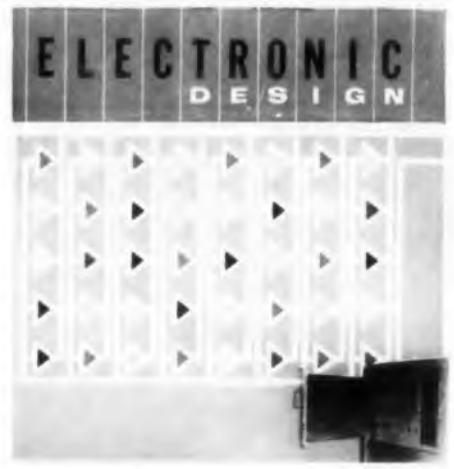
ELECTRONIC DESIGN

Parallel-Operated Components Raise Computer Speed . . . 34

HIGHLIGHTS OF ISSUE



Parallel-Operated Components Raise Computer Speed (Cover) 34

By operating its components in parallel the "Trice" digital computer achieves speeds comparable to analog computers. Self-contained digital integrators, multipliers, and servos are interconnected by means of a plugboard which serves as the means of programming. 100,000 iterations per second in parallel is obtained by this method of construction. Word length is 30 bits.

Electronically Controllable Bandpass 22

The bandwidth of an i-f amplifier can be changed just by varying the bias of a single tube. The change can be as high as 20 to 1 in a 30 mc i-f strip.

Design Curves for Thermistor Transistor Stabilization . . 26

One of our most popular contributors, Mr. Nisbet again provides the designer with some invaluable short cuts. He supplies an array of curves which make the selection of thermistors for transistor stabilization a rapid and simple operation. Some specific examples make the presentation particularly lucid.

Variable Speed Tape Drive . 40

This tape mechanism can search through a reel of tape faster than most computers can digest information. And, it works without a capstan.

September 17, 1958 Vol. 6
Number
19

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DESIGN

BEHIND THE NEWS

With this issue, we are beginning a more comprehensive news department for the design engineer. Each major development will be probed for significance, implication and application. We're out to get the design news "behind the news." Our new format will permit a more cohesive and attractive presentation.

Computer Simulation Speeds TV, Speech Research

Use of general purpose digital computers in the simulation of new coding and transmission devices shows promise of accelerating and broadening speech and television research, according to scientists at Bell Telephone Laboratories. The simulation techniques also promise to reduce greatly expense and time lags, and thus make it easy to investigate a large number of approaches to coding and transmission problems.

In speech research, speech is sampled; each sample is quantized into 10 bits or 1024 amplitude levels and delivered to a magnetic tape recorder. These coded samples are recorded in seven parallel tracks, with 200 characters to the inch of tape. These tapes are then fed into the computer, where they are processed according to pre-assigned programs based on the coding or transmission scheme being investigated. The processed signals are then re-recorded, decoded, and played back for analysis and listener evaluation.

Computer memory requirements for speech processing are severe due to the large amount of data generated by even a short section of speech. Rapid access memory units must have a capacity of several seconds of speech to be useful. A speech transmission scheme known as the "Extremal" method, studied by simulation at Bell Labs, illustrates the advantages of the new technique. In its simplest form, only the extremes, or peaks and valleys, of a speech wave are sampled. The amplitudes and time of occurrence of these points are then transmitted, instead of a detailed representation of the entire wave. At the receiver, an approximation of the speech wave is generated by interpolating a suitable mathematical function between these points.

Listener evaluation of the simulated speech produced in initial tests showed that intelligibility is high—above 90 per cent sentence intelligibility—but that the

(continued on page 6)

Speech input from the tape recorder to the analog-digital converter in the background is checked (above). Photograph is made (below) of TV picture reproduction after computer simulation.

quality is somewhat below that of commercial telephones.

