function pots, special non-linear pots, pressure and displacement transducers, unitized clutch modules with syncros, servo motors, spring returns, brakes, commutator switches, magnetic clutches and single or multiturn potentiometers. Technology Instrument Corp., 531 Main St., Acton, Mass.

NEW LITERATURE

Microwave Tubes 466

Principal electrical characteristics for 22 klystron tubes and nine planar triodes are listed in this four-page catalog. Tube applications include microwave communication transmitters and receivers, test equipment, beacons, and missiles. Frequency coverage of the klystron line is 500 to 7500 mc, with cw output power ranging from 20 mw to 2 w. The klystrons are divided into five basic outline styles, each illustrated by a proportionally scaled photograph. Rocket planar triodes are designed for oscillator or amplifier applications and are available in either pulsed or cw versions with a frequency coverage from 500 to 3300 mc. The catalog lists amplification factors as high as 90, and peak power outputs to 200 w for oscillator operation. Sylvania Electric Products Inc., Central Advertising Distribution Dept., 1100 Main St., Buffalo, N.Y.

Magnetic Tape 467

Magnetic tape for digital and analog recording is described in this four-page, illustrated bulletin. Information includes performance qualities of the new tape, production techniques, and specifications. Photographs are included in bulletin 1619. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

Tape Tension Gage 468

Type 5-050 dynamic tape tension gage for magnetic tape recorder/reproducers is described in bulletin 1621. The gage permits accurate tension measurement and adjustment to be made quickly and easily on fixed or mobile tape transports. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

Automatic Test Equipment 470

The firm's preprogrammed automatic test system which employs only solid-state devices in computer circuit modules is discussed in this 24-page, illustrated booklet. Features, objectives, applications, and a general description of the system appear. Stromberg-Carlson, Electronics Div., 1400 N. Goodman St., Rochester 3, N.Y.

Thermocouples 471

Illustrated catalog EN-S2, 52 pages, covers thermocouples and thermocouple components and accessories. It describes standard assemblies in protecting tubes and wells for general applications, specialized thermocouples and assemblies for laboratory and industrial applications, and a line of bare and insulated thermocouple wires, ceramic insulators, metal and ceramic protecting tubes, wells, and terminal heads. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

Cathode-Ray Tubes 472

Information on over 75 types of standard (JEDEC registered) cathode-ray tubes is tabulated in this short-form catalog. Sections discuss the latest crt's suitable for new equipment designs, replacement tubes, special design services, screens, and accessories for crt's. Physical and electrical parameters are tabulated for such crt categories as electrostatic deflection and electrostatic focus, magnetic deflection and electostatic focus, and magnetic deflection and magnetic focus. Allen B. Du Mont Labs, Inc., Electronic Tube Div., Clifton, N.J.

Coolers 473

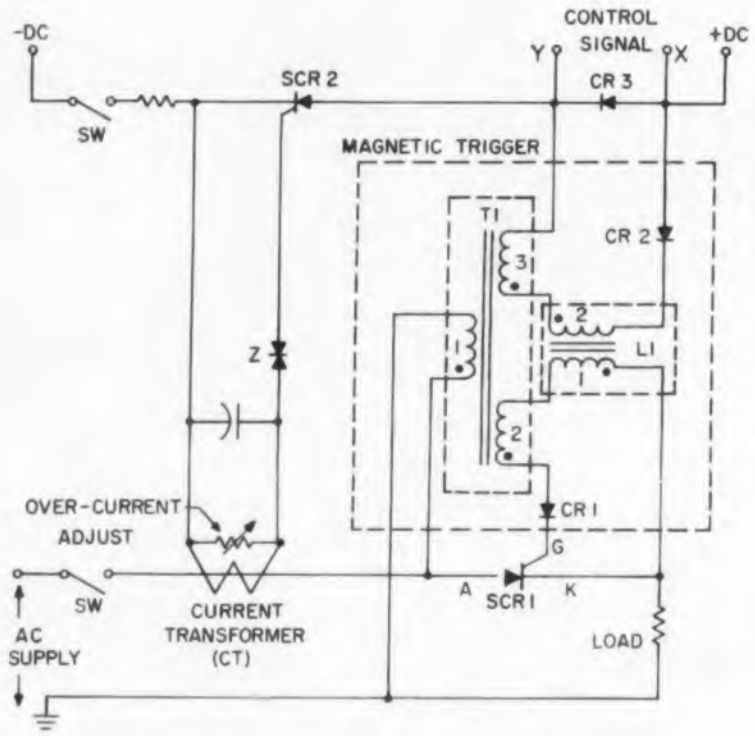
Tables and performance curves in this eight-page bulletin aid the engineer in selecting coolers that will maintain junction temperatures of semiconductors within design conditions. Diagrams and photos illustrate the units. Modine Manufacturing Co., Racine, Wis.

Controlled Rectifier Power Supply Is Short-Circuit Protected

DESIGNING AN all solid-state power supply that is light, rugged and delivers high power per pound, is problem enough. Short-circuit protecting the power supply where no fuses are allowed is quite another thing. Here is a circuit, Fig. 1, based on a silicon controlled rectifier that accomplishes the job.

The Silicon controlled rectifier *SCR* is connected in series with the input power and the load in a half-wave configuration. A full wave configuration may be obtained very simply by adding one *SCR* and a properly rated center tap transformer. For simplicity, only the half wave circuit is discussed here.

A fast-response magnetic trigger operating on the reset principle (Avion Model 408 or equal) is used to control the firing angle of the *SCR* during normal operation.



Short circuit protection is provided through a silicon controlled rectifier in this all-solid state power supply circuit.

An isolation transformer *T1* is connected across the input. This transformer steps down (or, when a low-voltage supply is involved, steps up) the voltage level, to provide a proper supply to the reactor *L1*. The phasing of the transformer *T1* outputs is important and is indicated by dots.

During the first half cycle of supply frequency, when the anode of *SCR1* is positive, rectifier *CR1* is forward-biased and will allow current to flow into the gate *G* of the *SCR*. The angle at which this current will flow into the gate is determined by the saturation level of the reactor *L1*.

Rectifier *CR2* insures that during the first half cycle, no current will flow into the control winding #2 of *L1*. Winding #1 of the trigger reactor *L1* is the gate winding through which the current for the gate-cathode junction of the *SCR* flows.

Rectifiers *CR3* and *SCR2* form part of the short circuit protection network.

Normal Control

During normal operation, proportional control of the output is achieved by varying the control signal, or the impedance in the control circuit. This control may be implemented by various means. Some are listed below:

1. Potentiometer for manual control
2. Transistor or *SCR*
3. Ac signal from synchros in phase opposition to voltage of *T1* winding #3
4. Half-wave variable signals buck-impedance of *CR3*, through forward biasing, to a very low value. Rectifier *CR3*, thus biased, will pass the current necessary to reset the reactor core to cut off.

A current transformer (*CT*) is connected in series with the load. The secondary of the *CT* is in series with a Zener diode and a gate cathode junction of *SCR2*. An over-current adjusting rheostat is connected across the current transformer *CT*.

Under normal conditions the secondary current flowing out of the *CT* can flow only through the rheostat. The voltage developed across the rheostat is lower than the breakdown voltage of the Zener diode. *SCR2* remains open, and does not allow current from the auxiliary dc supply to flow through it, diode *CR3* and a limiting resistor, to ground.

As soon as the load current exceeds a predetermined level, the secondary voltage drop across the *CT* exceeds the Zener voltage and triggers *SCR2; SCR2* fires and allows the auxiliary supply to forward-bias *CR3*.

Full reset current now flows through *CR3* and winding #2 of *L1* is subjected to full reset voltage. *L1* and *SCR1* cut off and the loading winding #3 voltage.

The firing angle of *SCR1* is determined by the firing angle of *L1*. When all the voltage is absorbed by winding #1 of the reactor *L1*, no output, except for very low exciting current, appears across the gate-cathode junction of the *SCR*. The amount of volt-second absorbed by the windings #1 of *L1* is determined by the voltage which is applied to winding #2 during the second half cycle of the supply frequency. If no voltage at all is applied to winding #2, then winding #1 allows load current to flow during the third half cycle, due to self-saturation. However if the full voltage is impressed on winding #2 during the second half cycle, no output current will flow during the following half cycle in the gate winding #1. Partial control voltage will allow firing of the *SCR*.

Short Circuit Protection

In order to cut off *SCR1*, then, the output of *L1* must also be cut off. One obvious way to achieve this is to allow the full voltage, induced in winding #3 of *T1*, to be impressed on winding #2 of *L1*. This is accomplished by reducing the current falls to zero. No telegraphing of *SCR2* occurs because once it is triggered it remains "on" due to the holding current supplied by the auxiliary supply. Resetting the supply to normal operation again is accomplished by opening and closing the switch *SW*.

Baruch Berman, Avion Division ACF, Paramus, N.J.

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CIRCLE 530 ON READER-SERVICE CARD

IDEAS FOR DESIGN

Slide-Rule Solution For $| 1 + j (f/f_o) |$

The quantity $| 1 + j (f/f_o) |$ can pop up in design work so often that a short-cut solution in decibels would be a boon. Here is a simple slide rule solution that yields the answer in db quickly and with reasonable accuracy.

To evaluate $| 1 + j (f/f_o) |$ in db on the slide rule, just follow these four steps:

1. Set f on the D scale opposite f_o on the C scale. Read (f/f_o^2) on the A scale opposite the B index.

2. Mentally add 1 to that value and set the hairline to $(f/f_o)^2 + 1$ on the A scale.

3. Multiply this value by itself, i.e., set the B index to $(f/f_o)^2 + 1$ on the A scale and move the hairline to the same quantity on the B scale.

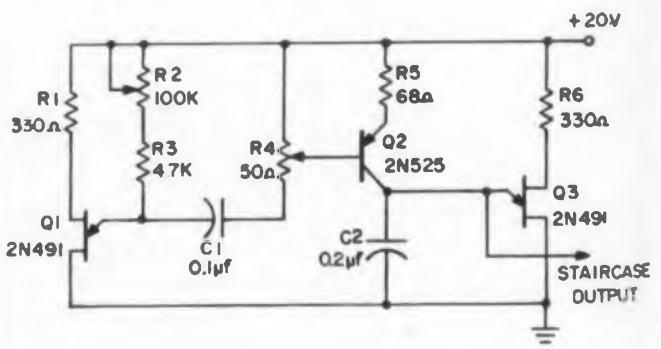
4. Look under the hairline on the L scale for the answer. If (f/f_o) is less than 3, read the answer in db directly. If (f/f_o) is between 3 and 10, add 10 db to the value on the L scale. (Ignore the decimal point for these readings.) If (f/f_o) is greater than 10, $| 1 + j (f/f_o) | \cong f/f_o$

For example, find $| 1 + j (4/5) |$. Setting 4 on D opposite 5 on C gives 0.64 on A opposite the B index. Set the B index to $1 + 0.64 = 1.64$ on A, and then move the hairline to 1.64 on B. Read 2.15 db as the answer on L.

Jesse Roth, Sr. Engineer, Avion Div., ACF, Paramus, N.J.

A Simple Staircase Wave Generator

A staircase generator having good stability and a wide operating range may be constructed as shown in the circuit diagram. Transistor Q_1 operates as a free-running oscillator generating negative pulses across R_4. These pulses produce current pulses from the collector of Q_2 which charge



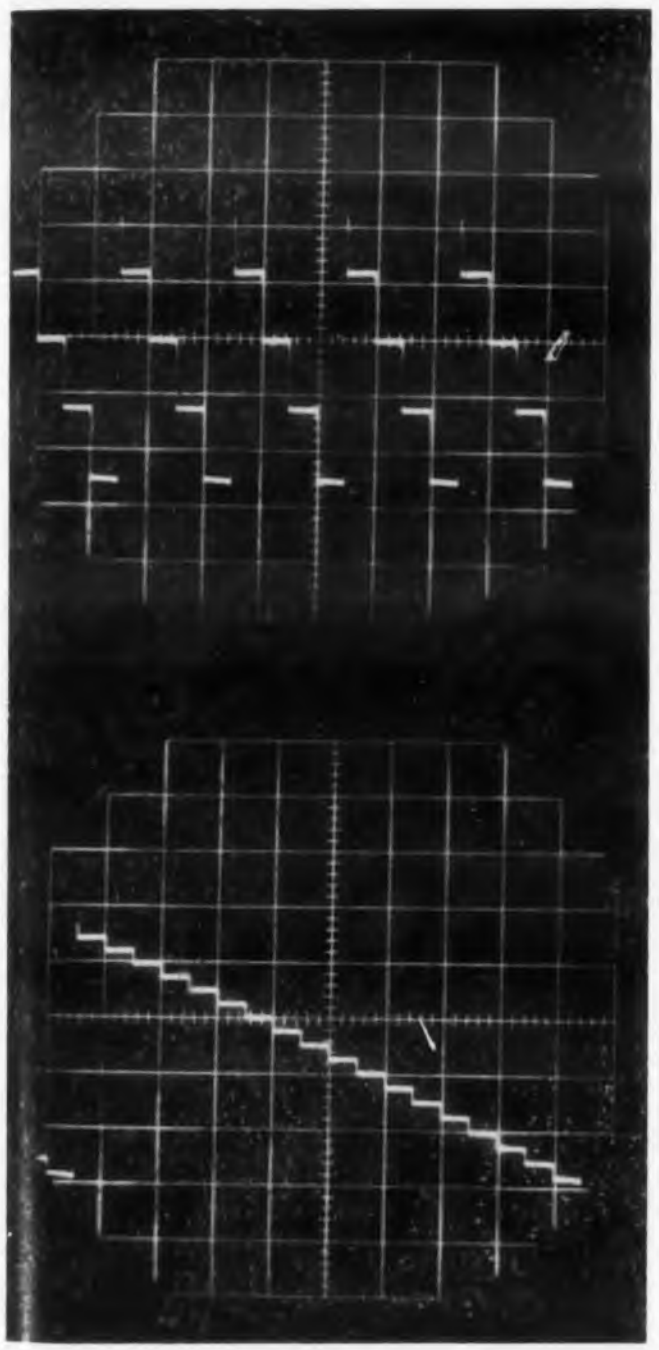
Schematic diagram of a simple staircase generator.

capacitor C_2 in steps. When the voltage across C_2 reaches the peak point voltage of Q_3, this transistor fires and discharges C_2.

Resistor R_2 determines the frequency of oscillation of Q_1 and thus determines the period of the individual step without affecting the number of steps per cycle. The setting of R_4 determines the amplitude of the collector current pulse from Q_2 and thus determines the number of steps per cycle without affecting the period of the individual step. The waveforms show operation at two different settings of R_4 which give four steps per cycle and 18 steps per cycle.

This circuit can easily be adapted to operate as a wide range frequency divider by cascading stages similar to the stage formed by Q_2 and Q_3.

T. P. Sylvan, Application Engineer, General Electric Co., Syracuse, N.Y.



Typical output waveforms. Vertical scale is two volts per division. Horizontal scale is one millisecond per division (right to left).

IDEAS FOR DESIGN

Zener Diode Expands Telemetering Monitor Scale

The circuit used for monitoring, via telemetry, the B+ voltage of the tracking beacon in the X-7A RJTV (Ram Jet Test Vehicle) is shown in Fig. 1. This circuit provided a check of the B+ voltage to the beacon and in addition was an indication of beacon triggering.

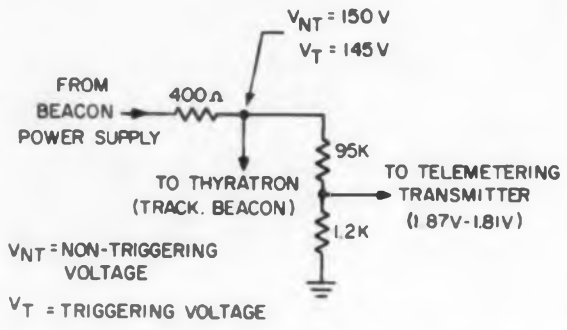


Fig. 1. Small voltage change in B+ telemetry circuit left room for doubt.

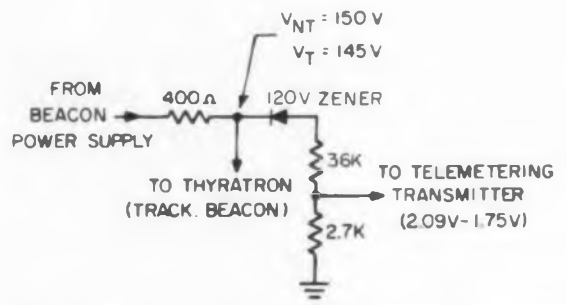


Fig. 2. Zener diode in circuit increase output range to transmitter from 0.06 v to 0.34 v.

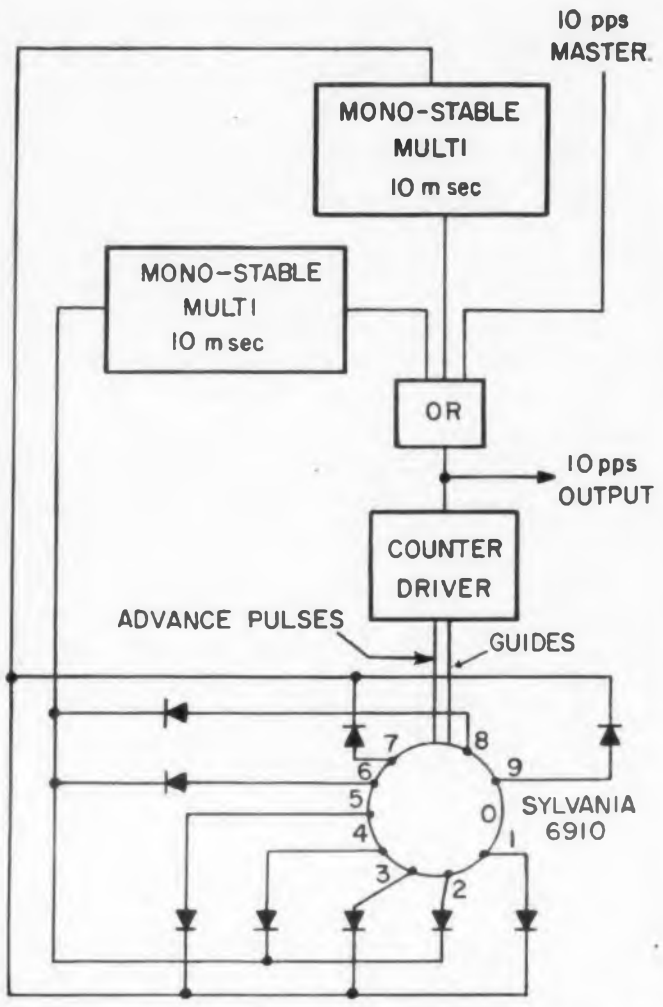
The difficulty encountered in the circuit of Fig. 1 was that the voltage change from trigger to no-trigger, when divided down for telemetering, was so small that the beacon's state of operation was often questionable.

Fig. 2 shows the change that was incorporated in the telemetering monitor circuit which clearly defines the trigger/no-trigger state of the beacon. The zener diode provides a constant 120 v drop so that the voltage divider now reflects the change of 25 to 30 v. The change to telemetry transmitter is now 0.34 v instead of 0.06 v as in Fig. 1.

P. A. Walter and R. U. Moody, Lockheed Aircraft Corp., Missile & Space Division, Van Nuys, Calif.

100 pps Pulse Train Synched From 10 pps Source

A need existed to provide a system which generates a 100 pps synchronized pulse train from a 10 pps source. The system must be reliable and



100 pps pulse train output is generated in this synchronized, fail-safe circuit.

also remain in absolute synchronization, with the source pulse becoming every tenth output pulse. Fail-safe properties must be incorporated in the system so that the output pulses cease if the source pulses are interrupted.

The solution utilizes the decade properties of a cold cathode glow transfer counting tube, Sylvania 6910. With the glow normally at cathode "zero," the master pulse advances the count to cathode "one." When the glow arrives at cathode "one," monostable multivibrator (MMV)-A is triggered which advances the glow to cathode "two" after a 10 ms delay. When the glow arrives at cathode "two," a positive transient is developed, triggering MMV-B which advances the glow to cathode "three" after another 10 ms delay.

This cycle continues until the glow reaches cathode "zero" where it remains until another master pulse arrives. The staggered arrangement of the MMV's is used to reduce the individual duty cycle to approximately 50%.

The system parameters can be modified to generate 1000 pps from a 100 pps source. The fill-in generators can be cascaded if desired. The counter driver and MMV's are transistorized. Circuit details may be obtained by contacting the authors.

Jack Star and Edgar H. Fischer, Applied Physics Lab, J.H.U., Silver Springs, Md.

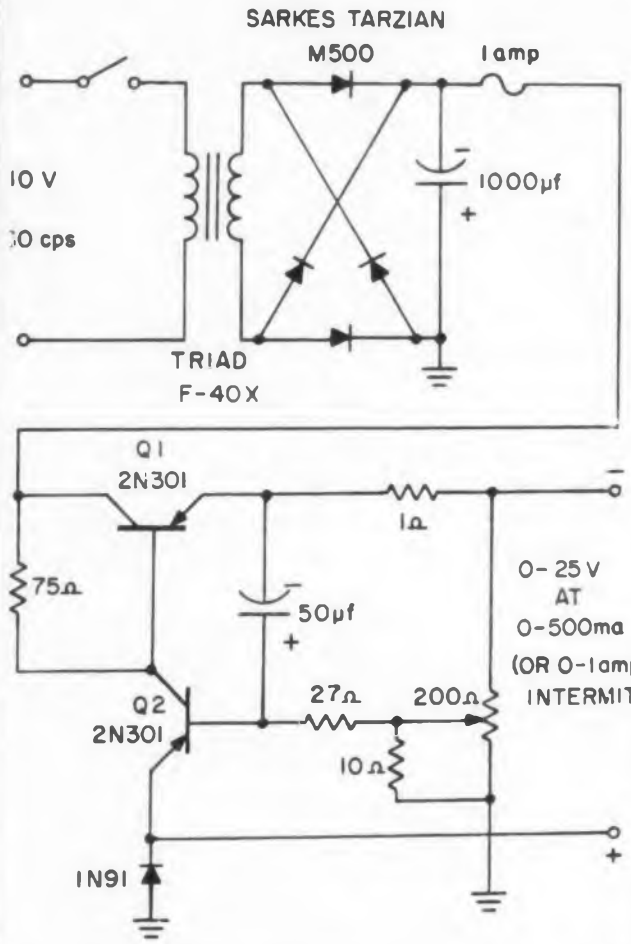
IDEAS FOR DESIGN

Power Supply Delivers Low, High I, Low Cost

This circuit fulfills the need for a high-current low-output impedance supply over an adjustable voltage range with a minimum of complexity and cost. The regulator is composed of two inexpensive power transistors and one 1N91 diode.

A 0-25-v adjustment over a 0-1/2-amp current output is featured. Output impedance varies from 0.5 ohm to −2 ohms. Ripple voltage is 100 mv p-p maximum over the entire output voltage and current range.

The regulator is conventional except for the negative current feedback effect from the dc output ground return. Instead of returning to ground directly, load current lowers the bias on *Q2* by increasing the forward drop on the emitter diode. This in turn lowers the bias on *Q1*, maintaining the load current constant. A number of diodes may be tried to get the correct "over-compounding" to balance out the inherent regulation.



Two inexpensive transistors and a diode from the basis of this power supply.

Charles T. Gage, Sigma Instruments, Inc., South Braintree 85, Mass.

Mix Two Oscillators Without Lock

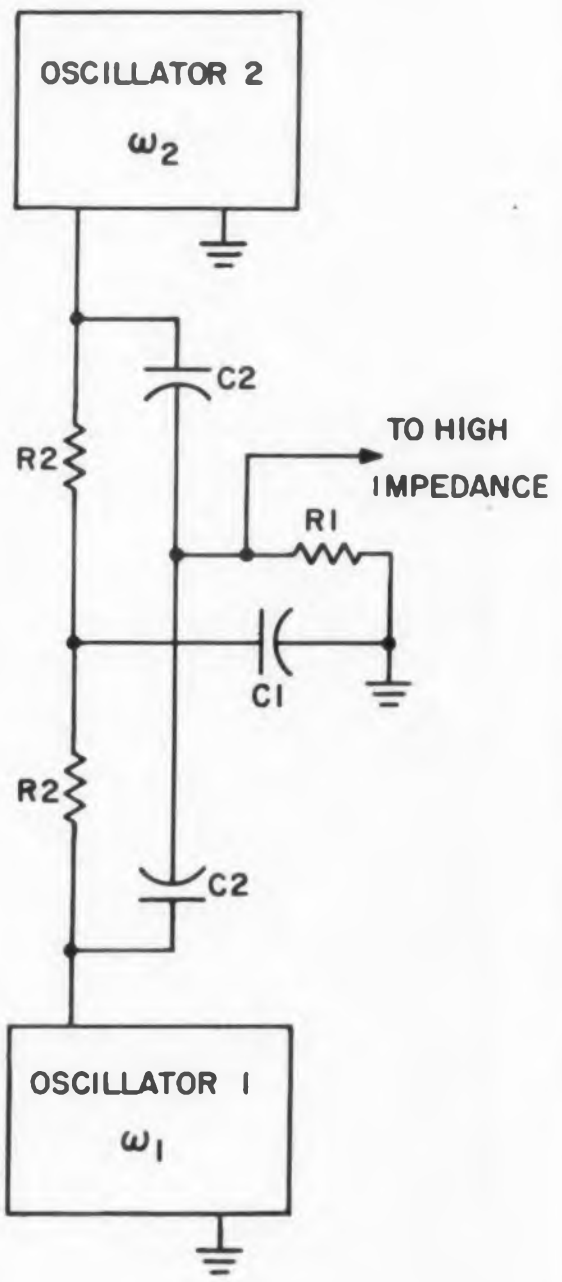
The outputs of two free-running-sine wave oscillators whose frequencies were only slightly different, had to be mixed without allowing them to lock together. The solution was provided by a parallel "T" circuit between the two oscillators.

The output is taken from R_1 and fed to a high impedance circuit. The values of the components are chosen so that there is zero transfer for one of the frequencies. This circuit was used in a beat frequency metal detector operating at about 3 mc.

The formulas for the circuit are as follows:

$$\omega_1 \simeq \omega_2$$
$$\omega^2 C_1 C_2 = 2/R_2^2$$
$$\omega^2 C_2^2 = 1/2\, R_1 R_2$$
$$C_1 R_2 = 4\, C_2 R_1$$

Jack Brotzman, Naval Research Lab., Washington 25, D.C.



Bridge "T" coupling circuit allows mixing without locking.

Increase Input Impedance Of Emitter Follower

An emitter follower such as might be used for the input stage of an amplifier often has its input impedance lowered by the loading effect of the bias resistors. A typical case is that shown in Fig. 1.

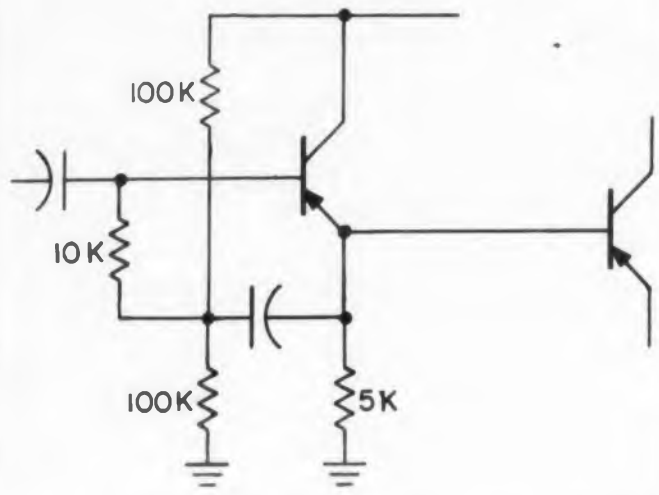


Fig. 1. Conventional emitter follower circuit parallels bias impedance with base impedance.

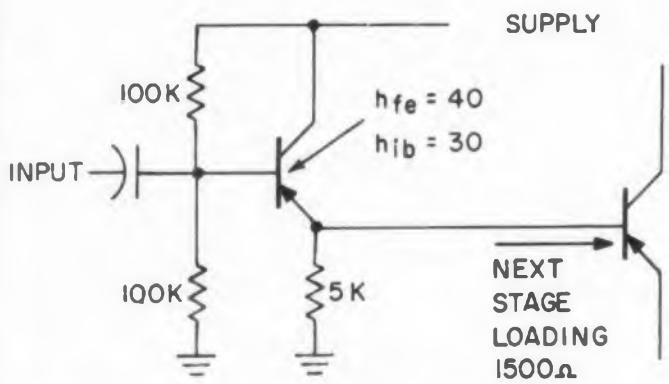


Fig. 2. Modified circuit transfers the bias resistor load to emitter circuit and almost doubles input impedance.

In this case the input impedance is the 47.3 K of the emitter follower base in parallel with the 50 K bias resistor impedance or 24.2 K.

The circuit of Fig. 2 transfers the bias resistor load to the emitter and raises the input impedance to 41 K.

The input device sees the 10 K resistor increased by a factor of $1/1 - A_v$, where A_v = the voltage gain of the emitter follower from base to emitter.

James G. Barr, The Martin Co., Denver 1, Colo.

Simplify Conversion From Binary to Decimal Numbers

A binary number such as 110110110 may be converted to a decimal by adding the radix 2 raised to the proper power for each 1 in the

binary number. In this case it would be $2^8+2^7+2^5+2^4+2^2+2^1$ or 256+128+32+16+4+2 which totals 438.

This method is long and tedious, and becomes much worse as the binary numbers become longer. The method presented here was tried and found to save considerable time in repetitious mental conversions. The method involves the use of a hexi-decimal system, which is a system using radix 16.

The binary number is broken into groups of four starting from the right so the above number would be 0001 1011 0110. The groups of four are then the coefficients of 16 raised to the appropriate power. The coefficients are evaluated by the ordinary method, mentioned above, for evaluating a binary number. However, this is a very simple mental calculation since the number must be between zero and fifteen. After some use, the values of the groups would be automatically recognized without calculation.

These coefficients are usually called 0,1,2,3,4,5,6,7,8,9,u,v,w,x,y,z, in order that only one character be used to represent one coefficient. The use of *12* instead of *w*, for example, might be mistaken to be *1,2*. To simplify the completion of the calculation, the accompanying table gives the values of the coefficient times 16 to various powers.

To find the answer to the problem, we see that there are three groups of four, representing 16^2, 16^1, and 16^0. The coefficient of the first group is 1. Looking at the table on the horizontal line corresponding to coefficient 1, it is seen that 16^2 gives 256. For coefficient v, 16^1 gives 176; and for coefficient 6, 16^0 gives 6. 256, 176, and 6 are added to give the answer 438.

Robert Banow, Ford Instrument Co., Bldg. 2, Division of Sperry Rand Corp., Long Island City, N.Y.

Table of Values for Radix 16

COEFF.	16^0	16^1	16^2	16^3	16^4
1	1	16	256	4096	65,536
2	2	32	512	8192	131,072
3	3	48	768	12288	196,608
4	4	64	1024	16384	262,144
5	5	80	1280	20480	327,680
6	6	96	1536	24576	393,216
7	7	112	1792	28672	458,752
8	8	128	2048	32768	524,288
9	9	144	2204	36864	589,824
(10) u	10	160	2560	40960	655,360
(11) v	11	176	2816	45056	720,896
(12) w	12	192	3072	49152	786,432
(13) x	13	208	3328	53248	851,968
(14) y	14	224	3584	57344	917,504
(15) z	15	240	3840	61440	983,040

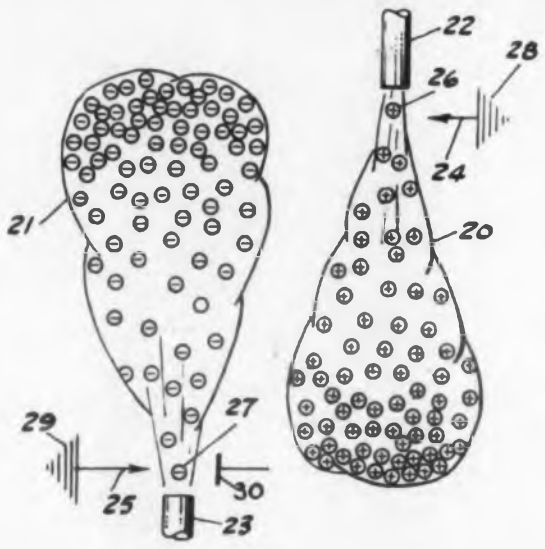
Photo courtesy Boeing Airplane Co.

PATENTS

Generation of Electrical Fields

Patent No. 2,881,335. Bernard Vonnegut. (Assigned to Arthur D. Little, Inc.)

A self regenerating means to produce separate dense charge formations is applicable to the creation and control of thunderstorms. Likewise it is possible by this means to transport particles to areas inaccessible by spraying, brushing or rolling.



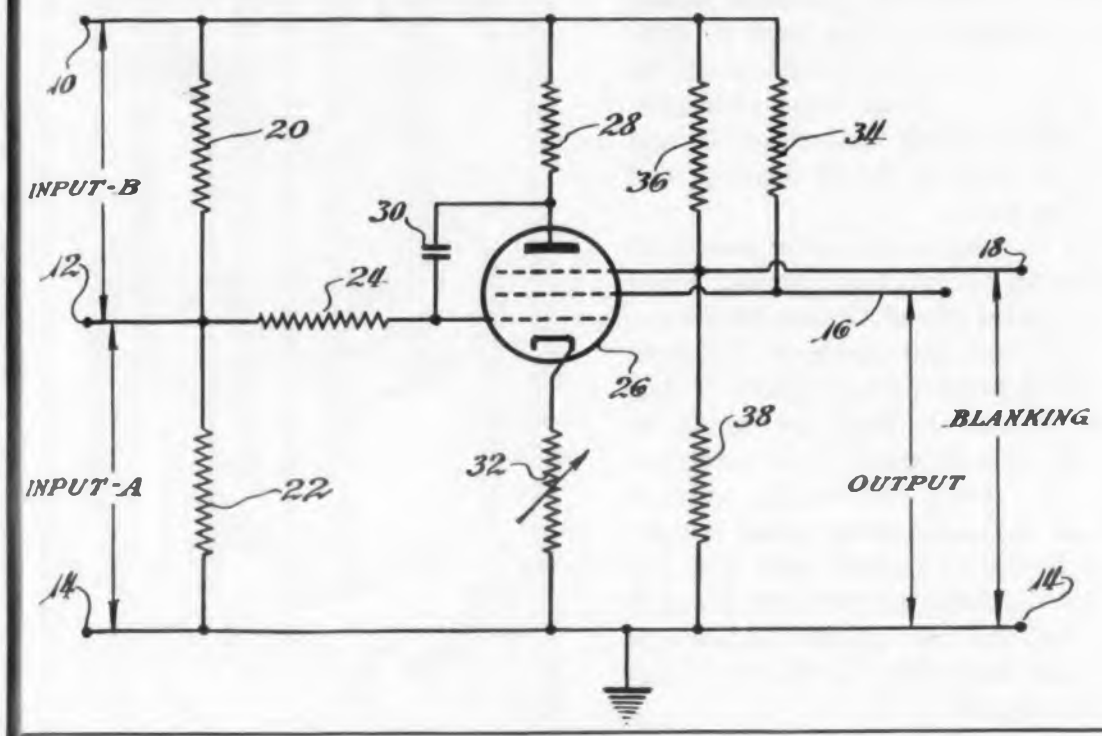
Initially, a positive voltage is applied to plate *30* to cause a corona discharge from point *25*. Negative ions moving towards plate *30* will become attached to cloud particles and the moving air will cause the negatively charged particles to accumulate at the top of cloud plume *21*. As a result, point *21* will discharge and the moving air will assist the accumulation of positively charged particles in plume *20*. With sufficient charge piled up in plume *20*, the discharge from point 25 is self-exciting and the potential difference between the clouds builds up sufficiently to produce lightning across the clouds.

Deviation Oscillator

Patent No. 2,898,554. Gale W. Crampton. (Assigned to Victor Adding Machine Co.)

Inputs *A* and *B* set the voltage on the control grid of a 6AS6 pentode phantastron and thereby determine the rundown time.

Initially capacitor *30* is charged to line voltage with the tube cut off. The capacitor discharges until control grid and plate voltages are equal at which time the pentode is cut off. The capacitor again charges to line voltage and the cycle repeats according to the voltage between the two inputs.



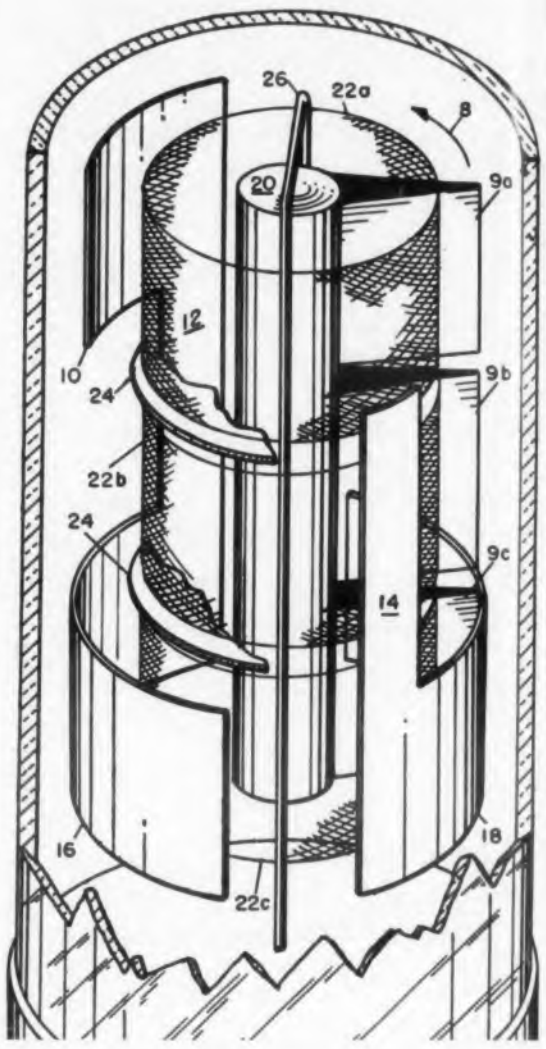
PATENTS

Synchronizing Signal Generator

Patent No. 2,884,561. Harold E. Beste. (Assigned to Allen B. Du Mont Labs., Inc.)

A single-sheet beam tube is used to generate the standard television timing pulses. Electrons emitted from an axial cathode are caused to rotate at 15,750 cps so as to impinge upon electrodes which are properly shaped, sized and located to produce the H, serrated, and equalizing pulses.

Sheet *9a* rotates the strike anode *10* once during 5 μsec (H-scan period). Sheet *9b* hits anodes *12* and *14* each revolution; the dwell time per anode is 2.54 μsec (equalizing pulse period). Sheet *9c* hits anodes *16* and *18* once per revolution dwelling on each anode 24.75 μsec (serrated pulse time.) The requisite gaps in the train of synchronizing pulses are obtained by gating control grids *22a, 22b* and *22c*. Initiation of the pulse series is prescribed by the narrow 31,500 cps pulses produced when the sheets impinge on wire loop *26*.



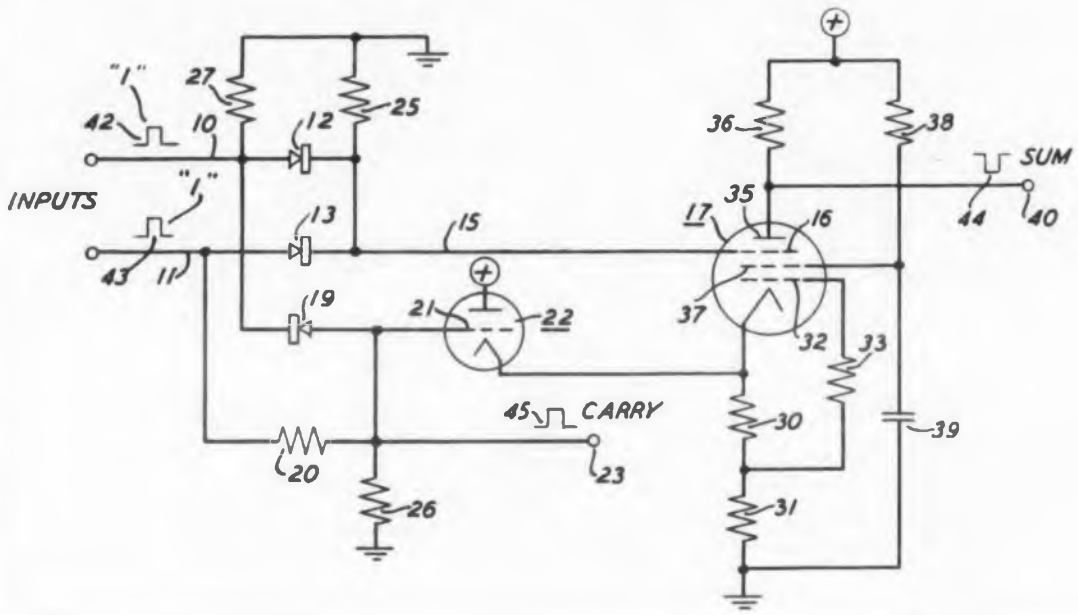
Binary Half Adder

Patent No. 2,901,602. Elmer L. Younker. (Assigned to Bell Telephone Labs, Inc.)

The logical circuit produces two outputs—a "sum" when the inputs are applied separately and a "carry" when the pulses are applied simultaneously.

Initially pentode *17* is conducting on the screen with zero plate 35 current due to suppressor *16* cut off. A positive pulse applied to the suppressor causes the plate to conduct the "sum" output. By contrast, if the positive pulses are applied simultaneously to the suppressor and the cathode, the suppressor-to-cathode voltage does not change and plate conduction is zero.

Note, however, that the simultaneous application of the positive pulses to inputs *10* and *11* causes diode *19* to cut off and a "carry" pulse is available at terminal *23*.



IMPULSE

A DIGEST OF NEW DEVELOPMENTS IN ELECTRONICS AND AUTOMATION

PUBLISHED BY ROME CABLE CORPORATION, ROME, N. Y.

PIONEERS IN INSTRUMENTATION CABLE ENGINEERING

GLEAM IN ELECTRONIC EYE. There's more than one way to distinguish male from female, but the Army's newly developed ultra-sensitive radar system is certainly the most up to date! It's so sensitive it can spot even the slightest movement behind enemy lines—and distinguish between a walking man and woman! The blips provide the tip-off: a woman walks differently than a man and produces a different wave on the radar. This ground-to-ground system operates in fog or darkness, enabling the Army to detect moving targets at long range. Vehicles can be spotted 10 miles away and, in tests under ideal conditions, a walking soldier has been spotted 15 miles away.

WATCH OUT FOR THE MOHOLE! Watch for a new geophysical race between American and Soviet scientists: drilling through the earth's crust and the mantle around the earth's core. A variety of electronic instrumentation will be used in the drilling of a "Mohole"—so named because the boundary between crust and core mantle is called the Mohrovicic Discontinuity. American scientists propose to go down 18,000 feet below the ocean floor to measure a number of physical and chemical properties, including density, radioactivity, elasticity, magnetism, electrical properties, thermal gradient, porosity, permeability, and pressure. Existing instrumentation can be used if the hole is not smaller than 4 inches in diameter. Steps are being taken to develop a satisfactory low-frequency seismometer.

WHAT'S NEW IN INSTRUMENTATION CABLE? This 8-page illustrated bulletin discusses cable insulation and jacketing material and lists typical multiconductor cable constructions available for use with telemetering equipment, data recording equipment, circuit control testing and electronic computers. Every design engineer working with electrical cable should have a copy. To obtain your *free* copy, write to IMPULSE, c/o Rome Cable Corporation, Dept. 1111, Rome, New York.

REAL-LIFE FLYING SAUCERS. Plans have already been made for saucer-like platforms to be stationed miles above the earth, powered by microwave energy beamed from the earth to the sky. A new scientific breakthrough—the development of a high-frequency, high-power microwave tube—makes this project feasible. Ergo, a previous engineering vice becomes a virtue: in communications, generated heat must be kept to a minimum; on the platform, the more heat generated, the more propulsion power is made available. It may not be long before there will be no question as to the authenticity of reported "flying saucers."

CABLEMAN'S CORNER. An important phase in multi-conductor cable manufacture is the manner and equipment used to "cable," or "twist," the various components together. The end use of the cable becomes an important factor in the assembly of a cable. Where flexibility is important, the length of lay, direction of lay, and the internal components all play important roles. Where connector fittings are employed, the sequential arrangement of the components may be important. Because of differing machine capabilities, even the selection of the specific piece of equipment for assembling your cable becomes important. To obtain the best results, consult a cable specialist—a man familiar with all the aspects of cable manufacture—your Rome Cable salesman.

These news items represent a digest of information found in many of the publications and periodicals of the electronics industry or related industries. They appear in brief here for easy and concentrated reading. Further information on each can be found in the original source material. Sources will be forwarded on request.