Reports so far indicate that a total of five minutes of speech was synthesized. Including "de-bugging," about three hours of computer time was expended at a cost of $1500. About four man-months of time was spent, partly in programming, but mostly in determining what to investigate. These figures are substantially less than required to build an actual laboratory model to perform the same function, roughly 1-1/2 man-years and $50,000 in equipment costs. Digital simulation has been applied to a number of other speech problems.

Picture coding research has also been carried on by computer simulation. In order to hold machine time and memory requirements to a reasonable level, the system uses an input picture of 100 x 100 elements, corresponding to an area about 1/25 that of a conventional TV frame. This 10,000 element "window" has proven to be of sufficient size to allow critical evaluation of the processed images. For typical coding schemes, the total computer time required is 5 to 10 seconds per picture.

A magnetic tape recording of the video signal is prepared by scanning a square picture with 100 scanning lines in 2.4 seconds. Each picture dot is quantized to 10-bit accuracy, providing 1024 amplitude levels, and recorded in the same form as the speech samples described above. The resulting signal is rooted, mixed with a synchronizing waveform in the conventional manner, and band limited to 2500 cps.

In playback, the computed picture signal is converted back to analog form. It is then passed through a low-pass filter, and displayed on a monitor with two kinescope tubes. One of these tubes has a show phosphor for direct viewing, while the other has a fast phosphor for photography.

A coding scheme which may have widespread significance in TV transmission, known as "Predictive Quantizing," has been studied by both simulation and conventional methods. This scheme takes advantage of the relatively low level of viewer perception during periods of scene change or motion, and in areas of picture confusion, these being the only regions in which predictive coding systems make significant errors. The method involves quantizing the difference between the original continuous signal and a predicted version of that signal. It employs fine quantum steps for small errors, and coarse steps for large errors, where the predictor and the viewer are surprised. This tapering of steps in the quantizing staircase allows the use of a smaller number of total levels, and thus reduces the channel capacity requirements.

A limiting case of predictive quantizing, in which the predictor is simply a one-sample delay, has been tested both with the simulation equipment described and with standard 525-line television, and found to afford a picture not significantly degrated from the original, and requiring only three bits per picture dot.

Ice Glow By Cerenkov

Under the impact of two million v electrons from a high-voltage Van de Graaff accelerator, a 50 lb block of ice gives off a visible glow known as Cerenkov radiation. The radiation detector developed by Westinghouse, Pittsburgh, Pa., uses an "electric eye" to detect the same glow in ordinary water from which the intensity of the atomic radiation causing the glow is measured. For protection, the photograph was taken through a circular three-foot-thick window containing a transparent solution of zinc bromide. The window is embedded in the equally thick concrete walls surrounding the Van de Graff machine.

BEHIND THE NEWS

Fast Wave Parametric

Fast wave parametric amplifier devised by Zenith Radio Corp., for use in ultra high frequency and microwave radio receivers is reported to have a noise figure of about 1 db and a gain up to 30 db.

Extension of the effective range of military defense radars and those of missile and earth satellite tracking systems is expected with the new tube.

Officials report that the amplifier is completely unilateral and unconditionally stable. It is based on the concept that a certain mode of motion on an electron beam (the fast wave) permits interchange of input signal and beam noise in a coupler. An electron gun generates beam of about 35 μamps which drifts at very low velocity, corresponding to only 6 v, along the lines of a 200 gauss magnetic field. Input and output couplers are tuned to the center of the signal frequency band, about 560 mc. The electron beam enters the input coupler with a

Solid State Amplifier

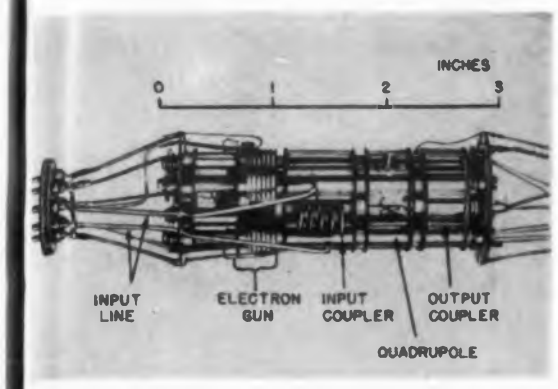
Basic improvement in a parametric microwave amplifier promises to offer particular advantages in the range of frequencies from 1000 to 10,000 mc and higher.