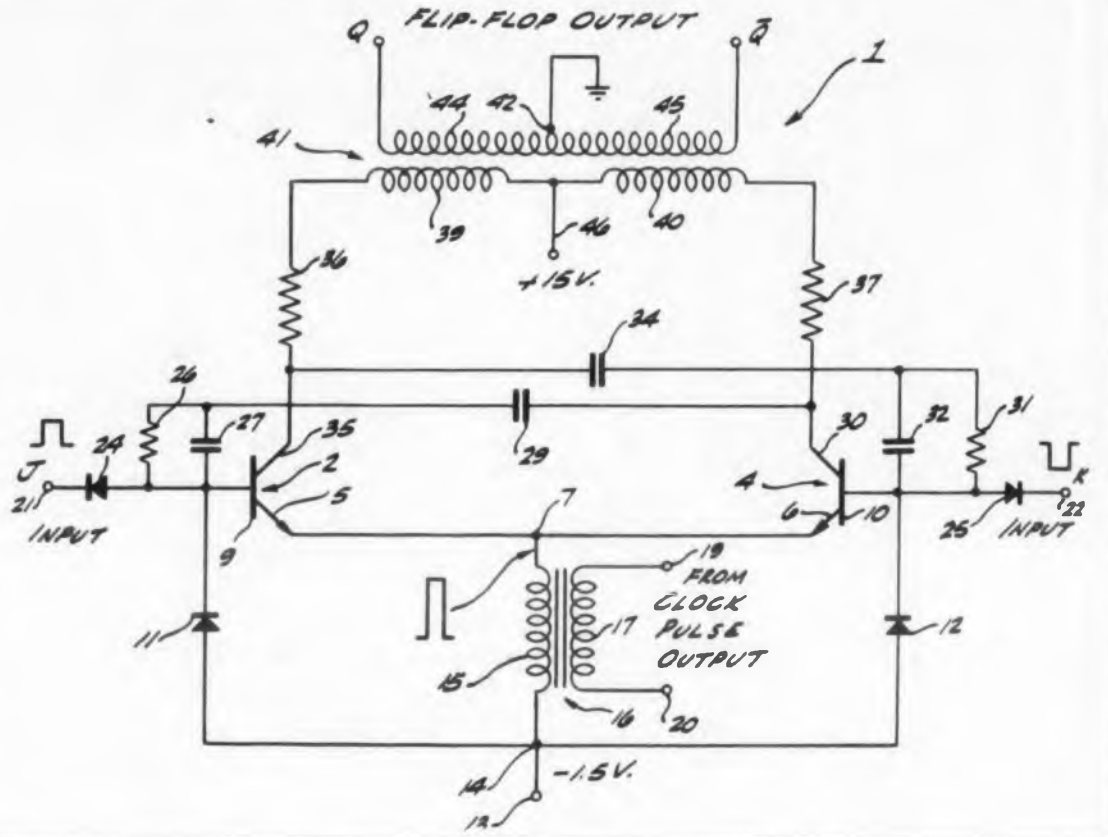
CIRCLE 555 ON READER-SERVICE CARD

PATENTS

Clock Pulse Circuit For Transistor Flip-Flop

Patent No. 2,898,479. Melvin R. Elroy. (Assigned to Hughes Aircraft Co.)

An improved transistor flip-flop circuit reduces the required clock pulse power and allows the application of relatively inexpensive components; 50 flip-flops re-



quire only about 200 ma of clock triggering current. An npn transistor flip-flop obeys the illustrated truth table as the clock pulses shift the common emitter voltage from −1.5 v to 0.5 v.

Assume, as shown, that the *J* input is at +1 v and the *K* input is held at −1 v; transistor *4* conducts while transistor *2* is cut off. Now, let the clock pulse shift the common emitter (terminal *7*) potential to +0.5 v.

Transistor *2* remains cut off but the emitter *6*—base *10* voltage is sufficient to cut off transistor *4*. A pulse couples back through capacitor *34* to flip transistor *2* to conduction. It is obvious that when both *J* and *K* inputs are simultaneously at +1 v, the flip-flop will be insensitive to the clock pulses and no change will occur.

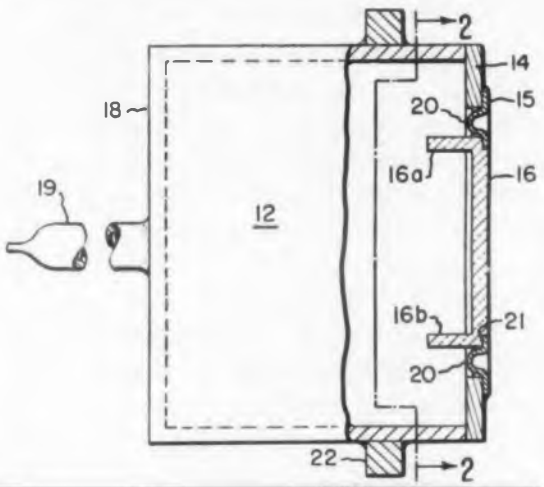
J	K	Q	$\bar{Q}$
+1v	+1v	NO CHANGE	NO CHANGE
-1v	+1v	T	F
+1v	-1v	F	T
-1v	-1v	CHANGES STATE	CHANGES STATE

Microwave Switching Device

Patent No. 2,900,568. Dudley N. Brewster. (Assigned to Sylvania Electric Products, Inc.)

A high-power discharge in a resonant TR device ordinarily causes sputtered metal to deposit on the iris or window. This tends to short-circuit the window, detune the cavity or make the window opaque to microwave transmission.

Invention lies in providing projecting ridges, *16a* and *16b*, of dielectric along the edges of the window adjacent to the area of sealing to the metal. Deposition of metal on the window is transparent to electromagnetic energy passage.



BOOKS

Foundations for Bioelectronics for Human Engineering

A. Ford, U. S. Navy Electronics Laboratory, San Diego, California NEL Report 761, OTS Publication, PB 151291, Distributed by U. S. Dept. of Commerce, Office of Technical Services, 119 pp, $2.75

Bioelectronics represents a union of electronics with physiology and psychology, for the purpose of measuring the electrical changes associated with the bodily functions of human beings. At its present stage, bioelectronics does offer great promise in human engineering. Dr. A. M. Small, Sr., formerly Head of the Human Factors Division, U. S. Navy Electronics Laboratory, saw the possibility of applying bioelectronics to several NEL problems. Dr. Small also saw that, without a survey, it would be impossible to know whether the new projects would overlap work being done elsewhere, and it might even be impossible to emphasize the safe bioelectrical techniques and avoid the unsafe ones. He therefore assigned the writer of this book the task of making a survey of 614 studies covered in the book. These 614 were selected from almost 800 studies by eliminating those which were obviously only slightly significant.

The presentation takes the form of an annotated description of work cited by author, title, and location. To secure complete data on work elsewhere, every form of research communication, informal as well as formal, has been considered and is listed herein. The papers include

unpublished doctoral and masters dissertations and, in some cases, even informal mimeographed notes of a research worker sent to his colleages in other places. Sometimes the citation is that of a progress report on a military contract, or the abstract of a proposed paper to be read before a scientific meeting.

The information has been collected by reading original reports, insofar as possible, which has been facilitated by correspondence with the authors and directors of bioelectronic research in other places. Many of these men provided copies of hard-to-get reports and memoranda not listed in any library. In a few instances it has been necessary to use abstracts of work written by other reviewers, but usually only in minor citations.

Source Book of the New Plastics

Herbert R. Simonds, Reinhold Publishing Corp., 430 Park Ave., New York 22, N.Y., 362 pp, $10.00

Included here are the new plastics, their properties, production, price, applications and selection. Sixty plastics producing companies contribute articles describing their own materials. These materials include the seven new primary plastics of 1958.

The book also describes the significant recent improvements in established plastics, and the 100 most important patents issued in the plastics field for 1958. An "Introduction to Polypropylene" explains Professor Natta's work and the earlier German development of stereospecific catalysts. The book also gives complete information about polypropylene and polycarbonate. A section on graft copolymers describes the use of that technique in modifying plastics properties.

This book is a unique approach to plastics that concerns itself almost exclusively with latest developments. It contains the first and only survey of federal-sponsored research in plastics, and was made by James Kanegis of the Department of Commerce. It continues the practical presentation begun in the author's famous "Concise Guide to Plastics."

BOOKS

Video Speed Servicing

Samuel L. Marshall, Howard W. Sams & Co. Inc., and the Bobbs-Merrill Co. Inc., Indianapolis, Ind., 160 pp, $2.95

This book contains a compilation of the troubles and repair procedures in specific TV receivers. It includes common breakdowns, troubles that cause unusual symptoms, and circuit changes that provide improved performance. Background material has been obtained directly from the manufacturers, from field service engineers, and from highly-skilled technicians. The book pinpoints the faults and describes in simplified detail the symptoms and the necessary repairs—the primary objective being the saving of your valuable time in diagnosing the trouble and making the repair.

The servicing information is presented in a straightforward and easy-to-follow manner. Accompanying each item is a simplified diagram of the section affected, to help the service technician identify and locate the defective component. A complete index of receiver chassis and models is provided, and a logical method of identifying and classifying receiver troubles is used.

Relays

Collection of Papers given at the Seventh National Conference on Electro-Magnetic Relays, 1959, reprinted by Potter & Brumfield, Division of American Machine & Foundry Co., Princeton, Ind., 134 pp.

Thirty-three papers are reprinted in this book. The subjects covered fall into these categories: contacts, environments, general design, operating characteristics, specifications, testing, and testing equipment. Most of the papers discuss topics that interest designers of relays. But there are papers covering areas that would also interest relay users. These areas include: how to specify relays realistically, factors that affect the selection of contacts, relays vs. semiconductors as switching devices, understanding relay pull-in, and effects of shunting circuits on relay operation.

Recorder Survey: Recording Surfaces and Marking Methods

George Keinath, U. S. Government Printing Office, Washington 25, D.C., 41 pp. 30¢

This publication surveys and compares the characteristics of continuous traces, dotted traces, and printed characters produced by inking, incision, impression, indentation, deposition, heat, light, electric discharge, electron beam, magnetism, chemical action, or fluid streamlines. Descriptive and reference materials are included on three physical components of the recording system—the reservoir of material or energy, the marking point or matrix positioned by the measuring element, and the chart surface which preserves the record. Recorders are used for many purposes, but most frequently to supervise industrial processes and to carry out mechanical, electrical, and chemical testing of materials and products.

This survey was undertaken to bring together available information on the various methods and problems of recording scientific and technical data. The survey covers some of the physical principles either currently or potentially available for recording variable measurands in laboratory experimentation or industrial production.

Many recording principles have found practical application in commercially available recorders, and both illustrations and performance information have therefore been drawn largely from manufacturers' literature. Information obtained from commercial sources has been carefully reviewed, but no test program was carried out to verify performance claims. The omission of any method or device does not imply that it is considered unsuitable or unsatisfactory. Conversely, inclusion of descriptive material on any proprietary instrument, product or process does not constitute endorsement.

This first volume deals with marking methods and recording surfaces. Work under way in the reviewing of recorder actuating mechanisms, special recording problems, and data presentation may result in the issuance of a later report on these aspects of recording systems and marking methods.

J. George Adashko

Multichannel Electron Multipliers

L. I. Andreeva B. M. Stepanov

ATTEMPTS to obtain higher pulsed currents from electron multipliers by "forcing" the power supply to the output stages date back some time.[1,2] Coaxial photocells[3] and electron multipliers with coaxial collectors[4] have yielded pulsed output currents of several amperes with a time resolution of up to 2×10^{-9} second.

Unlike these single-channel systems, the multichannel electron multipliers described here yield pulse outputs of up to seven amps, with a time resolution of up to 2.5×10^{-9} sec and a gain of 10^8 to 10^9. They can have from two to eight channels operating in parallel into one coaxial collector.

Fig. 1 shows a four-channel electron-optical system based on this principle. Each channel has a ten-stage electron multiplier with trough-like emitters. The collector is a short segment of 75 ohm coaxial line with slots in the outer conductor to permit passage of the electrons to the inner conductor.

The electron optics of the input to the coaxial collector is illustrated in Fig. 2, and again in Fig. 4.

Fig. 2 shows that this coaxial-collector construction provides good shielding between the collector field and the fields of the output emitters. This construction makes it possible to exclude the influence

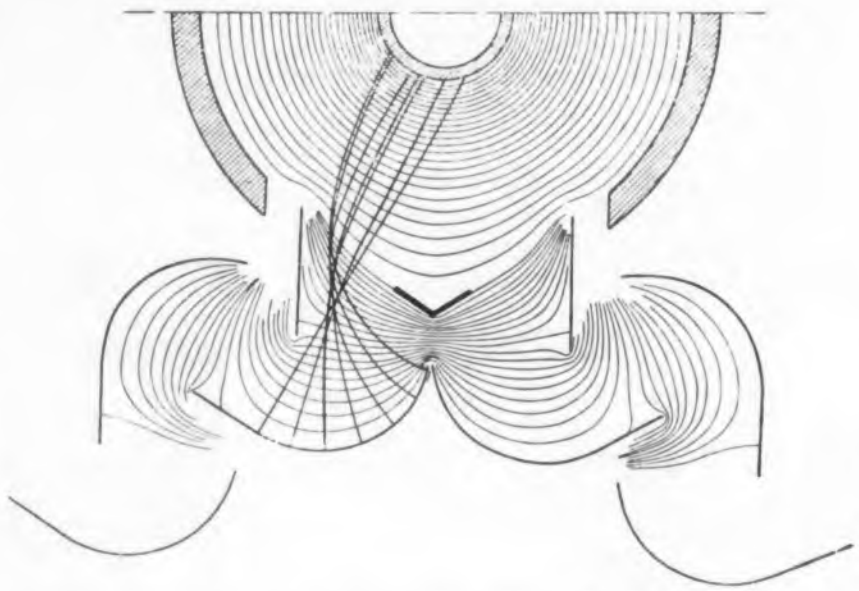


Fig. 2. The electron optics of the 75-ohm coaxial line which serves as the collector for the electron multiplier of Fig. 1.

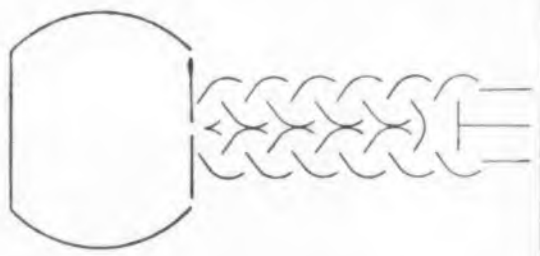


Fig. 3. A two-channel electron multiplier in which the collector is used in the form of a capacitor operating directly into a coax line.

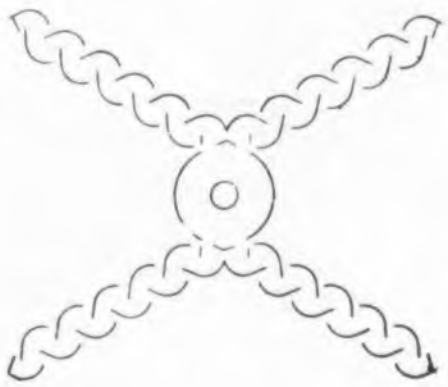


Fig. 1. (right) A four-channel electron-optical electron multiplier.

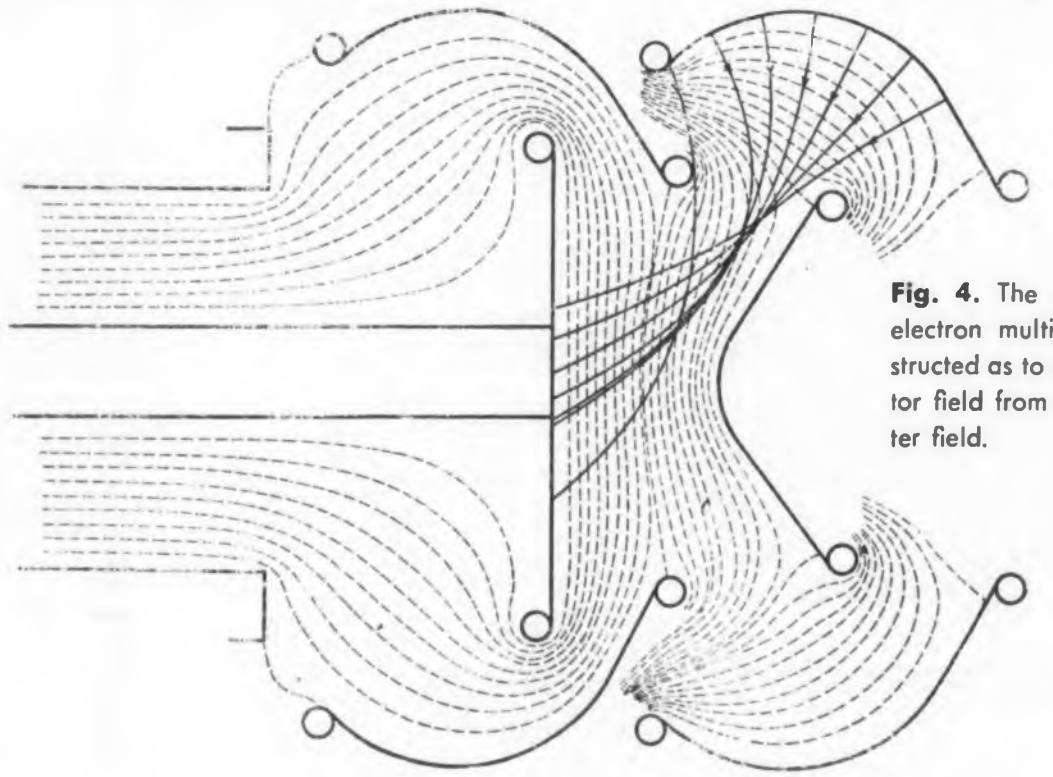


Fig. 4. The collector in this electron multiplier is so constructed as to shield the collector field from the output emitter field.

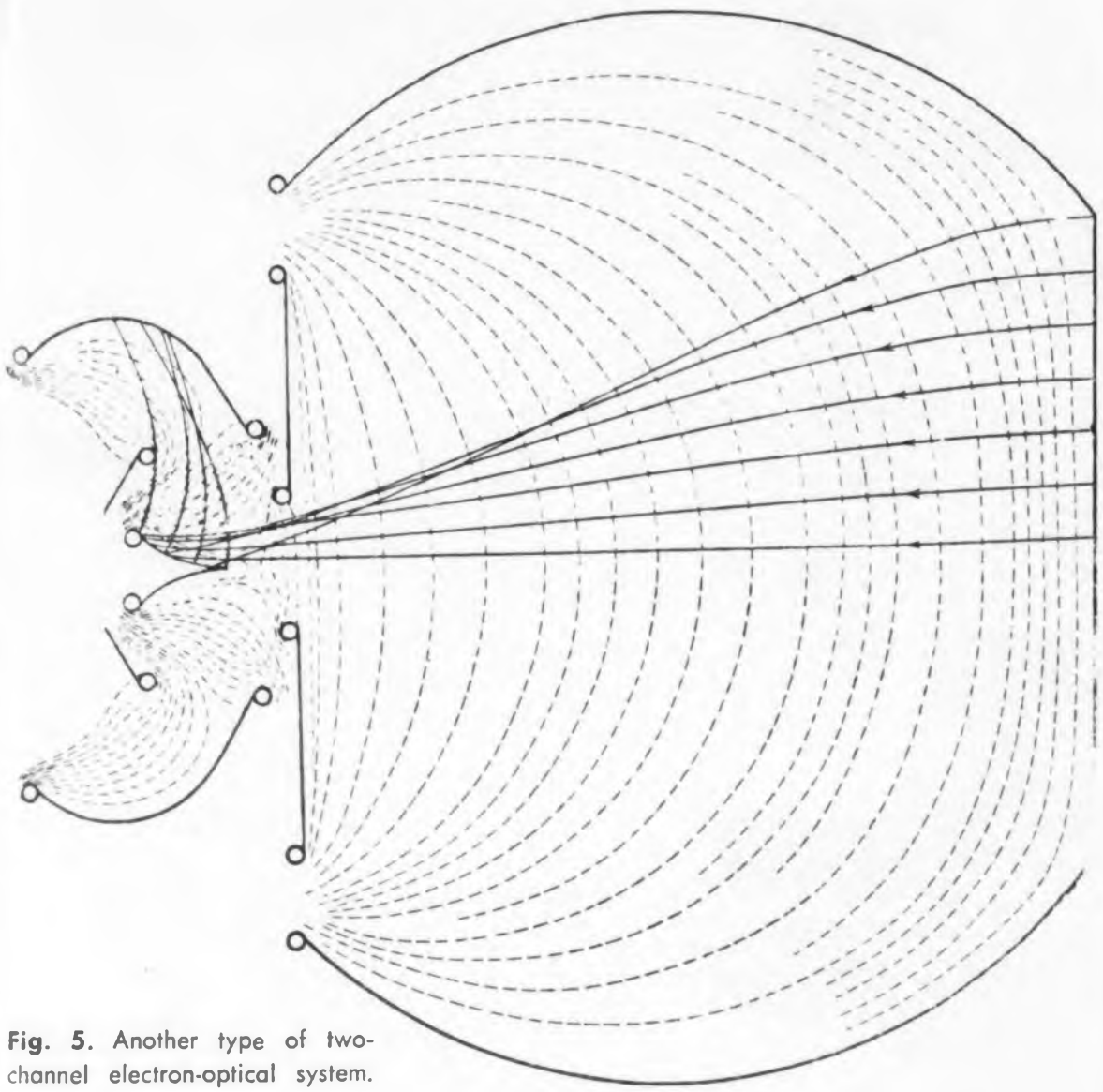


Fig. 5. Another type of two-channel electron-optical system.

on the electron-optical properties of the output emitters of the change in collector voltage during the instant of the current pulse.

Fig. 3 shows a two-channel electron multiplier in which the collector forms a capacitor that operates directly into the coaxial line. In this case too, the collector is so constructed as to shield the collector field from the output-emitter fields. This aspect is shown more clearly in Fig. 4.

In all systems, the output terminal of the coaxial collector is a coaxial metal-glass seal, permitting broadband transition to an ordinary 75 ohm coaxial cable through a special coaxial plug. The entire collector cable system has a flat frequency characteristic up to 10^9 cps.

The fact that several parallel channels feed a common collector makes it possible to use large emitter surfaces and still keep the entire device relatively small.

To permit registration of X-rays, a copper-beryllium cathode is used. This cathode, only 20 mm thick, has a quantum yield from 2.5 x 10^{-3} to 1.5 x 10^{-3} electrons/quantum for X-rays of energies from 0.5 to 1.3 Mev. One of the variants of the cathode electron-optical system, with two channels, is shown in Fig. 5.