The RCA development uses an experimental germanium diode to detect an incoming high frequency signal. Associated with the diode is either a transistor or a "pencil-type" tube oscillating at a lower frequency to provide a "pumping" action which amplifies the signal.

Parametric microwave amplifiers previously have been considered impractical for operation at these frequencies because they have required a pumping frequency higher than that of the signal to be amplified. RCA scientists reported that the new device has the capability of amplifying extremely weak signals which frequently are drowned out by operating noise in present types of equipment. They indicated that the new device requires a power supply of only a fraction

Roundup of recent developments in microwave amplifiers.

Amplifier Offers 30 db Gain, Noise Figure 1 db



Inside view of fast wave parametric amplifier.

certain amount of random motion. The fast wave component of this motion is given up to the input coupler and transformed into heat in the resistive portion of the signal source. At the same time, the beam absorbs signal energy and carries it in the form of a fast wave, thus interchanging beam noise and input signal.

Spiraling electron motion which carries the signal is amplified during passage through the quadrupole electrode, a structure that resembles the stator of a four-pole generator. A highly non-homogeneous transverse electric field of four-fold symmetry is produced. The quadrupole is connected to the "pump" which supplies about 10 mw at about 1120 mc.

One component of the alternating non-homogeneous field pattern in the quadrupole appears to revolve in synchronism with the spiraling electrons. This causes the radius of their orbits to increase or decrease exponentially, depending upon their phase at the instant of entry. When the two processes are averaged, exponential growth always outweighs exponential decay and gain results. The gain for which the pump power is adjusted has no effect on the bandwidth. The tube measures four inches in length.

Application has been made for patent rights and commercial production will be undertaken "as rapidly as possible."

Promises 1000 to 10,000 mc Operation

of a watt, compared to a hundred watts or more for present conventional microwave amplifiers. Moreover, extremely low temperatures needed in maser operation and magnetic fields for traveling wave tubes are not required by these solid-state devices. The amplifier can be packed into a space of four cu in., permitting its ultimate use in missiles, satellites, and airborne equipment. Principal application of the new technique lies in the centimeter and millimeter wave regions, where higher-frequency local oscillator power for pumping is difficult to obtain.