The insulating material used for the electron-optical systems of multichannel electron multipliers is synthetic mica. It has good vacuum properties and is easily machined. Before assembly, the synthetic mica should be degassed in vacuum at 450 C. ■ ■

This article was translated from the Russian journal Radio Engineering and Electronics *of July 1959.*

References

1. R. F. Post and N. S. Schiren, *Physical Review*, 1950, Vol. 78, pp 80, 81.
2. A. Lunly, *Physical Review*, 1950, Vol. 80, p 477.
3. W. C. Hall, B. M. Norton, J. W. Keller, and S. H. Liebson, *Nucleonics*, 1953, Vol. 11, No. 1, p 49.
4. J. D. Shipmen, M. R. McCraven, *IRE Transactions Nuclear Science*, 1956, Vol. S-3, No. 1, p 10.

GERMAN ABSTRACTS

E. Brenner

Frequency D

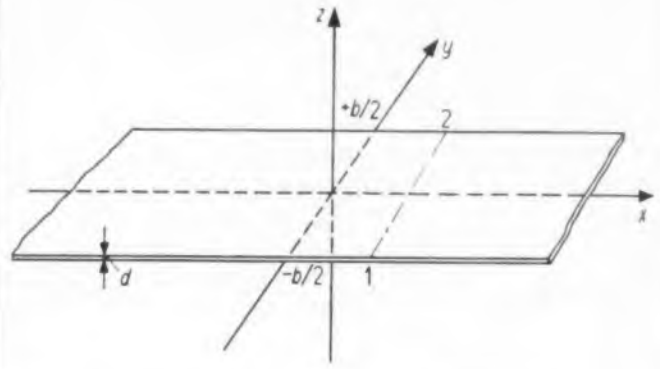
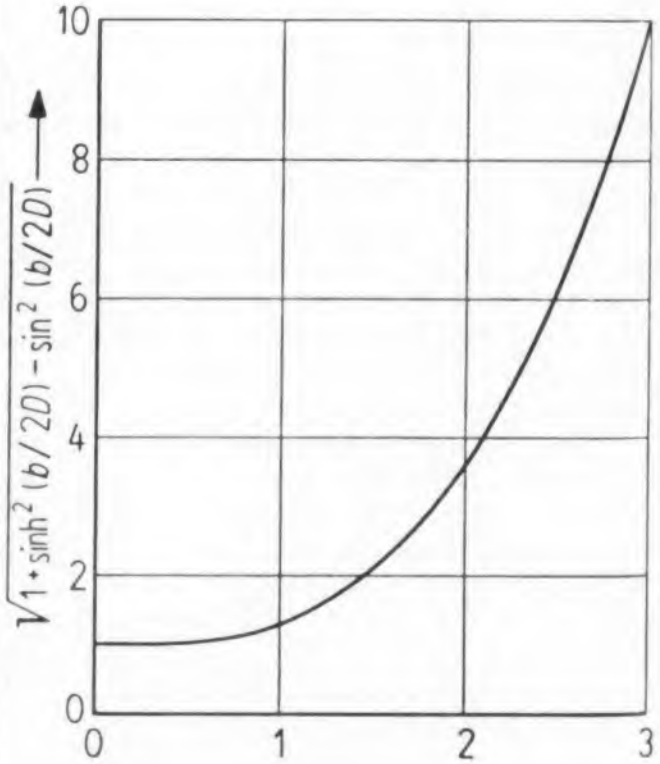


Fig. 1. Semiconductor plate in a coordinate system.



ncy Dependence

IF IT IS assumed, for an infinite semiconductor plate with geometry as shown in Fig. 1, that the magnetic field has only a $z-$ component which does not vary with z then the Hall voltage amplitude, V_h, increases with frequency over its dc value V_o according to the equation

$$\frac{V_h}{V_o} = (1 + \sinh^2 a - \sin^2 a)^{\frac{1}{2}} \quad (1)$$

where $a = b/2D$, $D = 1/(\pi \mu_0 \delta f)^{\frac{1}{2}}$ (1)

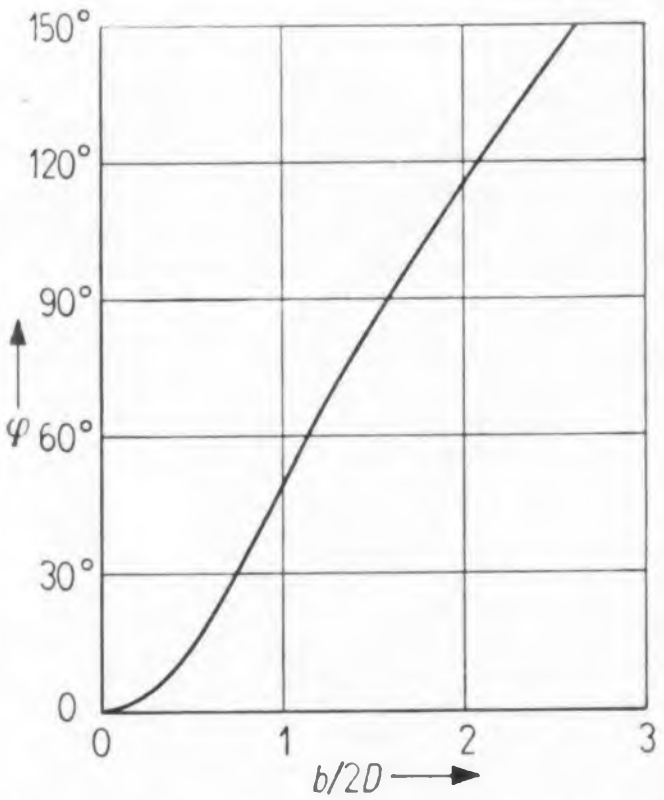


Fig. 2. Dependence of Hall voltage on the ratio $b/2D$ (i.e. with square root of frequency) (a) Amplitude (left). (b) Phase.

GERMAN ABSTRACTS

In addition, the Hall voltage leads the impressed magnetic field by the phase angle given by

$$\psi = \tanh a \tan a \qquad (2)$$

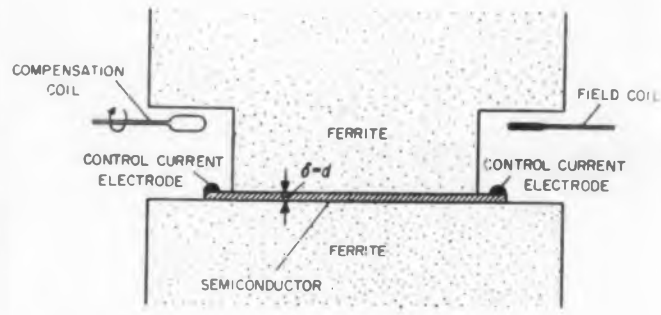
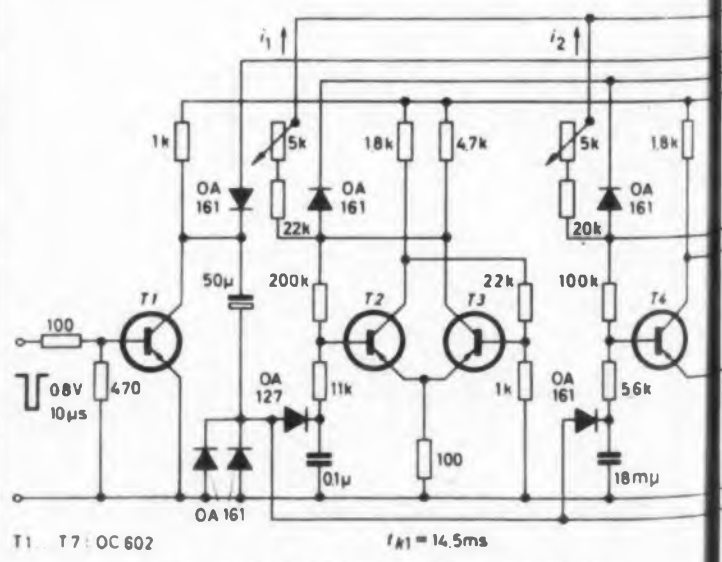


Fig. 3. Hall generator embedded in ferrite.

Quasilogarithmic Pu

A CIRCUIT which employs seven transistors, Fig. 1, has been developed for unambiguous quasilogarithmic pulse indication of pulse repetition rates up to 7 kc. The circuit consists of a cascade of three multivibrators whose mean output voltage approximates the logarithm of the pulse count but which has ambiguity when the time between pulses exceeds the relaxation time of the



Circuit of the quasilogarithmic pulse indicator.

Eqs. 1 and 2 are illustrated in Fig. 2.

In order to realize the assumptions regarding the space distribution of the magnetic field, it is necessary to embed the semiconductor plate in a material with high permeability, e.g. a ferrite, as shown in Fig. 3. The remaining airgap must be small compared to d. If this condition is not fulfilled, the calculated frequency dependence of the Hall voltage does not occur and a substantially frequency-independent amplitude is observed.

A detailed description of the experimental procedure and results, as well as a discussion of eddy current losses and their relation to control power, is included in the original paper.

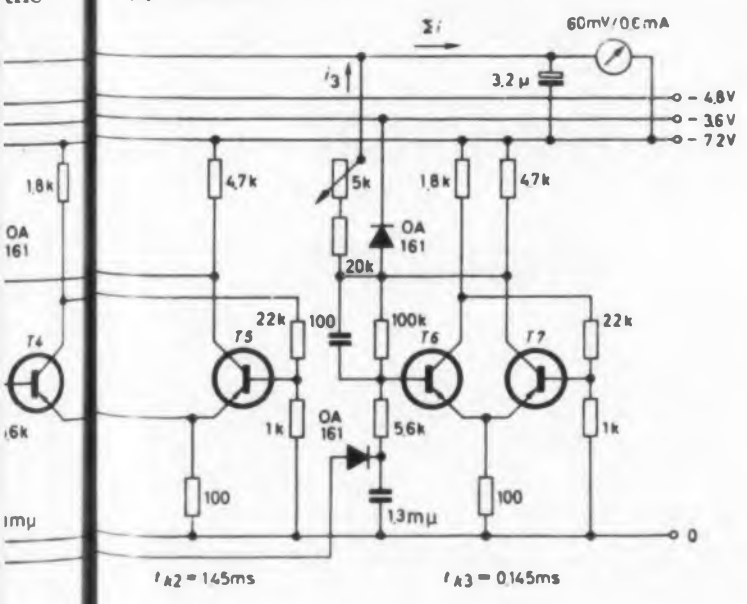
Abstracted from an article by F. Kuhrt, H.-J. Lippmann and K. Wiehl, Archiv der Elektrischen Uebertragung, *Vol. 13, No. 8, Aug. 1959, pp 341-347.*

mi Pulse Indicator

monostable circuits.

An analysis of errors in the new circuit shows that the indication differences between statistical and equal pulse distribution gives less than one per cent error at pulse repetition rates of 700 cps.

Abstracted from an article by T. Friese, Elektronische Rundschau, *Vol. 13, No. 8, August 1959, pp 283-285.*



GERMAN ABSTRACTS

Cross-Modulation in Frequency Tr

BOTH ANALYTICAL and experimental investigation of the behavior of high-frequency transistor circuits show that such circuits are generally more sensitive to cross-modulation than comparable electron tube circuits. For this reason,

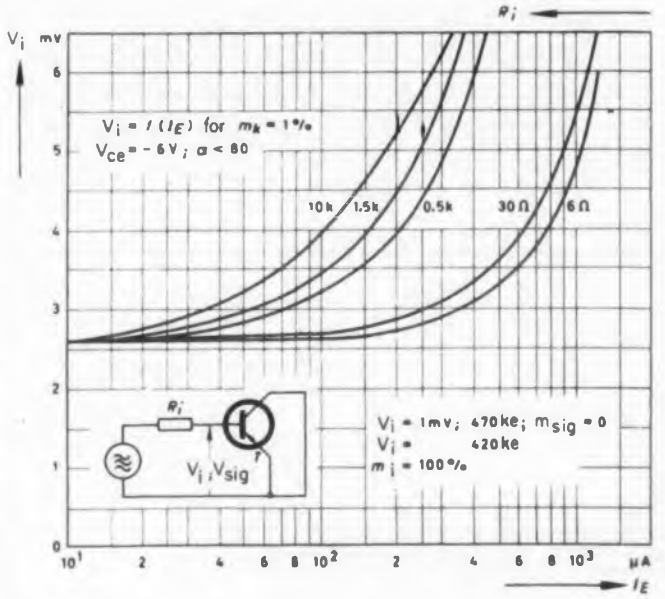


Fig. 1. Influence of source output impedance R_i on the effective value of interfering voltage to produce one percent cross-modulation.

An Organic Nonlinear Dielectric

LANESTEROL is an organic substance whose dielectric constant exhibits a marked dependence on field strength. Using a metallized, Lanesterol impregnated paper capacitor in a bridge at 800 C, it is found that the momentary super-position of a dc potential results in a momentary decrease of capacitance. The original

n High Transistors

special transistor circuits in which cross-modulation is minimized must be developed.

The cross-modulation factor K is defined as

$$K = 3\,\frac{cm_i}{am_a}\,V_i^2$$

where m_i is the amplitude modulation index of the interfering signal, V_i is its amplitude, m_a is the modulation index of the signal proper and the parameters a and c are defined from the assumed input voltage-output current equation

$$i = I_0 + av + bv^2 + cv^3 + \ldots$$

For unmodulated signals, the cross modulation index m_k is defined as

$$m_k = 3\,\frac{c}{a}\,m_i\,V_i^2$$

For very small emitter current, the effective interfering voltage which produced one per cent cross modulation corresponds to about 0.1 v ($V_T = kT/e$) when the interfering signal is 100 per cent modulated. With increasing emitter current, the effective value of V_i needed for m_k = one per cent increases, as shown in Fig. 1, at a rate depending on source resistance.

Abstracted from an article by H. Lotsch, Elektronische Rundschau, *Vol. 13, No. 8, August 1958, pp 290-294.*

capacitance value is restored after removal of the dc component.

The dependence of dielectric constant on field strength has the form

$$\frac{\Delta\varepsilon}{\varepsilon} = -aE^b$$

where, for the impregnated paper, a typical value of b is 1.90.

Unfortunately (from the point of view of capacitor applications) the superposition of long time constant voltages results in time–and temperature–dependent decreases in capacitance which persist after discharge.

Detailed experimental results are cited in the original paper.

Abstracted from an article by G. Helwig Zeitschrift fuer Angewandte Physik, *Vol. 11, No. 7, July 1959, pp 255-259.*

ELECTRONIC DESIGN
DIGEST

Tunnel Diode Oscillator Works At 3010 Mc, Uses Lumped Parameter Design

THE USE of the negative-resistance diode, also called the Esaki or tunnel diode, in very high frequency oscillator circuits using wave guides and cavities as tuned elements has met with difficulties as a result of so-called parasitic oscillations that arise from having to drive the circuit from a very low impedance dc source. A different design approach, based on lumped-parameter principles, which is free from this type of biasing problem, is described here. It has produced oscillators that operate well into the microwave region (3000 mc) where it has not previously been thought profitable to use only lumped-parameter elements. (A more recent model has a fundamental frequency of oscillation of 4020 mc.)

The structure used in these oscillators (shown schematically in Fig. 1) consists of a highly doped *n*-type germanium wafer, about 2 mils thick, which is soldered to a 3-mil nickel mounting tab that serves as one electrode of the circuit. Two tin impurity dots, one doped with gallium, the other with arsenic, are alloyed to the *n*-type wafer in close proximity to each other. The SnGa dot forms a recrystallized *p* region which makes an abrupt junction with the heavily doped *n* material. This produces a negative resistance of the Esaki type when a forward bias in the region of 50 to 350 mv is applied. The SnAs dot forms an ohmic contact to the *n*-type wafer. If the resistance between the SnAs dot and the mounting tab is smaller than the absolute value of the negative resistance of the Esaki diode, then the system oscillates at a very high frequency when a shorting bar, which acts as the second electrode of the circuit, is connected as shown. A biasing current

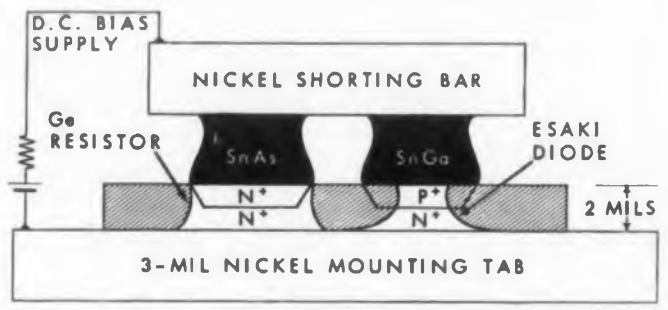


Fig. 1. Schematic cross section of the semiconductor microwave oscillator. Shaded area is heavily doped n-type germanium wafer.

Fig. 2. Simplified equivalent circuit of the microwave tunnel diode oscillator.

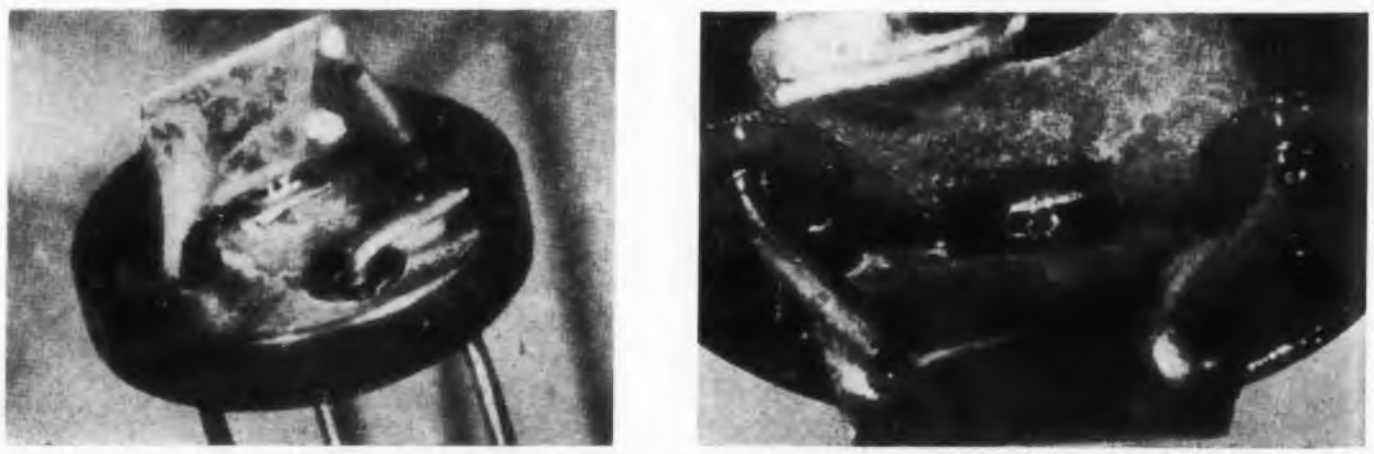


Fig. 3. Two views of the microwave oscillator mounted on conventional header.

then flows through the resistive part of the circuit of sufficient magnitude to produce a dc voltage across the tunnel diode, making it behave as a negative resistance.

The oscillator frequency is increased as the dimensions of the dots and their spacing decrease. The frequency of such an oscillator structure can be increased by etching away the shaded areas of the Ge wafer. This etching procedure has the effect of reducing the area of the tunnel diode junction, hence also its capacitance. Etching also isolates the bias resistance part of the circuit from the diode part and suggests the simplified equivalent lumped-parameter circuit of Fig. 2. Here the diode part of the circuit is represented by a negative resistance $-R_E$ shunted by a capacitance C_E. The bulk resistance of the diode is not explicitly represented in this simplification. The bias resistor, which is concentrated under the SnAs dot, is represented by R and the loop inductance of the circuit is represented by L. A necessary condition for oscillation is that:

$$R < |-R_E|$$

Experimentally, the frequency of a given oscillator increases as the diameter of the tunnel diode junction area is decreased. Table 1 shows the results of measurements for one oscillator.

The resistor portion of the germanium was covered with stop-off wave, and for each successive measurement shown in Table 1, the diode portion

Table 1. Frequency vs Tunnel Diode Junction Area

Frequency in Mc	*Diameter of Esaki diode junction in mils*
1490	3.5
1850	2.9
2240	2.4

was electrolytically etched in dilute KOH. This etching action concentrates the removal of germanium in the vicinity of the junction so that the junction capacitance is mainly affected while the loop inductance is essentially unchanged. This condition will not hold if the etching is continued to the point where the germanium becomes a very thin pedestal and contributes to the total loop inductance. Assuming that the junction is uniform over its area, and that area is proportional to the square of the measured diameter, then these results strongly suggest that for this oscillator, in the frequency range indicated, the frequency is very nearly inversely proportional to the square root of the junction capacitance.

Experiments show that the frequency generally decreases slightly as the forward dc bias is increased. For a typical oscillator operating at 2200 mc, the frequency decreased approximately 30 mc

as the voltage was increased by 30 mv. This decrease in frequency is consistent with increase in capacitance to be expected with increasing forward bias. But the change in negative resistance with bias, which is not accurately known for these units, can also have an effect. The range of forward bias voltage (normally about 0.1 v) over which the oscillations are sustained is so small, and the experimental error of measurement so large, that the exact functional relationship between frequency and bias cannot be easily deduced from measurements made thus far.

For convenience of making electrical connections to the oscillator structure, the units were mounted on conventional 3-pin circular transistor headers (Fig. 3). The dc bias was applied between the center pin which is soldered to the base of the header and one of the two outer pins which support the shorting bar. The frequency was essentially unaffected by the lengths and positions of the leads to the external dc bias supply—if the resistance in the supply loop is high compared to the resistance of the germanium resistor in the oscillator structure. Since these resistors have typical values of about 50 milliohms, the power supply impedance will be sufficiently high if it is one ohm, a condition easily achieved in practice.

The frequency is measured by placing a small length of wire, which serves as a pick-up antenna, near the oscillator and mixing the pick-up signal with that of a known oscillator, then detecting the difference frequency on a General Radio if amplifier and detector. The use of this type of loose coupling prevents the generation of spurious signals produced by interactions of the strong local oscillator signal with the nonlinearities of the Esaki diode structure, which otherwise makes the determination of the true fundamental frequency difficult.

Other methods of detecting the oscillations have included strongly coupling the output into a coaxial line that is directly connected to a receiving system. The lack of influence of the power supply

Fig. 4. Photomicrograph of the oscillator. The tunnel diode is the thin pedestal on the right. The narrowest dimension is about 1 mil.

wires on frequency may be attributed to the fact that the header leads are of much greater inductance than the loop inductance of the oscillator structure itself, and hence they act as rf chokes. The dimensions of the critical portions of the oscillator are small compared to the wavelength of the oscillations even at S-band frequencies.

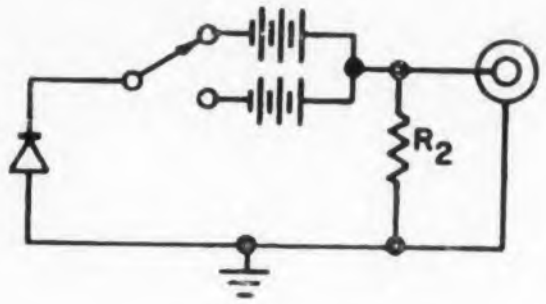
Fig. 4 is a photomicrograph of an oscillator which oscillated at a fundamental frequency of 3010 mc. The significant features shown correspond to those in the schematic cross-section of Fig. 1, the tunnel diode portion being the right pedestal and the germanium resistor the thicker pedestal on the left. The *p-n* junction is almost coincident with the bottom edge of the tin dot, and its diameter in this unit is about 1 mil. The capacitance per unit area for *p-n* junctions formed by the same alloying techniques on the same *n*-type crystal wafer used in constructing the oscillator units has been found to be 3 μf per cm², so that the capacitance for this diode is about 20 μμf. To produce resonance at 3000 mc would require an inductance of 0.15 mμh, a value reasonable to expect for the loop inductance of the oscillator structure. An estimate of the peak current of the tunnel diode *p-n* junction, based on measurements of the peak current per unit area of units similarly fabricated, is about 10 ma. Considering that the negative resistance region is thus limited to a few milliamperes of current and 100 mv of voltage, the rf power output of this oscillator is, at most, a few tens of microwatts. It is believed, however, that improved fabrication techniques will allow higher powers in future models. The arsenic concentration in the *n*-type crystal was measured to be 1.4×10^{19} atoms per cc.

Abstracted from an article by R. F. Rutz in the "IBM Journal," October, 1959.

Switching Circuits: Measuring Recovery Time

A SEMICONDUCTOR diode, when switched from forward current conduction to a reverse bias condition, will briefly allow an appreciable amount of current to pass in the reverse direction (shown in Fig. 1). The phenomena of "charge storage"—more specifically, "minority carrier storage"—causes this effect.

A number of test circuits have been proposed for predicting the probable performance of a par-



BASIC SWITCHING CIRCUIT

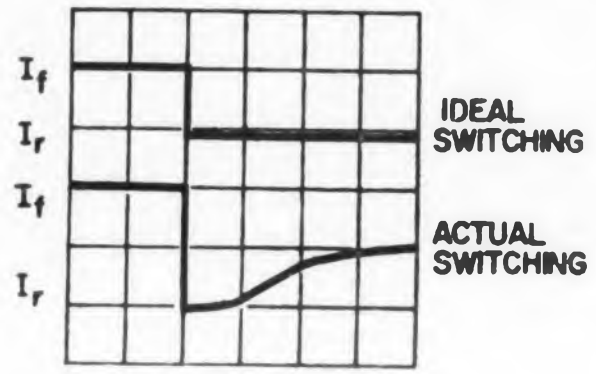


Fig. 1. Basic switching circuit.

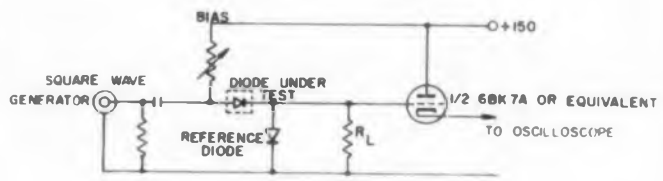
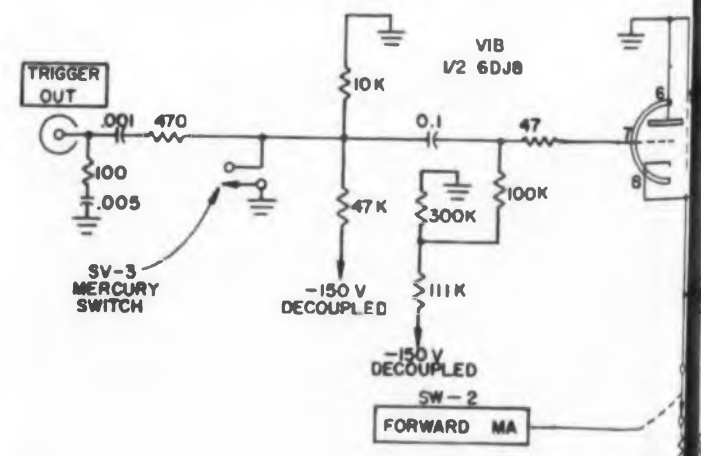


Fig. 2. The JAN-256 Test Circuit.

ticular diode in a given switching circuit. Some of them are described and illustrated here.

A simplified schematic of an early standard test circuit, the JAN-256, is shown in Fig. 2. In this circuit, forward bias is supplied by the +150 v plate supply. The diode is switched off by the external square wave generator. And the time required for the initial diode reverse current to decay



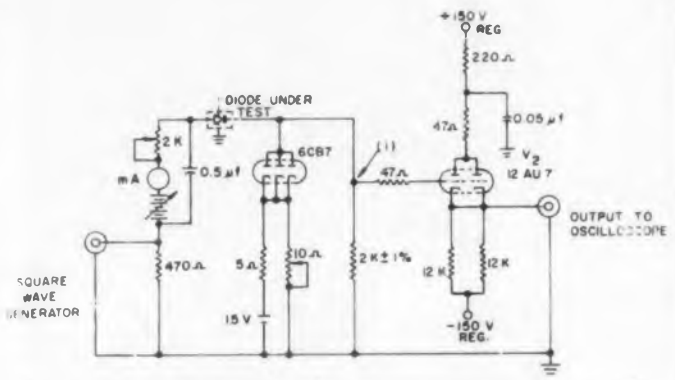


Fig. 3. The standard circuit proposed by the Electronic Industries Association.

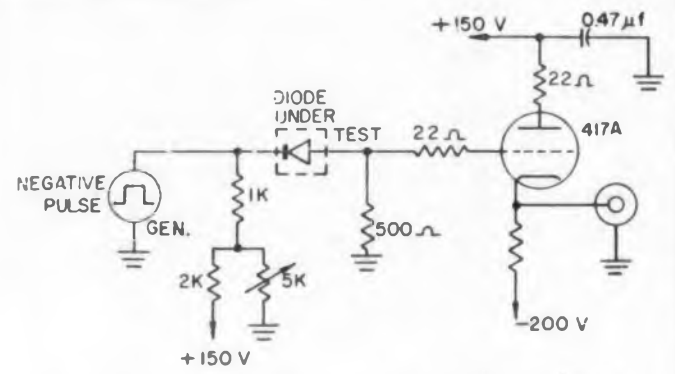


Fig. 4. The modified Bureau of Standards circuit.

to the specified value is measured by observing the voltage drop across R_L. Since it is usually necessary to measure the time required for the diode to reach a high reverse impedance (small reverse current), it is necessary that R_L be relatively large. To allow reasonable supply voltages, and prevent over driving the oscilloscope input stages during the

(Continued on p. 202)

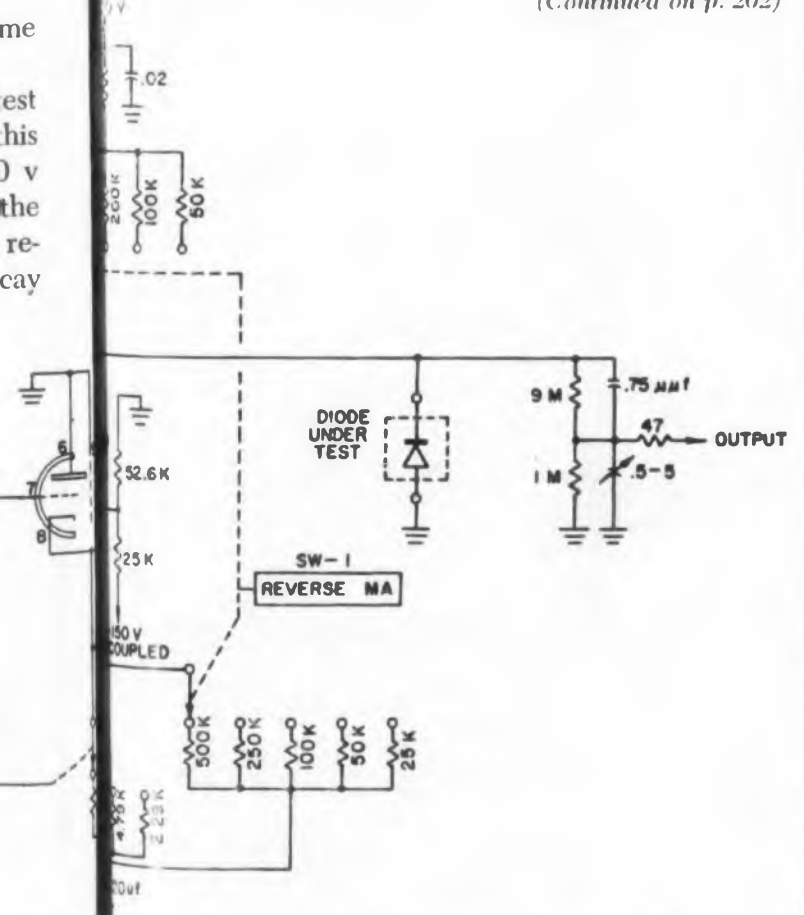


Fig. 5. Tektronix plug-in test circuit.

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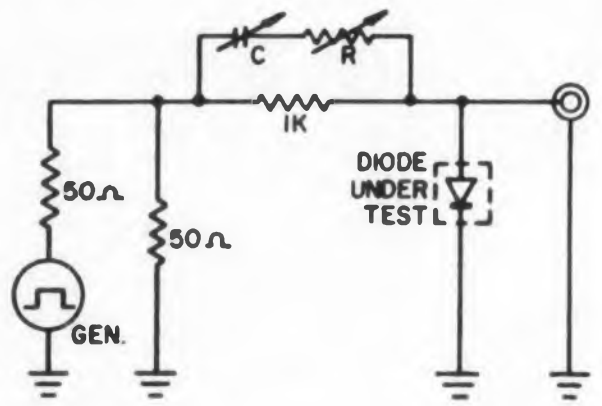
forward current pulse, a "reference diode" is placed across R_L to clamp the drop across R_L to a low value.

Since the JAN-256 circuit uses a semiconductor clamp, there is some question about the circuit's accuracy. An alternative circuit is that described in EIA SP590 as Method I (Fig. 3). Up to the point marked (*1*), this is the old IBM "Y" circuit. The cathode follower has been added because of difficulties found in trying to correlate readings made by different users and manufacturers. For example, minor differences in the length of the cable connecting the tester to the oscilloscope caused significant differences in recovery time measurements.

The Most "Accurate" Tester

Probably the most "accurate" recovery time tester is the Bureau of Standards circuit, which has been modified (Pacific Semiconductors, Inc.) as shown in a simplified schematic (Fig. 4). This circuit avoids the problems associated with the use of clamping diodes by reversing the diode so that the forward pulse drives the triode into cut-off. There are, unfortunately, other problems with this circuit.

The most serious criticism of the circuit arrangements already described is that the diodes are tested under *very specific* conditions of forward bias, reverse bias and load resistance. Figs. 4 and 5 show two attempts to devise circuits that will measure a property of the diode, independent of the external circuit parameters. Fig. 5 shows the Tektronix circuit. It allows measurement of the charge stored in the diode as a function of the forward current. This quantity, coulombs per ma, appears,



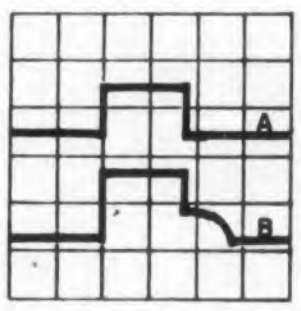


Fig. 6. Stromberg-Carlson test circuit.

under certain circumstances, to be a "constant" for a particular diode, allowing fairly good prediction of diode performance in almost any circuit. The circuit in Fig. 6 (Stromberg-Carlson) shows a bridge type measurement of this quantity. Here R and C are adjusted until the output (B) appears like the input (A). The values of R and C then give a measure of the equivalent capacity and series resistance of the diode.

The circuit in Fig. 7 is an example of the complications that arise when attempting to measure

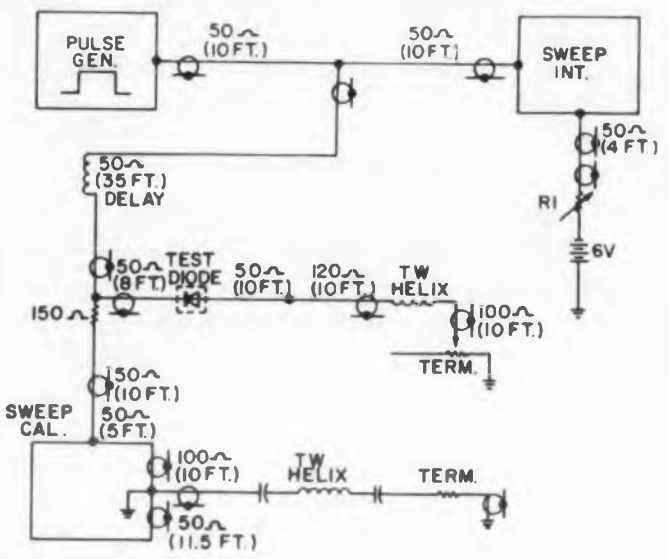


Fig. 7. Edgerton, Germeshausen and Grier test circuit.

the characteristics of some of the newer "millimicrosecond diodes." Since the forward currents used in testing these diodes are usually small, clamping is not necessary. Stray capacitances and bandwidth consideration are important.

Abstracted from an article by W. Macdonald in Semiconductor Product Application News, September-October, 1959, published by Hoffman Electronics Corp., Semiconductor Div.

How To Specify Relays Realistically

A REALISTIC re-evaluation of his relay application may allow the designer to use existing relays with subsequent cost-saving and often immediate delivery. Points to keep in mind during re-evaluation are:

Vibration

The vibration resistance of a relay is most important in its effect on size, weight and cost. The average magnetic relay has a fundamental resonant frequency in the range of 200 to 500 cps. Vibration specifications below 200 cycles tend to minimize cost and facilitate delivery. Vibration

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resistance at the resonant frequency and above presents a design problem. Relays meeting these vibration categories can and are being produced today but at slower rates and higher costs.

Basically, the vibration resistance of a relay may be increased by either decreasing the mass or strengthening the component parts. Decreasing the mass results in smaller and lighter units which are more difficult to produce. Strengthening the parts introduces a weight penalty. The approach to this dilemma is to recognize the existence of these resonances and investigate the need for vibration resistance at these frequencies.

Shock And Acceleration

Specifications sometimes call for shock and acceleration requirements in which the g level is far greater than 20 or 30 g. A relay which will withstand 20 g of vibration will withstand the same order of magnitude for acceleration and usually three or four times this g value for shock. Serious consideration should be given to determine the necessity of meeting extreme g values. If these high values are satisfied, there is a possibility that other environmental features will suffer. Realistic requirements will result in minimum weight and size.

Size

Small size and producibility do not go hand in hand. The smaller the relay, the more difficult it becomes to manufacture on a mass production basis. Inquiries for size reduction of the "crystal can" size relay have been received and turned down for one reason: the required practical optical instruments necessary to produce these smaller units on a production basis are not available.

Life

The following hypothetical case illustrates an extreme condition frequently occurring among relay users: Circuit designer *A* requires a relay capable of performing 50,000 switching operations maximum for a particular application. He requests components engineer *B* to write a specification for this relay allowing a safety factor of 100% for a total of 100,000 operations. Purchasing agent *C* receives the subsequent specification and is advised to procure the relay with a "little safety factor," say 100%. Relay manufacturer *D* receives an inquiry about the availability of this relay and discovers that his standard in-stock item, type *X*, with a selling price of *Y* dollars, would meet all requirements except for life which is rated for 50,000 operations (probably with the usual 100% safety factor). Therefore, the relay would "have to be redesigned." Purchasing agent *C* then is advised that the relay he wants can be made but at

a cost of 2Y dollars with an allowance of six to eight weeks for tooling.

Contact Rating

The contact rating of a relay is also a measure of its relative cost and size. Realistic contact requirements will prevent the relay designer from using special contact materials which will perform substantially above the actual requirement—but will result in a costlier item. The larger the contact load, the larger will be the contact size. It is advantageous to limit contact rating to a reasonably safe limit since large contact masses cause a consequent penalty in shock and vibration resistance.

Contact Bounce

Increasingly more relay specifications dictate a contact bounce limit in terms of maximum allowable total bounce. The thought behind this is: keeping the bounce time as low as possible will increase the longevity of the relay contacts. In the majority of relay applications, the bounce time of a relay will not adversely affect its control function.

Contact Arrangement

Many users will procure all 4-pole relays to be used in either 1, 2, 3 or 4-pole applications. This encourages mass production. The program, however, is sometimes defeated when the manufacturer is asked to decrease the weight of the entire 4-pole line, when a 1 or 2-pole type would have solved the user's weight problem. Specify only the required number of contacts.

Temperature Limits

Many manufacturers are producing Class A relays using materials which are completely satisfactory for Class B temperatures. In many cases, the only Class B requirement which these Class A relays do not meet is: minimum attract voltage at maximum temperature. To minimize costs, determine if the requirements for low voltage operation and maximum temperature exist simultaneously.

Relay Coil Power

The size and cost of magnetic relays are dependent on allowable coil power. The operating ampere-turns are proportional to the power input and the size of the magnetic structure. For a given set of operating conditions, decreasing the size of the magnetic structure will increase the required coil power. Conversely, increasing the size of the magnetic structure will decrease the required coil power. Many relay users specify a value of allowable coil power which is less than that required for optimum performance. This leads to a "sensitive" relay adjustment. It means

decreasing contact pressure and contact gap to the point where the allowable power will just operate the relay. This is not recommended for long life and optimum performance. Stringent shock, vibration and acceleration specifications are not compatible with sensitive relay adjustments.

Ac vs Dc Coils

Pure ac coils are inefficient. More contacts can be actuated by a 5 w dc coil than by a 5 w pure ac coil. The use of pure ac introduces weight and size penalties. An ac unit has far less inherent shock vibration and acceleration resistance than its dc counterpart. Many close differential units and relays requiring specific attract and release values are impractical to produce for pure ac use. The efficiency of dc structures can be utilized for ac operation by the use of rectification networks. This results in all of the advantages of the dc relay with only a cost penalty for the rectification network.

Attract And Release Values

Where simple on-off operation is the basic requirement of a relay, the minimum operating value should be determined by the lowest voltage anticipated in the application. In a like manner, release values specified where differential operation is not required, increase the cost of manufacturing and may penalize the user from the standpoint of vibration, shock and acceleration resistance.

Dielectric

The dielectric specification of a relay is often much higher than actually required with a consequent penalty in size, weight, and cost. Specify a higher voltage rating than the open circuit condition to safeguard against high voltage surges, but be reasonable.

Leak Testing

The method of leak testing hermetically sealed relays should be seriously considered. Most relay specifications permit the use of either mass spectrometer testing or water testing for production inspection, and usually require both for qualification approval. The water test is the fastest and least costly of the two. A water test performed under a vacuum equivalent to 80,000 ft altitude is about equivalent in sensitivity to an allowable mass spectrometer leak rate of 1000 x 10^{-8} cc per sec. Thus a relay of the size of MS-25024-2, which could have an allowable leak rate of about 10,000 x 10^{-8} cc per sec when tested per MIL-R-6106-C, could positively be detected by a water test.

Finish

The finish specification of a sealed relay is often overlooked in cost-saving analysis. Extensive testing under extreme environmental conditions indicates that plating properly applied has the endurance of paint at substantially lesser cost.

Abstracted from a paper by John Schmidt, Jr. and W. Warren Wright of Guardian Electric Mfg. Co., delivered at the Seventh Symposium of Electro-Magnetic Relays and reprinted by Potter & Brumfield, Div. of American Machine & Foundry Co.

Three Tentative Definitions Given For Relay Contact Loading

How Dry Is Dry Circuit Area?

IN GENERAL terms, the Absolute Dry Circuit Area is that area of contact loading in which only mechanical forces (impact, pressure, wipe, abrasion, strain-hardening) can change the condition of the contact interfaces; there can be no thermal effects (softening, melting) or electrical effects (arc transfer, bridge transfer, loss of material). Thus the Absolute Dry Circuit Area shall be defined as that in which the open-circuit contact voltage does not, for an appreciable time, exceed the softening voltage for the contact material used.

For example, with the contact temperature at 0 C, the softening voltage for gold is 0.08 v, the lowest value among the practical contact materials, and for platinum it is 0.25 v, the highest value among the practical contact materials. Therefore, the Absolute Dry Circuit Area may be designated as that area in which the open-circuit contact voltage does not exceed 80 to 250 mv, for more than 1 μsec when operated so as to maintain the bulk temperature of the contact at 0 C, the exact millivolt maximum limit depending on the contact material used. The softening voltage decreases as the contact bulk temperature increases, the softening voltage for gold being 0 mv at 100 C, and the softening voltage for platinum

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being 200 mv at 140 C, 122 mv at 340 C, and 0 mv at 540 C.

Intermediate Energy Level Area

In general terms, the Intermediate Energy Level Area (formerly called a fringe or gray area) is that area of contact loading in which mechanical, thermal, and electrical effects, except arcing, can change the condition of the contact interfaces. Thus, the Intermediate Energy Level Area, in which somewhat variable contact performance may result due to softening, melting and/or bridge transfer, shall be defined as that area of contact loading exceeding the softening voltage and less than the minimum arcing level for the contact material used.

For example, the intermediate energy level area for pure gold contacts would be the softening voltage (80 mv at 0 C) and the minimum arcing level (approximately 15 v peak maximum and/or 0.38 amp peak max when operated in normal atmosphere at room temperature with 90% humidity); similarly, the intermediate energy level area for pure platinum contacts would be between the softening voltage (250 mv at 0 C) and the minimum arcing level (approximately 17.5 v peak max and/or 0.9 amp peak max when operated in normal atmosphere at room temperature with 35 to 60 per cent humidity). For the common contact materials, the minimum arcing voltages range from 11 ±5 v for silver-gold and silver-palladium contacts operated under normal atmospheric conditions to 21 ±5 v for pure silver contacts operated in a dry hydrogen atmosphere and the minimum arcing currents range from 0.25 amp for silver-gold contacts to 0.9 amp for pure platinum contacts, both operated under normal atmospheric conditions.