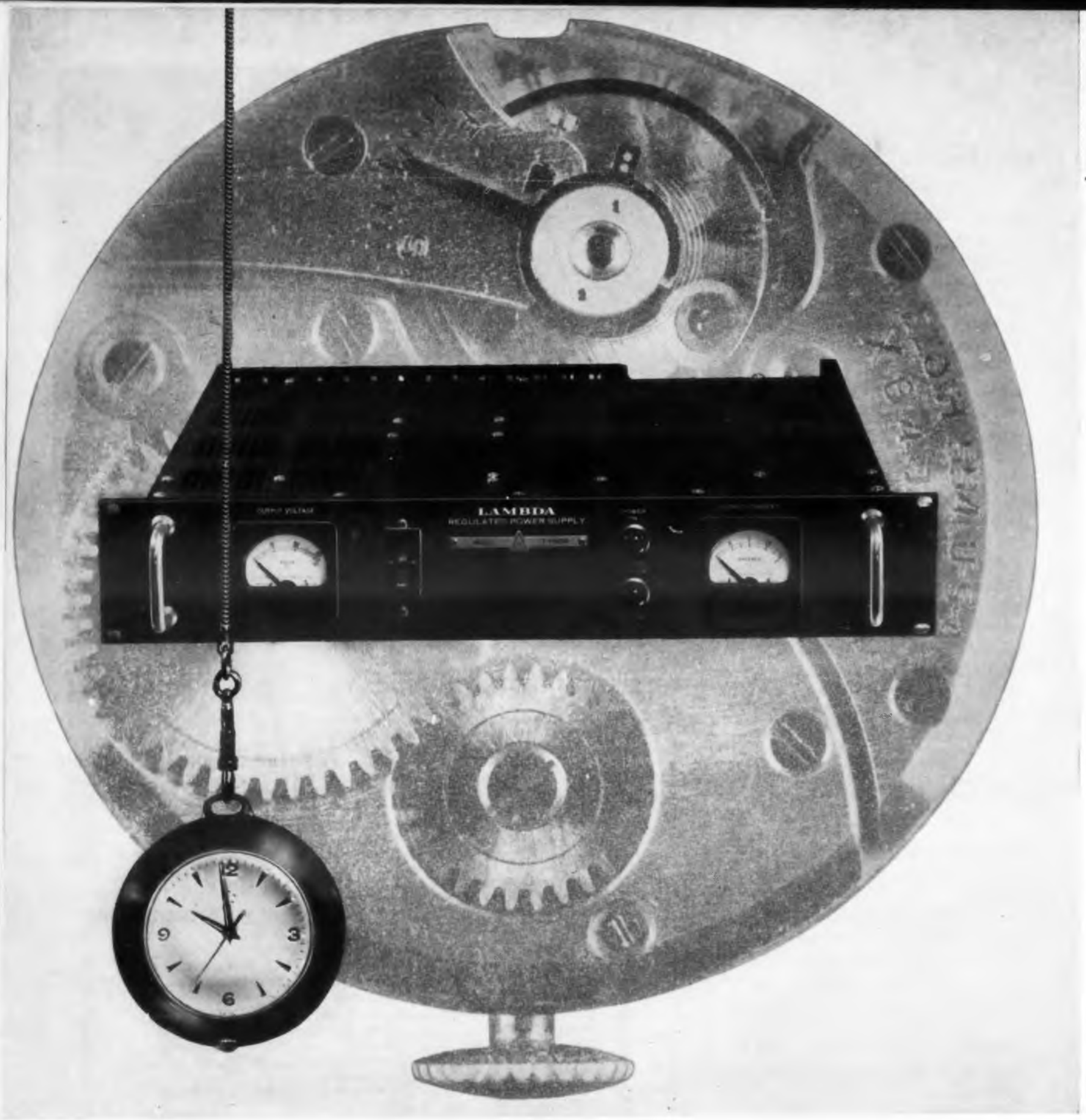
K. K. N. Chang and Stanley Bloom of the RCA Princeton Labs who developed the new technique stated: "The parametric amplifier principle has been placed in an entirely new light, and the technique promises to push back the present practical frequency and signal-level limitations to microwave communications."

TWT Maser Operates at 25 mc; Shows 23 db Forward Gain

Bell Laboratories developmental traveling wave, non-regenerative maser amplifier operates at 25 mc with a forward gain of 23 db according to test reports.

This maser offers high stability and unilateral gain. At 25 mc, a reverse loss of 29 db was noted. The non-reciprocal device is quickly tunable over the 350 mc bandwidth, a noteworthy figure compared to cavity type masers which are limited in bandwidth and gain by the microwave cavity circuit. Maser material used in the new device is ruby. Expectations are that this amplifier will be initially used in ground based equipment.

This development is another result of Bell Labs intensive investigation of microwave amplifiers.



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BEHIND THE NEWS

Study Radiation o

Characteristics of magnetic ma terials exposed to a radioactiv source can be measured by a new device. The instrument, a remote controlled "torque magnetometer," is used by Westinghouse Electric materials engineers to measure and record the torque exerted on a thi disk of magnetic material sus pended in the gap of an electro magnet. As the sample of material i rotated, the torque exerted on th disk changes according to th change in magnetization of the ma terial. This is measured by th torque magnetometer and automati cally plotted on a strip chart re corder. The result is a curve o torque versus angular position o the disk, with respect to the direc tion of the applied field. The infor mation can then be used to deter mine the "anisotropy constants"–

Light Measure

Far more precise measurement of magnetic forces originating in side the earth and in outer space may now be possible with the per fection of a new measuring method by the Department of Commerce.