High Energy Level Area

In general terms, the High Energy Level Area (formerly called a power area) is that area of contact loading in which mechanical, thermal and electrical effects can change the condition of the contact interfaces, and in which arcing and arc transfer will take place. Thus, the High Energy Level Area shall be defined as that area of contact loading which exceeds the minimum arcing level for the contact material used. In this area, arcing will rupture any films present and contact life and performance will be determined by such factors as loss of material, arc transfer, mechanical sticking, welding, and particle contamination.

The high energy level area will include all contact loadings exceeding those previously specified

as the minimum arcing level values.

Abstracted from Relay Testing Procedures, Technical Committee II Progress Report, National Association of Relay Manufacturers.

Reliable Relay Contact Systems: What To Consider Before Specifying Them

MUCH can be done to minimize the erratic nature of relay contact performance—thus improving the reliability of electronic equipment—by considering some basic facts about contact materials and cleanliness before specifying the relay contacts.

The initial contact of two spherical metal surfaces results in point contact. Deformation occurs as the compressive force between them increases, and the point becomes a small area. Other contact points occur and become small areas, perhaps merging with the first. Under normal conditions, surface molecules are not pure metal. They may be adherent gaseous or hydrocarbon molecules, tarnishes, or oxides, plus minute dirt particles. The thickness of these films of foreign materials may be considerable.

In the accompanying enlarged sketch of the contact area, note the shaded portion in which insulating films are substantially undamaged, and two small conducting ("*A*" spots) in which insulating films have been badly cracked or displaced. One widely held theory states that a potential difference between the two mating metal surfaces results in a small trickle of current, but rather sizeable I^2R losses at the tiny *A* spot. This energy loss becomes heat, and metal is melted. A bridge of molten metal continues to enlarge, increasing current and reducing contact resistance, and indirectly resulting in a reduction of potential drop between the mating contacts.

The energy dissipated is now greatly reduced, and the metal bridge solidifies. This mated pair of contacts now carries current in an entirely acceptable manner. The metallic bridge breaks as

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contacts are opened, and surface films generally reform quite rapidly.

When surface films are relatively thick and tough, and the potential difference between contacts is relatively small, the trickle of electrons through cracks in this film, if any, is too small to result in any effective energy dissipation. No metal is liquefied, and no metallic bridges formed. Contact resistance remains high—possibly 100 ohms, or 1000 ohms, or many megohms. If we open and close the contacts, the surface films will crack or deform in a different manner and a substantially different contact resistance may result.

Factors Affecting Contact Performance

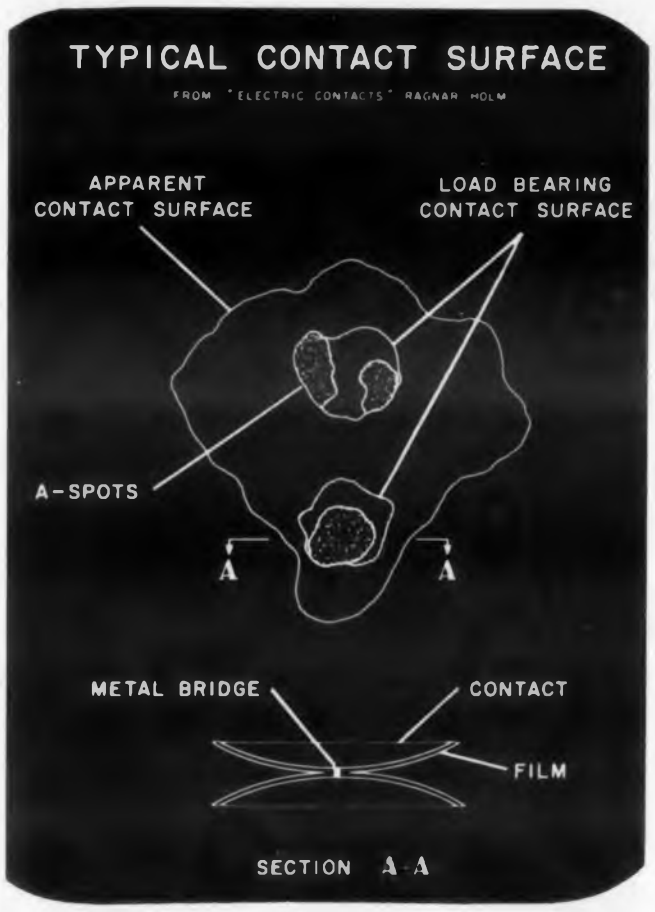
It is evident, then, that contact performance is readily affected by these key factors:

Circuit Characteristics. Low level circuits, in which the total energy available for dissipation at the contact surfaces, may be insufficient to build a metallic bridge. High resistance, or apparent open circuits, occur very often unless all other conditions are ideal. If the current and voltage level are excessive for the contact in question, the resulting metal bridge may be sufficiently large to damage the contact surface upon rupture, or perhaps even result in sticking or welded contacts. Excessive contact heating will promote the growth of films.

Contact Movement. Contact closure might in some remote way be considered analogous to a hammer hitting an anvil. It is apparent that there will be a tendency to rupture the surface film. And there will be a tendency for the contacts to bounce. Also, there may be a lateral, or wiping movement associated with contact closure. Well designed contact systems feature the practicable hammer action on closure even though this hammer action is of insufficient magnitude to deform or penetrate tougher surface films. Contact bounce, however, may be either inconsequential or detrimental, depending on the intended application. Circuit intermittence for a millisecond or more after contact closure, associated with contact bounce, may be objectionable in some cases. Generally, for contacts intended only for low level applications, a small amount of contact bounce is not harmful, and may aid slightly in deforming or breaking surface films. Bounce is usually considered harmful where contacts are intended for currents and voltages of a higher level, as each bounce represents an opportunity for arcing to occur. Contact wiping action is helpful in the removal of particles of foreign material which occasionally interfere with normal contact performance. Contact opening, and the reopening associated with contact bounce, will result in arcing unless the circuit is low level. The cumulative

effect of this arcing is the major factor in limiting the normal life of high level contacts.

Contact Pressure And Shape. High contact pressures are helpful in squeezing or rupturing some surface films. Therefore, for contacts not intended to handle higher currents, small size is necessary to obtain higher contact pressure from a given force system. When high currents must be considered, contact size is governed by the need to provide adequate area of contact, so that over-



heating and subsequent damage will not occur.

Contact Materials. The ideal contact material should have conductivity comparable to silver or copper, the heat resistance of tungsten, the freedom from oxidation of platinum and paladium, the freedom from affinity for surface films of gold, and should be dirt cheap. All of the above are used as contact materials, but perhaps none so much as dirt. The most desirable contact material changes depending on conditions. Experience shows that gold and some gold alloys, such as the 60% gold, 25% silver, and 6% platinum are about the best materials for low level circuits. Palladium is a poor choice in hermetically sealed enclosures due to affinity for hydrocarbons. Flash platings of gold over some less expensive metal are frequently unsatisfactory due either to the tendency of the base metal to migrate through the gold or

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the gold to wear off after a limited number of operations.

Foreign Particles And Dust. Minute foreign particles which become lodged between mating contacts may be responsible for unrepeatable open or high-resistance circuits that are vexing during tests. There is no sure way to eliminate all foreign particles from the contact area. A minimum of protection is provided by hermetic sealing.

Surface Films. The ease of establishing an electrical circuit is inversely proportional to the thickness of the surface film on the contacts. The contact enclosure should, if at all possible, be completely devoid of organic materials. Glass and ceramics are the preferred insulation materials in this enclosure. The vacuum bake is primarily to insure riddance of organic materials.

Specifying Contacts

A specification for components and component parts incorporating contacts should contain performance requirements for these contacts, and should contain or reference test procedures for insuring conformance. The maker should be told of the closed circuit current, maximum permissible resistance, and the available open circuit voltage. It should be noted whether this voltage will be available at closure, and whether the current will be flowing as the contacts are opened.

The nature of any surge currents should be described, including amplitude and duration. The required contact life should be noted in number of operations, taking into account all component, sub-system, and system testing plus a reasonable safety factor.

Note all external environments, such as shock, acceleration, vibration and temperature. In the event failure of contacts to make, or high resistance, for any one operation might cause a critical circuit failure, a run-in, or "miss" test should be specified for each unit. When this critical operation takes place either well above or well below the room ambient area, testing at the extreme temperature should be specified. The specification should avoid requirements for specific design details, such as contact material, size, force, type of enclosure, etc. However, where certain necessary performance requirements are impractical, there is no alternative to specifying such readily controlled details as hermetical sealing or gold alloy contacts.

Abstracted from a paper by Howard P. Lynch of the General Electric Co., delivered at the Seventh Symposium on Electro-Magnetic Relays, and reprinted by Potter & Brumfield, Div. of American Machine & Foundry Co.

Switching Devices: Relays vs. Semiconductors

IN COMPUTER and business machine circuitry there is a degree of overlap in the switching characteristics of semiconductors and relays. A proper analysis of the application, and the functional, cost, physical and standardization requirements will determine which device should be used.

The functional characteristics of the semiconductors and relays are:

Functional Characteristics

Semiconductors	Relays
1. Microsecond range with faster speeds already proven feasible.	**1.** 250 μsec and up.
2. Reliability appears to be much superior.*	**2.** Average reliability from our laboratory tests —1 failure in 5,000,000 contact operations.
3. Single point.	**3.** Multiple points with single control.
4. Low power requirements.	**4.** Reasonable power but adds appreciable inductance and capacitance.
5. Off state resistance: many megohms for transistor but in the 100 K region for photo conductors.	**5.** Infinite.
6. Forward resistance: a few ohms for transistor and in the 10 K region for photo conductors.	**6.** Short circuit (1 ohm or less).
7. Current carrying capacity affects operate time.	**7.** Capable of handling heavy loads.

*(The reliability of a component is often nebulous and this is particularly true when trying to compare an electromechanical device with an electronic one. Our experience with relays indicates that we can expect one contact failure in 5,000,000 contact operations. Using transistors, our experience indicates one failure in 10,000,000 transistor hours.)

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Functional Characteristics

Semiconductors	Relays
8. Contact bounce or chatter: none.	**8.** Measurable.
9. Life: in excess of 10,000 hr.	**9.** Life: average 10,000 to 300,000 operations.

Factors In Relay Replacement

A rough estimate of components needed to replace a 4-position transfer relay would be 20 resistors rated at 1/2 w, and 8 bilateral transistors. This is not considering the actuating device in either case. The semiconductor actuating device has more components than the actuating device of the electrochemical.

Point by point replacement is not economically feasible at this time and it appears that it will not become economically feasible for quite some time. The unit cost of a semiconductor would have to be considerably less than the present cost of industrial transistors. However, economics is not the only factor to be considered in replacing relays and in some critical applications functional characteristics make it necessary to use a semiconductor.

Replacement of relays by transistors or semiconductors primarily for functional gains (speed advantages, etc.) permits flexibility in circuit design which enables the circuit designer to use different concepts in performing machine logic thus, in many cases, reducing the quantity of circuit switches required. Information which was formally fed in parallel can now be fed serially and circuit duplication reduced substantially.

These advantages and disadvantages in each mode of switching are:

Electrochemical Switches

Advantages	Disadvantages
1. Positive action; the desired effects are very pronounced.	**1.** Inherent contact bounce and chatter on most types.
2. Flexible in contact material and construction to provide numerous contact combinations.	**2.** Operating speed limited by mass.

Electrochemical Switches

Advantages	Disadvantages
3. A proven device; backed up with many years of engineering effort.	3. Actuating coil introduces transients in circuitry.
4. Can be made independent of temperature, humidity or radiation, within reason.	4. Contact materials and pressures restrict use in so-called dry circuits.
5. Relatively low cost switching when figured on a per contacts basis. (Relays at from 15 to 30 cents per point can be made on a multipoint basis).	5. It is possible to get intermittent failure.
6. Readily available.	6. Life is limited due to wear of moving parts.
7. Can be made to carry and break large loads.	
8. Visual analysis of operation or state is usually possible.	

Semiconductor Switches

Advantages	Disadvantages
1. High speed except for photo conductors.	1. Cost high on a per point basis.
2. Reliable.	2. Complicates the power source.
3. Low power.	3. Reverse voltage limitations.
4. Small.	4. Relatively new; still undergoing development.
5. Long life.	5. Has a definite shelf life.
6. No contacts; thus no chatter or bounce.	6. Affected by temperature.
7. Versatility in types of control.	
8. Flexibility in logic.	

Abstracted from a paper by G. L. LaPorte and R. A. Marcotte of IBM Corp., delivered at the Seventh Symposium on Electro-Magnetic Relays, and reprinted by Potter & Brumfield, Div. of

REPORT BRIEFS

System Reliability Studies

The research under this contract has been concerned with some theoretical studies in the field of Reliability and Probabilistic Networks. The following specific results have been obtained: (1) A proof for the Shannon-Moore Expansion Theorem. (2) A generalization of the above expansion theorem. (3) Certain necessary conditions for realizability of h(p) functions. (4) Development of some basic inequalities for h(p) functions. (5) Evaluation of certain upper-bounds for coefficients of reliability functions. (6) Calculations of coefficients of reliability functions for series, parallel and composition of networks. (7) Development of a difference equation for reliability functions. *System Reliability Studies, F. M. Reza and S. Jutila, Syracuse University Research Institute, N. Y., Dec. 1958, 42 pp, Microfilm $3.30, Photocopy $7.80. Order PB 139579 from Library of Congress, Washington 25, D. C.*

PNPN Triodes in Magnetic Core Memories

Magnetic core switching arrays require a large current drive for fast operation. Series driving circuits using tubes or transistors dissipate excessive power. A shunt current pulser using trinistors (pnpn triodes) appears promising as an efficient driver. Trinistors have two states, ON (low impedance) and OFF (high impedance). Base current may be used to trigger the trinistor to either state. The turn-off time depends on base current and collector current. Increasing collector current increases turn-off time, and increasing base current decreases turn-off time. Trinistors, in their present state of development, were found to be unsuitable for use as drivers for magnetic cores. *Application of PNPN Triodes To Magnetic Core Memories, Aultman Doty, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio, Mar. 1959, 46 pp, Microfilm $3.30, Photocopy $7.80. Order PB 140728 from Library of Congress, Washington 25, D. C.*

Photoconductive Detectors

A description of the basic characteristics of photoconductive detectors is given to aid in the interpretation of data obtained in photo conductive research and experimentation. Properties described include variation in signal and noise with bias voltage; frequency response; time con-

stant; spectral response; black body sensitivity; temperature dependence; and sensitive contours. *Characteristics of Photoconductive Detectors, A. J. Cussen, Naval Ordnance Laboratory, Corona, Calif., Feb. 1958, 24 pp, $0.75. Order PB 151728 from OTS, Washington 25, D. C.*

Ferrites: Properties and Microwave Uses

Interim Report No. 2, Faraday rotation at microwave frequencies in waveguide structures containing ferrites. Interim Report No. 3, analysis of the non-reciprocal reflections expected when a microwave field propagates through a ferrite of finite length in the direction of propagation. Interim Report No. 4, experimental arrangement for measuring the scattering matrices of microwave devices. Interim Report No. 5, development of a microwave circulator as a cascaded arrangement of identical non-reciprocal coupling holes between two rectangular waveguides. *Electronic Properties of Ferrites and Their Application to Microwave Devices, D. W. Healy, Jr. and R. A. Johnson, Syracuse University, Research Institute, N. Y., Oct. 1956, 6 pp, Microfilm $1.80, Photocopy $1.80. Order PB 137279 from Library of Congress, Washington 25, D. C.*

C-Band Klystron

A series of experimental C-band klystron oscillator tubes, resonator test apparatus, and an electron gun were designed and tested. Fourteen tube models were built according to the floating-drift-tube-klystron theory and nine tubes were developed to the point of producing useful rf output power. Reported in detail are the characteristics and electrical performance of all tubes manufactured, along with cross-sectional drawings of the various models. A new and original principle of klystron operation, the reflex floating-drift-tube klystron theory, was used in one experimental model and the results are described. The resonator test apparatus was used to investigate the resonant frequency of the floating-drift-tube resonator and a number of other important characteristics, including the figure of merit. Accurate information regarding the beams produced by convergent-flow electron guns was provided by the gun tester. *Development of C-Band Klystron, W. H. Thon, Sylvania Electric Products Inc. for Wright Air Development Center, U. S. Air Force, Washington 25, D.C., Sept. 1958, 94 pp, $2.25. Order PB 151332 from OTS, Washington 25, D.C.*

REPORT BRIEFS

Electron Physics

A drift-tube klystron with a harmonic resonator was constructed and operated as a self-excited frequency multiplier at millimeter wavelengths. It is believed that this multiplier has potential capabilities at well over one watt at 2 millimeter wavelength. The mixed-field reflex oscillator provided a power output of 270 mw with a beam voltage of 500 volts at a wavelength of 3.05 cm. New methods of generating millimeter waves were studied preliminary to construction, with some parts for the first designs being built. Results from test to predict electron trajectories and to determine electrode geometry showed the proposed designs feasible. These tests were completed with an analog computer and an electrolytic tank automatic plotter. A powerful tool in cathode evaluation was developed in the thermionic electron emission microscope. *Electron Physics at Millimeter Wavelengths, E. M. Boone and others, Ohio State University Research Foundation for Wright Air Development Center, U. S. Air Force, Washington 25, D.C., Oct., 1958, 72 pp, $2.00. Order PB 151553 from OTS, Washington 25, D.C.*

Transistors

A 1959 revision of its *Catalog of Technical Reports* on transistors lists 146 technical reports available to industry through the facilities of OTS, in some cases in printed form and in others in photocopy or microfilm. The reports are the results of research by the Army, Navy, and Air Force between 1949 and June 1959. *CTR-310 Transistors OTS, U. S. Department of Commerce, Washington 25, D.C., 10 cents a copy.*

Ferrites

This paper summarizes the ferrite development program at the Diamond Ordnance Fuze Laboratories (DOFL). A brief discussion of the fundamentals of magnetic materials and the results of the theory as related to ferrites are included to give the electronic design engineer a better understanding of the function of ferrites in microvave systems. A number of significant ferrite components developed at DOFL are described and the experimental results obtained are given to illustrate applications of the theory

and to provide basic design data for microwave-systems engineers. *Properties of Ferrites and Their Applications to Microwave Systems, F. Reggia and R. D. Hatcher, Diamond Ordnance Fuze Laboratories, Washington, D. C., Feb. 1959, 59 pp, $1.50. Order PB 151749 from OTS, Washington 25, D. C.*

Sensitivity of Active Networks

An important consideration in the design of an amplifier is the extent to which the amplifier's performance can be desensitized to changes in its active elements. In this report the three possible methods of achieving gain constancy despite changes in the parameters of a linear network are described. *Sensitivity of Active Networks to Variations in Internal Parameters, E. M. Davis, Jr., Stanford Electronics Laboratory, Stanford University, Calif., Aug 1958, 174 pp, Microfilm $8.10, Photocopy $27.30, PB 140881 from Library of Congress, Washington 25, D. C.*

Power Resistor Mounting Hardware

Mountings for the twelve resistor styles under investigation were divided into three groups, each with similar resistor-tube diameters. Three hundred ceramic washers for all three groups were procured, with associated L-brackets, through-bolts, nuts, locking washers, and resistors. Only two manufacturers (AG and D) of the seven included could provide the type with the ceramic insulating washers. The investigations consisted of the following mounting torque, temperature cycling, thermal shock, moisture-resistance cycling, and high-temperature exposure. The D ceramic insulating washers, being smaller in size than those from Manufacturer AG, showed up the weaker, breaking at lower values of mounting torque and failing during temperature cycling, thermal shock and high-temperature exposure. The brackets and bolts from both manufacturers corroded extensively when exposed to moisture-resistance tests. A standard set of mounting hardware was suggested, separated as before into three groups of similar resistor styles. A sequence of tests was also suggested for future qualification of the hardware. *Component Evaluation and Specification Engineering. Final Report on Task XXVIII. Power resistor Mounting Hardware, L. H. Stember, Jr. and P. G. Perry, Battelle Memorial Institute, Columbus, Ohio, June 1956, 47 pp, Microfilm $3.30, Photocopy $7.80. Order PB 137081 from Library of Congress, Washington 25, D. C.*

REPORT BRIEFS

Reliability and Maintainability

A new philosophy of reliability and maintainability is suggested as a means of assuring that newly developed military electronic equipment will be reliable and maintainable. This philosophy would shift the burden of detailed reliability specifications concerning component parts from Government to industry, leaving only the specification of functional operation and evironment in Government hands. This shift of responsibility necessitates a change in contracting attitude. Contractors must be assumed competent unless proved otherwise. The new philosophy also requires contractors to be responsible for maintenance of equipment for a predetermined period of time so that all defects can be removed and maintenance techniques simplified. *Reliability and Maintainability Assurance, Walton B. Bishop, Air Force Cambridge Research Center, Bedford, Mass., Nov. 1958, 17 pp, Microfilm $2.40, Photocopy $3.30. Order PB 139588 from Library of Congress, Washington 25, D. C.*

Thermoelectric Generators

The thermoelectric effects are described and the efficiency of a thermoelectric generator is developed based upon the assumptions that the thermal conductivity, the electrical resistivity and the Thomson coefficient are constant along the length of the material. This development differs from the usual ones presented in the literature in that the thermoelectric power is not assumed to be constant but instead is assumed to vary with temperature in a manner so that $\tau = T\,(da/dT)$ is a constant. *The Efficiency of Thermoelectric Generators, Jose M. Borrego, Henry A. Lyden and John Blair, Aeronautical Accessories Laboratory, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, Sept. 1958, 81 pp, $2.25. Order PB 151748 from OTS, Washington 25, D.C.*

Cooling Considerations for Airborne Equipment

The purpose of this paper is to acquaint the electronic designer with some of the problems concerned with cooling electronic equipment in high-speed aircraft. *Cooling Considerations for the Design of Airborne Electronic Equipment, Henry Cohan, Riverside Research Laboratory, Motorola, Inc., Calif., July 1956, 42 pp, Microfilm $3.30, Photocopy $7.80. Order PB 140751 from Library of Congress, Washington 25, D. C.*

The Hall Generator

A Hall Multiplier is an electrical device which makes use of the Hall effect to multiply two electrical signals. The device is subject to a large number of errors due to various effects which are inherent to the device. However, the magnitude of these errors can be reduced by applying certain techniques and principles in the construction of the multiplier. Accuracies of 1% of full scale can easily be attained, and it is anticipated that a further study of the error problem will materially improve accuracy. *The Hall Generator As An Analog Multiplier, F. H. Miller, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio, Mar. 1959, 49 pp, Microfilm $3.30, Photocopy $7.80. Order PB 140942 from Library of Congress, Washington 25, D. C.*

Electromechanical Filters

This report summarizes the techniques which have been found applicable, within the scope of the contract, to the design of piezoelectric bandpass filters with their center frequencies greater than one megacycle per second. While the most important aspects of the problem are discussed in detail, many others are dealt with more briefly, but in such cases copious references to the more extended discussions of the quarterly progress reports are included. *An Investigation of the Characteristics of Electromechanical Filters, C. R. Mingins, A. D. Frost and others, Research Laboratory of Physical Electronics, Tufts University, Medford, Mass., Feb. 1954, 70 pp, Microfilm $3.90, Photocopy $10.80. Order PB 139610 from Library of Congress, Washington 25, D. C.*

Radiation Damage in Semiconductors

Experiments to determine the effects of radiation upon silicon carbide diodes. When a voltage was applied to the diode in either forward or back direction, this appears to remove all accumulation of radiation effects of permanent nature. After 1.18 x 10^{16} nvt integrated dose, the diodes tested had a forward to back current ratio of approximately 7400, indicating these devices to be as good as they were at the begining of the experiment. *Annealing of Radiation Damage in Semiconducting Devices, Vern E. Bryson, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio, Mar. 1959, 50 pp, Microfilm $3.30, Photocopy $7.80. Order PB 140729 from Library of Congress, Washington 25, D. C.*

STANDARDS AND SPECS

Sherman H. Hubelbank

Data Given On Standardizing Interconnections

Covering standardized interconnections and index pin codes, this publication is noteworthy for the listing contained and the guidance notes for designers of plug interconnections. Standardized index pin code arrangements have been adopted to guard against airborne equipment from being inadvertently placed in the wrong rack location.

By standardizing specific combinations of index pins (on the rack) and corresponding index holes (on the equipment) for each specific unit of equipment, a unit cannot be installed in a rack location where it is not intended to be. Each unit of equipment having a particular size and a set of pin connections will be assigned a specific index code arrangement. It is this compilation of index pin code arrangements that is listed in this ARINC (Aeronautical Radio, Inc.) publication.

In assigning pin numbers (if technical considerations permit) these factors should be considered:

1. Assign pin numbers for functions which can be related to the pin number. For example, in a device which might use ten selectable channels, it is useful in simplifying maintenance to assign Channel 1 to Pin 1, Channel 2 to Pin 2, etc.

2. Another useful technique is to assign pin numbers by groups. One group of perhaps ten pins for channel selection, the second group for gain, volume, and sensitivity controls, the fourth group for power, etc. It is particularly useful here to provide a small number of spares immediately after a group. This permits the spares to be used in a logical manner when modifications are made at a later date.

Precautionary considerations are also involved. Do not assign input and output leads so that they are adjacent in the plug. Isolate high-impedance leads such as AVC bus (for testing).

Sensitive circuits, or circuits where leakage may be a problem, should be arranged so that any leakage is to ground via adjacent pins rather than to other sensitive circuits or to circuits above ground.

Pins for circuits requiring twisted, shielded leads should be adjacent to each other and to a ground connection, or to a pin which can carry a ground connection through to some common ground. In most cases, ground pins must be pro-

vided in the plug if a ground is to be used for a particular purpose such as shielding.

And designers should select pin types and sizes suitable for the functions for which they are used. Not only normal operating currents, but also possible overload conditions should be considered in selecting pin ratings.

Copies of this document are available from Aeronautical Radio, Inc., 1700 K St., N.W., Washington D.C. ARINC No. 406, Airborne Electronic Equipment Standardization Interconnections and Index Pin Codes.

Standards Cover Magnetic Tape And Wire

Covering recording tape primarily for home use, this newly issued standard is published by the Electronic Industries Association. The standard establishes dimensions and preferred operating speeds for standard 1/4-in. magnetic recording tape. This tape may be used for single, dual, or four track recording. Copies of this standard are available from EIA, 11 W. 42nd St., New York 36, N.Y., for 30 cents each. EIA RS-224, Magnetic Recording Tapes, August 1959.

Also issued by EIA is a standard on magnetic wire. This standard specifies the nominal wire speed, direction of rotation, the wire size, and the recording wire spool dimensions. Available from EIA for 25 cents, specify EIA RS-223, Magnetic Recording Instruments, August 1959.

Definitions And Descriptions Of Transmission Lines Provided

This new standard issued by EIA limits itself to gas-filled rigid coax transmission lines and their connectors. Semiflexible transmission lines and their connectors are not covered. It is the intent of this standard to provide complete mechanical interchangeability for all rigid coax connectors and lines. Standard definitions are established for terms such as average wall thickness, characteristic impedance, attenuation, standing wave ratio, and power and voltage ratings. In addition, the upper frequency limit is established. Tables and illustrations are provided to show the dimensions, tolerances, characteristic impedance and cutoff frequencies for rigid air dielectric coaxial transmission lines having 50-ohm impedances. Copies of this standard are available from the Electronic Industries Association, 11 W. 42nd St., New York 36, N.Y., for 80 cents each. EIA RS-225, Rigid Coaxial Transmission Lines 50 Ohms, August 1959.

MIL-P-20693 Plastic Compounds

Upgrading of this spec has been accomplished by including the standard responsibility for inspection clause. Amendment 2, 12 June 1959.

STANDARDS AND SPECS

Reference Data Included In Industrial Control Standard

Valuable reference data for any design engineer is contained in this NEMA standard. Among other things, this standard covers the rating and application of control devices, such as contactors, relays, resistors, etc. It also covers ac general purpose controllers and dc controllers. Available from National Electrical Manufacturers Association, 155 E. 44th St., New York 17, N.Y., for $6.00 per copy. NEMA IC 1-1959, Industrial Control.

Radiation Measurements Standardized

Standardized methods of test for determining rf radiation from broadcast radio and television receivers are established by this new IEC publication. These methods were established to make possible comparison of the results of radiation measurements obtained by different observers. The first section covers radiation at frequencies below 30 mc from am receivers and from television receiver time-base circuits. Frequencies between 30 and 300 mc are covered in a second section. Copies of this International Electrotechnical Commission standard are available from the American Standards Association, 70 E. 45th St., New York 17, N.Y., for $3.60 per copy. IEC Publication 106.

Test Methods Covered For Ceramic Capacitors

Ceramic dielectric capacitors specifically suited for resonant circuit applications or where low losses and high stability are essential are covered in this IEC standard. Excluded are capacitors for rf currents exceeding one ampere or for a large reactive power. Test methods are described as are color codes for marking. Copies are available from the American Standards Association, 70 E. 45th St., New York 17, N.Y., for $3.20 per copy. IEC Publication 108.

Standard For Fixed Resistors Under 3 W Issued

Fixed resistors having a rated dissipation less than 3 w are covered by this IEC standard. The total resistance value is between 10 ohms and 22 meg. These resistors are intended for use where high stability of the resistance is not of major importance. Copies of this standard are available from the American Standards Association, 70 E. 45th St., New York 17, N.Y., for $3.20 per copy. IEC Publication 109.

New Candlepower Standards Available

New candlepower standards consisting of inside-frosted lamps with monoplane filaments and medium-bipost bases are now available from the National Bureau of Standards. These lamps are available in sizes of 100, 300, and 500 w. These standards show little or no variation in intensity with change in orientation. They follow closely the inverse square law and are easily calibrated on the photometer bar. The lamps may be procured from the Photometry and Colorimetry Section, National Bureau of Standards, Washington 25, D.C. They are priced at $37.00 for the 100-w size; $34.00 for the 300-w size; and $35.00 for the 500-w size.

New Semiconductor Spec (2)

General tests specified include: breakdown voltage; capacitance; case insulation; drift; dew point; high and low temperature operation; noise figure; and thermal time constant, resistance, and response time. Adequate inspection procedures and precautions are included for proper inspection and test. The devices shall also be subjected to environmental tests such as: bending moment; burnout by pulsing; constant acceleration; moisture resistance; and operation life, storage life, and intermittent life tests. Special test procedures are also established for the diodes covered by this spec. MIL-S-19500B, General Specifications for Semiconductor Devices, 30 June 1950. At the same time a detail spec was issued for a 25-milliwatt, high-frequency, germanium, pnp transistor for use in high-frequency amplifiers and oscillators and video circuits. The Transistor is type JAN-2N128, MIL-T-19500/9A.

New Semiconductor Spec Approved By DOD

Approved by the Department of Defense, this spec is mandatory for use by the Army, Navy, and Air Force. This spec, MIL-S-19500B, covers the general requirements for semiconductor devices used in Military equipment. Specified requirements for a particular type of semiconductor are listed in the applicable detail spec.

Included in this spec are transistors and semiconductor diodes. Identification numbers of semiconductors meeting this spec will be assigned by the Joint Electron Device Engineering Council. The numbers agree with the type of numbers currently in use.

The type designation may be either marked in accordance with MIL-STD-130 or color coded. A suitable polarity marking shall be included on diodes. Country of origin shall also be marked.

An appendix to this spec contains definitions of terms used with semiconductor devices. Another appendix covers abbreviations and symbols.

Blocks to CREATIVITY

Perception Deception

DESIGNING YOUR FUTURE

A. L. Simberg, AC Spark Plug Div.
General Motors Corp., Flint, Mich.

IT IS NOT surprising today to find at the head of some of our largest industrial corporations men with degrees in engineering. What are the routes by which these men achieved their present position? Traditionally, the young engineer going into a company has one of two routes open to him. The first of these is through his technical know-how, his engineering specialty. In short, he becomes an expert. The other traditional alternate way to the top has been through the path of supervision, accepting higher and higher supervisory responsibilities, until he reached the top of the organization.

In the past few years, especially since the Korean War, a third way to the top has opened. It is by means of creativity.

With the ever increasing competition, especially in the area of electronic development, those companies are successful which find the unusual, the unique new products, processes, manufacturing methods and cost reductions. All positive change comes about as a result of someone's ideas, a newer and better way of doing or making something.

Ideas mean creativity. Creativity means being able to develop end results which will satisfy the needs of the organization in a way which they have never been satisfied previously. All engineers have within them the basic capacity to be creative. What prevents many of them from doing so are obstacles which must first be overcome.

The obstacles to creative thinking lie primarily in three areas: perceptual, cultural and emotional. This article will deal with the first of these obstacles, the perceptual blocks to creativity.

The family of perceptual blocks is probably the single most frustrating and damaging one. These are the types of blocks that make us "want to kick ourselves" for not having seen the solution previously. They are caused primarily by not seeing what the problems are or what actaully may be wrong in the situation. These are the types of blocks that cause us to begin our work in problem solving without the proper goal in mind. These have to do primarily with our statement of the problem, our biases toward and preconceived notions about the problem. While we are not talking about attitudes as such, it should be realized that there is very little in our outward behavior that it not colored in some manner or other by our attitudes toward them.

To a great degree, our perceptual blocks may be classified as merely having a mental set or predisposition toward see-

This is the first of three articles on blocks to creativity. Subsequent articles will discuss cultural and emotional obstacles.

ing the situation in a certain way, no matter how closely or how thoroughly we look at it. Let us look at a few examples of this type of block:

1. *Difficulty in isolating the problem.*

This is the case where the individual is unable to separate the real problem from related problems, or as we say, he cannot see the forest for the trees.

While this sounds basic and elementary, it is nevertheless extremely important to pinpoint the problem specifically. Too often we are not tackling the real problem at all. This is similar to the physician who treats symptoms rather than curing the disease or to the mechanic who when unable to figure out whether the car has ignition, fuel system or other trouble, will eventually decide on a complete overhaul.

To show just how deadly these little blocks can be, try some of the problems associated with them. You will find the answers to these problems at the end of the article.

TIME FLIES YOU CANNOT THEY FLY TOO FAST

Try to punctuate this sentence so that it makes sense.

2. *Difficulty caused by narrowing the problem too much.*

This block is caused by paying little or no attention to the environment surrounding the problem. It is not unusual to find in scientific endeavors that experiments are sometimes conducted to determine a particular point while the effect of other variables of the total situation is ignored.

The above block comes about primarily because of our inability to see the problem stated in any other terms than it is. For example, try the little exercise below:

HOW CAN YOU MAKE FOUR NINES EQUAL ONE HUNDRED

3. *Difficulty in not investigating the obvious.*

Once we have become accustomed to looking at certain situations and problems in a particular way, it becomes increasingly difficult not to do this. Everyday we look at the same things, but really cease to "see" them. Pass the same bulletin board every day, and even though the notices change from time to time, unless there is something really different about the new notice (a different color paper, etc.) the chances are that we will not see it. So it is with our design problems. The first reaction to the assignment of designing a new component is to look for components which are similar and provide the same function. Is it not just as easy to sit down and ask yourself what better or simpler or cheaper method could be used to achieve the same end result?

The person who first thought of using a flexible ice cube tray got the idea from noticing that some water in his boots, which had been left outside, had frozen during the night and had flipped out quite readily when the boot was turned inside out. How obvious.

Try this problem:

Two Indians, a big one and a little one, were walking through the woods. They resemble each other and in truth are related. The little Indian is the son of the big Indian, but the big Indian is not the father of the little Indian. What is their relationship?

4. *The failure to distinguish between cause and effect.*

The young engineer, especially one who has his sights set on a career in research, often feels quite confident that he

knows the difference between cause and effect. However, these, as he will learn, are not always this clear-cut. Nor do statistics always provide the correct answer.

For example, in a large university, it was recently found that engineering senior students who made poor grades were much heavier smokers than those earning good grades. Did the smoking cause poor grades or did the poor grades cause more tension which led to heavier smoking? Or is it possible that both the poor grades and the heavy smoking were a result of a common cause? Or is it possible that none of these facts was related to one another, except by coincidence?

The person who would be creative must learn not to jump to conclusions regarding causality.

5. Failure to use all of the senses in observing.

While we have talked about the five senses for years, and although we know what these are and also know that we can observe through all of them, when we use the word observation the meaning is still for most of us in terms of vision only. A great amount of information can be gained from experiences other than visual. Concept formation, the reaching of conclusions, classification of situations—all of these can be formed through other than visual methods.

We are all familiar with people who have a deficiency in one of the five senses. People who are either blind or deaf are able to compensate by the strengthening of the faculties which they have remaining to them. Try sometime shutting your eyes for awhile and try doing things with your eyes shut. You will find, after the first few frustrations and bumped knees, that you can do quite well really by using the senses of touch, hearing and smell. ■ ■

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MAIL CAREER INQUIRY SERVICE FORM TO READER SERVICE, ELECTRONIC DESIGN, 830 THIRD AVE., NEW YORK 22, N. Y.

Answers to Problems of Preceding Story.

1. Time flies (insects)? You cannot! They fly too fast.
2. 9¢ + 9/9
3. His mother

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Sprague Electric Company

Sprague Electric is made up of many departments and divisions: Research and Engineering, Sales, Sales Engineering, Manufacturing, Production Engineering, Plant Engineering, Employe and Community Relations.

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Employe and Community Relations, Sprague Electric Co., Dept. ED, North Adams, Mass.

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Autonetics invites the prospective employe to study this 26-page illustrated brochure and to consider the opportunities presented in the scientific and engineering frontiers. Department areas are: Inertial Navigation, Digital Computers, Flight Control and Special Products. A synopsis of helpful background requirements is given for

each area, in addition to the available working facilities.

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Autonetics, Div. of North American Aviation, Inc., Dept. ED, Downey, California.

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Radio Corporation of America

"Working in Research at RCA," a 36-page brochure, outlines activities and aims of the Radio Corporation of America. Technical operations fall into three categories: manufacturing, services and Research.

Manufacturing includes engineering, development and production of a wide range of electronic equipment. Services include the operations of the National Broadcasting Company, with its radio and television systems; RCA Communications, Inc., with radiotelegraph facilities, and RCA Institutes, which train thousands of electronic technicians.

The work of the research laboratories is directed toward improvement in methods, devices, production, and operation in every branch of radio, television, electronics and allied fields and toward the creation of new products and services.

Descriptions of the various laboratories and their functions are covered and depicted in the brochure. The laboratories covered are Physical and Chemical, Electronic, Acoustical and Electromechanical, Systems and Radio.

Educational opportunities, including employe fellowships, a tuition loan and refund plan, part-time study and study abroad are discussed. An Administrative Chart is given, and a map delineating community facilities concludes this brochure.

Radio Corporation of America, RCA Laboratories, Dept. ED, Princeton, N.J.

CIRCLE 872 ON READER-SERVICE CARD

YOUR CAREER

NEWS AND NOTES

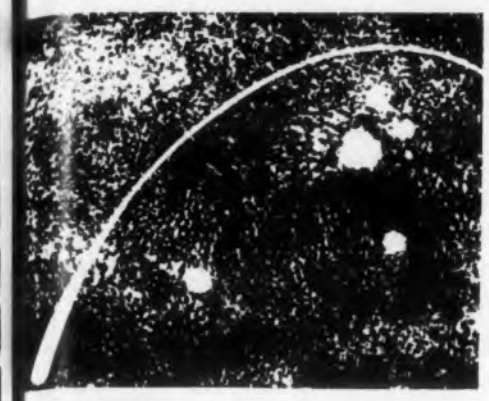
Back to school for engineers describes the purpose of UCLA's two-week courses in fast-moving technologies. Headway in some engineering fields is so rapid that often engineers only five years out of school find themselves thrust, by interest or company expansion, into areas in which they have no solid foundation—and indeed in some cases where there is no recent unclassified literature. Some of these fields are infrared, information storage and retrieval (come a long, long way in five years) astrodynamics and rocket navigation and nuclear rocket propulsion systems.

Recognizing the paucity of academic information specifically designed for engineers who are already working in, or interested in entering, such fields, the University of California at Los Angeles Extension Division has set up a program of short engineering and math courses. These courses last two weeks. The engineer attends school from 8:00 a.m. to 5:00 p.m. —with midterms on the first Friday and a final exam on the second.

UCLA is not the first university to have such a program, of course, but it has one of the most extensive. This past summer marked its first full scale venture into the program. Its summer courses included Nonlinear Problems in Random Theory (Norbert Wiener of MIT heading the course); Astrodynamics and Rocket Navigation (Robert M. L. Baker, Jr. of Aeronutronic Systems Div., Ford); Thermochemistry of Rocket Propulsion (Donald J. Simkin, Marquardt Aircraft); Theory and Applications of Infrared Radiation and Detection (K. N. Satyendra, now with Nortronics Div. of Northrop, and Max Garbuny of Westinghouse Research); Strain Gauge Techniques (William Murray, MIT); Metal Processing,

(*Continued on p. 234*)

Two-week infrared course at UCLA was sparked by Dr. K. N. Satyendra (l), Dr. Max Garbuny (c) and Tom Vogl (r), all with Westinghouse Electric at the time. Dr. Satyendra is now with Nortonics.



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CAREER NEWS

(*Continued from p. 232*)

Cutting (Milton C. Shaw, MIT); Statistical Methods in Industry (Edward P. Coleman); Information Storage and Retrieval (R. M. Hayes, Magnavox R & D Laboratories); and other courses not of consuming interest to electronic design engineers, such as Design of Prestressed Concrete Structures.

Cryogenic Engineering, Corrosion Engineering, Communications in Science and Industry, and Packaging, Plant Layout and Material Handling were given during November. Currently finishing up are a series of lectures on "Foundations of Future Electronics."

Good Investment for Engineers, Industry says Dr. Sam Houston, dynamic assistant head of the UCLA Engineering Extension. The intent of the courses, according to Houston, is to cover the fundamentals and applications in each field as thoroughly as possible in 70 hours.

Cost of courses is about $150 per person—a pretty good deal considering the two units credit given for passing the course.

"We try to get the top people in the field to set up and coordinate the courses," says Dr. Houston. "These are on-the-job men and can tell what their engineering confreres want and need to know. They can point out gaps in present-day knowledge and describe new trends and developments.

"Courses themselves are chosen in different ways—by request from industry or the military, or by talking to engineers and deciding a blank exists in a given category. One of the problems in frontier courses like these is classification. We are never too sure how broad a field we should cover."

UCLA plans to conduct two courses per month throughout the year on roughly a graduate level. The program, to be successful, calls for an average of 50 students in each course. This has so far been achieved easily—the spread is from about 40 to 100 students, depending on the course. As a rule more students apply than were planned for—the infrared course expected 50, got 113; Norbert Wiener asked for no more than 20, got 33.

How good are the courses? To find out ELECTRONIC DESIGN went to the *Theory and Applications of Infrared Radiation and Detection* course.

In two weeks the class covered the origin and nature of infrared radiation, physical phenomena for infrared detection, industrial uses and target detection, terrestrial infrared and modern aspects of infrared and missiles.

During the first week of the course the fundamentals, background and physics of infrared were given relatively exhaustive treatment. Students were expected to have a solid grounding in mod

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CIRCUIT DEVELOPMENT—Transistor circuit design and application; design automatic and semi-automatic test equipment.
MECHANIZATION—Design and develop high speed automatic machinery.
Please write to C. A. Besio, Dept. 1104, P. O. Box 312, Dallas, Texas

CIRCLE 904 ON CAREER INQUIRY FORM

APPARATUS DIVISION

MANUFACTURING ENGINEER—To perform the planning and coordination of the manufacture of electro-mechanical/electronic systems and components on an assigned project basis; to determine action to be taken; follow-up and report successful operation of the course of action selected. BS in EE, ME or IE, with minimum 3 years experience in manufacturing processes, tooling, scheduling, and costs.
QUALITY CONTROL ENGINEER—To establish and maintain standards of quality and inspection methods for all raw materials, work in process and finished products. BS in EE, ME or IE with minimum 3 years experience in working to customer requirements, procedures, quality reports plus prevention and detection of defects in electro-mechanical apparatus.
SENIOR MICROWAVE ENGINEER—To perform applied research and development in the field of microwave and high-powered transmitter equipment including ASR transmitter and automatic performance monitoring. MS in Physics or EE with minimum 5 years experience in the field of microwave and high-powered transmitting equipment.
SENIOR ELECTRONIC ENGINEER—To conduct engineering analysis of techniques that will be incorporated into various product lines. Electronic design experience associated with the missile field involving circuit (transistor), computers, telemetry, and guidance systems design essential. MS in EE, ME or Physics with minimum 7 years experience in field of missile electronic design and systems planning and analysis.
CIRCUIT DESIGN ENGINEER—With strong instrumentation background with emphasis on circuit design. Experience in application of transistor circuits to instrumentation highly desirable although not essential. BS or MS in EE or Physics with minimum 5 years experience.
RESEARCH ANALYST—To perform industrial marketing research in the field of military and industrial electronics; requires analytical ability with imagination to foresee variables and recognize limitations and data; ability to present ideas clearly in verbal and written form. Must also be able to interpret and point out use and conclusion of statistical studies to division management. BS in ME, EE or MBA or MA in Economics.
SENIOR GUIDANCE ENGINEER—To design microwave antennas and circuit components; supervise engineering personnel in design and development of complete missile antenna and microwave systems; contribute original advancements in missile microwave and antenna concepts for proposals and system development. BS in EE or Physics with minimum of 5 years experience in stripline microwave design. Also thoroughly familiar with radiation and propagation theory.
MATHEMATICAL STATISTICIAN—To specialize in the study of noise applications; to perform systems analysis of sonar and radar product lines; to provide consulting service to other technical personnel. MS or PhD in Mathematics with minimum of 6 years experience in applied analysis of advanced mathematics.
MATHEMATICIAN—To specialize in transform calculus as applied to servo mechanisms and network analysis and continued fraction work; provide consulting services to other technical personnel. MS or PhD in Mathematics with minimum of 6 years experience in applied analysis of advanced mathematics.
Please write to John Pinkston, Professional Placement, Dept. 1104, 6000 Lemmon Avenue, Dallas 9, Texas

CIRCLE 905

GEOSCIENCES AND INSTRUMENTATION DIVISION

MECHANICAL DESIGN ENGINEERS—BS or MS in ME to design small electro-mechanical mechanisms.
ELECTRICAL DESIGN ENGINEERS—BS in EE or Physics to design and construct supervisory control systems of electro-mechanical and electronic design; transistor test equipment, requiring heavy experience on electronic circuit design, preferably with transistors; digital computers with experience in detailed logical design.
MANUFACTURING ENGINEER—BS in ME or IE with experience in production, planning, production control, methods and tooling in the electronics industry.
SALES ENGINEER—BS in EE, Physics or ME with sales experience in electro-mechanical instruments.
Please write to Dave Turner, Dept. 1104, 3609 Buffalo Speedway, Houston, Texas

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HEAD—DEVICE SECTION—4 to 5 years experience in semiconductors plus experience in group leadership and proven ability to supervise a variety of technical projects. Will be responsible for directing work on design, fabrication and evaluation of new solid state devices. Educational requirement is MS or PhD in either Physics or EE.
SOLID STATE THEORIST—Responsible for the understanding and interpretation of the physical properties of semiconductors and other solid state materials. Educational requirements: PhD in Physics with concentration in quantum mechanics. Solid state experience desirable but not necessary.
DEVICE THEORIST—Responsible for the design of new solid state devices and interpretation of their characteristics in terms of physical and fabrication parameters. Educational requirement is PhD in Physics or EE, or MS with 2 to 3 years experience in solid state device theory.
SEMICONDUCTOR TECHNOLOGY—Responsible for the design and interpretation of experiments on the technology of semiconductors, including impurity diffusion and alloying. Educational requirement is PhD in Physical Chemistry or Metallurgy. Experience requirement: 3 to 4 years experience in semiconductor technology.
THEORETICAL PHYSICIST—2 to 3 years experience in electron or nuclear magnetic resonance with interest and background to perform theoretical analysis of EMR and NMR to develop possible new types of magnetometers or to make significant improvement in present types. Sufficient experimental background and interest to assist in translating theoretical results into experimental projects.
PHYSICISTS—Either MS or PhD with 1 year minimum experience in the fields of superconductivity and low temperature physics. Should be acquainted with conventional techniques of transferring and handling liquid helium and designing circuits and instrumentation for studies in this area.
Please write to A. E. Prescott, Dept. 1104, P. O. Box 1079, Dallas, Texas

CIRCLE 907 ON CAREER INQUIRY FORM

CIRCLE 904 THROUGH 907 ON CAREER INQUIRY FORM

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CIRCLE 915 ON CAREER INQUIRY FORM

CAREER NEWS

(*Continued from p. 238*)

ern physics: the first week was in the nature of orientation and a more intensive examination of the characteristics of 0.75 to 1000 micron frequencies.

In more detail, the class covered emission and absorption of heat radiation, emission and absorption of selective excitation, transmission phenomena, ir radiation sources for measurement and detection, ir optical systems, thermal detection, quantum detection, limits of detection, thin films, thermal detectors, photoconductivity and emissive cells, infrared imaging, the evolution of detectors and infrared electronics. Applications of infrared detection systems were enumerated and described: industrial safety and quality control, imaging and scanning systems in darkness and fog viewing, air-to-air and air-to-ground uses, radiation of missiles during escape and reentry, uses of ir for satellites and space vehicles, infrared spectra of extraterrestrial objects and so forth.

Sound like a lot of ground to cover in a short time? It was. Each day students attended a lecture from 8:00 to 9:45. A coffee break followed, and a discussion period after the break until 12:15. After an hour and a half lunch at the faculty club—during which most students continued to hash out problems among themselves—another lecture, from 1:45 to 3:15, was given. Coffee break, then another discussion period until 5:00.

On Saturday a field trip to Aerojet-General Corp. in Azusa exposed newcomers to infrared processes, techniques and equipment.

In many ways the discussion periods were the most helpful. Homework problems were reviewed, students got a chance to work out mutual difficulties in the design of infrared equipment and made some very fine contacts with other people in the field.

Generally the course level was graduate. K. N. Satyendra, then of Westinghouse in Philadelphia, presently then Nortronics Div. of Northrop in Hawthorne, Calif., and Max Garbuny of Westinghouse Research in Pittsburgh guided the course. "The amount of material covered," Dr. Garbuny said, "would otherwise have been given during a sixteen-week term. Some of the material of course dated back as far as the 1890's—Wien, Rayleigh, Planck—but some, as far as possible without exposing classified information—was brand new."

Dr. Satyendra commented on the feasibility of giving so much material in so little time. "You must realize that first of all we require the student have at least a Bachelor's in Engineering or Science or its equivalent. Then, in each group are a number of PhD's in Physics. Many people are now working in infrared by necessity and do not

(*Continued on p. 240*)

of changing your someday?

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CIRCLE 918 ON CAREER INQUIRY FORM

CAREER NEWS

(*Continued from p. 238*)

have the appropriate foundation. They are often specialists in one small part of the field—through experience—and realize their shortcomings in other areas."

Some 113 persons attended the infrared course. They came from all over the United States and Canada. Military, academic, research and engineering personnel were numbered in the group. "Most people, of course," Garbuny said, were newcomers to infrared. This is the most often-occurring situation—the boss sends a new man to a short course to pick up information quickly." Viewed from this perspective it is hard to see a better investment of time and money, particularly if the company does not have a working training program of its own.

Independent talks were avoided in the series set up by Satyendra and Garbuny. The course was presented as an integrated unit. Other experts invited to lecture—J. R. Hansen of Westinghouse Research, Pittsburgh; W. Horn of Westinghouse Air Arm, Baltimore; and T. Vogel of Westinghouse Research, Pittsburgh—based their presentations on practical experience.

To insure good coordination, not too many big-name lecturers were chosen—five seemed plenty. Moreover Satyendra and Garbuny insisted that most of the teaching be based on practical experience. "We preach what we practice," said Dr. Garbuny.

This was not a matter of each expert presenting a unit lecture, however. When this happens there are often too many redundancies and too little material covered—it amounts to a speech on infrared electronics or ir detectors or the like, with no relation to the material that has gone before or will come after. The course as presented was written as a whole; each expert contributed one or more chapters as a natural growth of the information presentation.

The notes distributed at the lecture will be published: they make a good-sized book, complete with as much new information as possible. The book should be a valuable contribution to the study of infrared.

To engineers in the field it may seem strange that an infrared course was given in Los Angeles. "Like bringing oranges to California," commented Garbuny. With such centers of infrared activity as the Santa Barbara research centers, Hughes Aircraft, Raytheon, Stanford Research Labs, Lockheed, Berkeley, Thompson-Ramo-Wooldridge, Nortronics and Aerojet-General, there is certainly no dearth of enterprise in infrared on the West Coast.

"Actually it is practical and appropriate to

have the course in Los Angeles," said Garbuny. "First, the UCLA program is very well set up. Then Eastern people can get away from office worries and concentrate on just one thing. We have the advantage of a certain cross-pollination of information."

UCLA hopes to repeat the course next year. Satyendra and Garbuny are already planning their future activity. "It seemed quite a successful course," says Dr. Satyendra. "Perhaps next year we will arrange for a little extra time and more get-togethers. The problem and discussion sessions were very useful."

The UCLA short courses are a pleasure to attend. There is first of all the knowledge that the course provides the student with as much information as he can absorb in two weeks. He spends his whole day concentrating on one subject to the exclusion of all else. Months of this treatment would be dreary, but two or three weeks of it is satisfying and rewarding.

Courses are set up with plenty of notes, so the student can review the work after he has left.

Instructors and lecturers are experts currently working in the field. The student is always certain the information he is getting is of singular practical importance.

As mentioned before, most students taking the short courses are engineers entering the field, who want to pick up as much advanced information as possible as quickly as possible. But there are usually a healthy number of PhDs in attendance; as well as engineers currently working in the field. These latter two types get most of their new information from the discussion periods, where they bring up problems that have been bothering them.

In this sense, the course is like a two-week symposium, with all attendees living in fairly close proximity; able to talk shop at leisure.

How can you go? Most students are informed of the courses via their company training officer. The training officer receives a brochure from UCLA and asks the chief engineer if he can name somebody he'd like to have attend the course.

UCLA's facilities for locating companies that might have an interest in any given field are limited, of course. Moreover, Harold Caysen, assistant to Dr. Sam Houston, notes that the school is presently involved in deciding just which classes to give. Some that are planned for next year include Missile Silo Construction and Ventilation; Plasma Physics and Controlled Fusion; Behavior of Dislocations (involving failure of materials); Human Factors; Operations Research and Systems Analysis; Hot Cell Technology (nuclear

(Continued on p. 242)

CAREER NEWS

(*Continued from p 241*)

power plants); Computers, Advanced Programming; and, tacked on to the original infrared course, an extra week in Advanced Infrared. Microminiaturization, Cryogenics, Advanced Cryogenics and Applications of Generalized Harmonic Analysis will also be included—all in addition to the courses mentioned in the first part of this article.

Do any of these strike a note? To receive the UCLA program for any given course, write to the Engineering Extension, University of California at Los Angeles, 405 Hilgard, Los Angeles 24, Calif.

New course ideas are being sought by UCLA Extension Division. They are very open to suggestion, and always willing to consider any fields they may so far have overlooked.

ENGINEER-IMPROVEMENT COURSES AND SEMINARS

Below are courses and seminars intended to provide the engineer with a better knowledge of various specialties. Our grouping includes several different types of meetings: National Courses—those held on consecutive days and intended to draw attendees from all geographic areas; One-Day Seminars—one-day intensive seminars which move from city to city; and Regional Lectures—regional symposia or lecture series which generally run one night a week for several weeks.

National Courses

UCLA Engineering and Management Course, January 25-February 4

A course for the professional development of managers and engineers, will be held at the University of California, Los Angeles. The 10-day program will offer a choice of 22 subjects to fit the needs of both executives of large industries or of middle-level personnel from small companies.

Emphasis will be on the principles and techniques which form a systematic approach to management, and on the quantitative methods which supply the facts for such an approach. Information on registration and living accommodations may be obtained from Reno R. Cole, College of Engineering, University of California, Los Angeles 24, Calif.

Training Course In Value Engineering and Analysis, IEI, November 30

This five-day course, which will be held in Boston, starting Nov. 30, has been developed by the Industrial Education Institute, in cooperation with the Materials Handling Institute. The program, covering all phases of the subject, has been designed especially for men responsible for product design, procurement and manufacturing in industry and government.

Value Engineering and Analysis is a technique developed for reducing product cost. It is a concentrated effort to improve the value of any product by eliminating unnecessary costs in product design, manufacture and procurement.

The five-day training will combine formal instruction, guest lectures, informal discussion, demonstration, case study and problem solving. Through specially developed work projects, the participants will learn "by doing" by value analyzing a wide variety of products. Through the free exchange of information with men with similar responsibilities and problems, the registrants will pick up new functional design and procurement techniques they can apply to their own products.

The members of the faculty have been drawn from industry, government and education. They include L. S. Miles, Manager of Value Services, General Electric Co.; Rear Admiral A. G. Mumma (USN Ret.), Vice President, Engineering, Worthington Corp.; Rear Admiral R. S. Mandelkorn, (USN Ret.), Chairman of Value Engineering Committee, Electronic Industries Association; Vincent de P. Goubeau, Vice President, Materials, Radio Corp. of America; Frederick S. Sherwin, Manager, Value Analysis Service, Raytheon Co.; Don Otis, Controller, Electric Typewriter Div., IBM Corp.; Bernard W. Eades, Manager, Value Engineering, Stromberg-Carlson Co., and President of the Society of American Value Engineers; Raymond J. Benard, Value Analysis Education, U. S. Army Ordinance; Morgan D. Roderick, Office of Value Engineering, Bureau of Ships, U. S. Navy; Louis J. De Rose, Executive Director, Materials Man-

CAREER COURSES

agement Institute, and others. Further details and registration information may be obtained from the Registrar, Industrial Education Institute, 25 Huntington Ave., Boston 16, Mass.

Fastener and Report Writing Courses Offered By Engineering Institute

The Engineering Institute of the University of Wisconsin is offering two 3-day courses of interest to electronic engineers: Industrial Fastener Application, Nov. 19-20 and Technical Report Writing, Jan. 20-22. For further information write to: Engineering Institute, University Extension Div., 3030 Stadium, The University of Wisconsin, Madison 6, Wis.

One-Day Seminars

Communications One-Day Seminar, Boston, New York and Philadelphia

The Industrial Education Institute is offering a one-day seminar entitled, "More Effective Communications." Conducted by Don Fuller, the seminar will be held at the hotels: Sheraton-Plaza, Boston, Mass., Nov 2; Park-Sheraton, New York, N.Y., Nov. 4; Sheraton, Philadelphia, Pa., Nov. 5.

The program outline is as follows: The Role of Communication in the Organization; The Report as an Aid to Decision Making; Tailoring Presentations to Get Desired Action; Insuring the Proper Perspective and Emphasis; The Creative Procedures in Putting Thoughts on Paper; Recognizing and Avoiding Communication Traps; Meeting Objections to Presentations; and Developing the Most Effective Format. For further information write to: Industrial Education Institute, 25 Huntington Ave., Boston 16, Mass.

Regional Lecture Series

Telecommunication Technology Study, New York

The Communication Division of the New York section of AIEE is offering a fall, winter and spring study-group course in Telecommunication Technology. The fall session on transmission media is under way now; the final three meetings are scheduled for Nov 10, 17, and 24.

The winter session on transmission techniques starts Jan. 12 and meets weekly through Feb. 23. All meetings run from 7 to 9 P.M. and are held

at the Western Union Building Auditorium, 160 Broadway, New York, N.Y.

PAPER DEADLINES

Convention Program Chairmen have issued the following deadlines to authors wishing to have their papers considered for presentation.

December 15: Deadline for abstracts of 150-200 words for the **1960 Electronic Components Conference** scheduled for **May 10-12** in Washington, D. C. Please send in triplicate to: *Gilbert B. Devey, Technical Program Chairman, Sprague Electric Co., North Adams, Mass.*

November 2: Deadline date for Transaction papers for the **American Institute of Electrical Engineers** scheduled for next **January 31** through **February 5, 1960,** in New York City. (**December 2:** Deadline for full text of conference papers—preprints only). Abstracts of prospective papers are needed as soon as possible. *Address all correspondence to: G. L. Hollander, Chairman, c/o Philco Corp., 4700 Wissahickon Ave., Philadelphia 44, Pa.*

November 9: Deadline date for papers for the **1960 Western Joint Computer Conference** scheduled for next **May 3-5** in San Francisco, Calif. Papers to be submitted to the **Technical Program Committee** should be prepared on the basis of a thirty-minute delivery. No advance abstract of the paper will be required. *Forward three copies of the original draft to: H. M. Zeidler, Chairman, Technical Program Committee, 1960 Western Joint Computer Conference, Stanford Research Institute, Menlo Park, Calif.*

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CORPORATIONS, INC.
700 LIBERTY AVE., UNION, N.J.

BREEZE PRODUCTS: ACTUATORS • HOISTS • TRANSMISSIONS
GENERATORS • STARTERS • STARTER GENERATORS • BELLOWS
SLIP RINGS • HOSE CLAMPS • HITEMP FLEXIBLE TUBING
CIRCLE 676 ON READER-SERVICE CARD

ADVERTISERS' INDEX
November 11, 1959

FOR A CHECKUP

A year ago, he was only reading about cancer, just as you are now. But cancer was something that happened to the other fellow. No need for *him* to go to a doctor.

Now that he knows better, it is unfortunately too late. He is one of the 75,000 cancer patients who will die needlessly this year because they did not see their doctors in time.

...AND A CHECK

Nor could he see any reason, last year, for backing the fight against cancer with his dollars.

But cancer always strikes close to home—in two of every three families, to be exact. This toll can be reduced by supporting the medical counterattack with a contribution.

The other fellow? He's always one of us. Some find it out the hard way. What will it take to convince you?

Guard your family—
fight cancer with a
checkup and a check.

Send your check to "Cancer,"
c/o your local post office.

AMERICAN CANCER SOCIETY

SHAGGY FISH STORY

At the height of the Boston Tea Party, while the "Indians" were busy throwing everything in sight over the side, the British radar operator suddenly found himself pitched overboard.

Since he couldn't swim, he clung precariously to a wooden tea case bobbing in the water, and floated aimlessly around, thrashing wildly and yelling for help.

Just as he was about to lose his grip on his precious raft, a codfish surfaced nearby.

"What's going on here?" the codfish asked.

"Some wild Indians surprised our radar, overran the ship, and threw all the tea overboard," the radar man gasped.

"Well," the codfish said, "Bet you a fin you didn't have any Bomac tubes in that radar of yours."*

"Good cod, here I am drowning in front of your eyes and you have to give me a commercial," the man said. "I can't hang on much longer!"

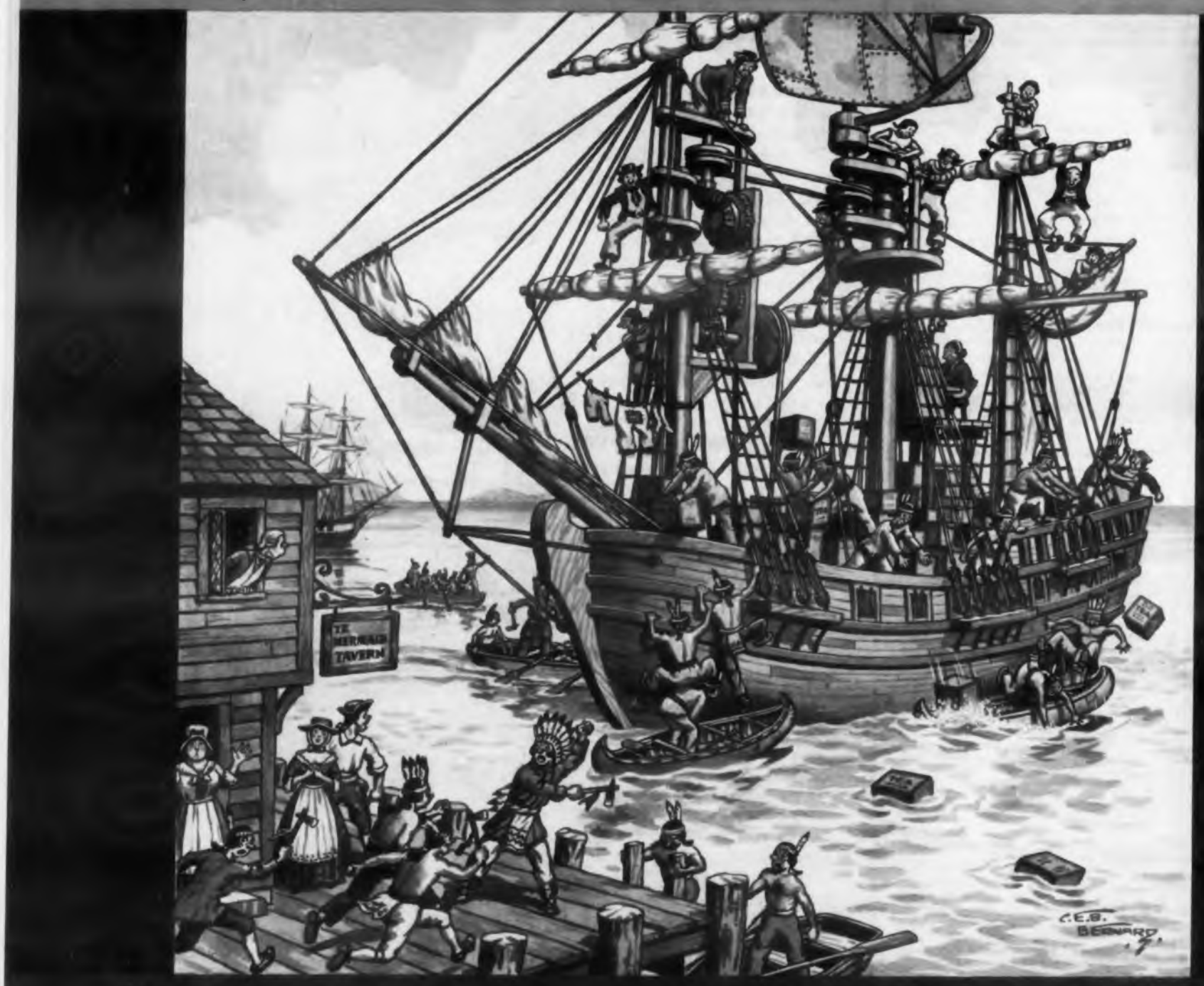
The fish ignored him. " . . . Anybody knows Bomac makes the finest microwave tubes and components either side of Boston Harbor," he said.

"Look," the man said. "I've just about haddock. But tell me this: How do you know so much about microwaves?"

"I'm no expert," the codfish said. "I just dabble in it for the halibut."

"O," the man said. And he sank silently into the sea.

No. 16 of a series . . . **BOMAC LOOKS AT RADAR THROUGH THE AGES**



**Bomac makes the finest microwave tubes and components either side of Boston Harbor*

BOMAC Laboratories, Inc.

Leaders in the design, development and manufacture of TR, ATR, Pre-TR tubes; shutters; reference cavities; crystal protectors; silicon diodes; magnetrons; klystrons; duplexers; pressurizing windows; noise source tubes; high frequency triode oscillators; surge protectors.

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