A beam of light is sent through a tube containing a small quantity of vaporized rubidium. The man ner in which the light is absorbed indicates the strength of the magn netic forces. The explanation is tha the absorption of light depends on the spinning of the electrons in the rubidium molecule, and the spin in turn is controlled by the magnetic forces, or field.

According to Commerce Dept officials, instruments embodying the principle will be simple, highly miniaturized, and capable of meas uring very small magnetic fields– "perhaps one billionth of the mag netic force developed by the moto

CIRCLE 8 ON READER-SERVICE CARD

Magnetic Materials

measurement of the ease with which a material can be magnetized in a certain direction.

Samples of material and all adjustments on the "torque magnetometer" must be handled by mechanical manipulators. In this photograph, the sample being tested is mounted on the support positioned in the gap of the electromagnet.

Magnetic Forces

that runs an apartment house elevator." They will be suitable for use in rockets and satellites. One possible application is in planned probes of the moon.

Telephone Diagnosis of Heart Possible

Long-distance diagnosis of heart ailments may soon be possible with the development of a 5-pound transistorized unit which transmits heart sounds and electrocardiograph signals by phone. No patient-to-phone connections are necessary. The transmitter, attached to the patient, is applied to the phone mouthpiece. At the receiving end a second unit carries signal to another electrocardiograph machine for consultant's reading. The device was developed at the University of Kansas Medical Center.

CIRCLE 9 ON READER-SERVICE CARD ➤

All Quiet on Any Front With New Army Earphone

Development of an experimental electronic earphone, that shuts out loud noises which interfere with combat communications was announced by the Department of the Army.

The artificial quiet is created by adding more noise with a miniature microphone in the special earpiece to create a second noise, just as loud, but opposite in phase. This phase opposition greatly reduces the noise level. The earphones, which are expected to have many commercial as well as military uses, resulted from early noise reduction experiments conducted at RCA, Camden, N.J. and application of the concept to earphones was conceived at the U.S. Army Signal Engineering Laboratories, Fort Monmouth, N.J.

Experimental earphones contain a tiny circular microphone (lower disc) which picks up noise that leaks through ear cushioning. It then produces a second noise opposite in phase to first which cancels the first in large measure, and produces an artificial quiet.

Transistor Chart Correction

Our 1958 listing did not include many Texas Instruments Inc. and General Electric Co. types that originally appeared in our 1957 chart.

A complete listing of the missing transistors along with their characteristics will appear in the October 1st issue.

Japanese Atomic Clock Uses Ammonia Gas

Second atomic clock developed in Japan again uses ammonia gas rather than the cesium beam of English and American clocks.

Although the United States and United Kingdom clocks provide far greater accuracy, this Japanese design marks the success achieved in controlling the molecular vibrations of ammonia. The announced accuracy of the British clock is two parts in 10,000 million, or an error factor of one second each 150 years. Atomichron, the U. S. product, has an accuracy of 5 parts in 10,000 million, or an error factor of 1 sec every 150 years. The Japanese clock has an error factor of one second in 50 years. Japan's first atomic clock, developed 15 months ago, had an error factor of one second in 15 years.

"American and British physicists consider ammonia gas unsuited for atomic clock use since they found the vibration frequency of the ammonia molecule was not as constant as that of the cesium atom," said Dr. George Michio Hatoyama, physicist at the Government's Electric Laboratory who developed both Japanese atomic clocks.

They found the frequency varied from time to time according to such conditions as room temperature, gas pressure, and gas purity, he explained.

The Japanese physicist learned to control these factors to get the consistency of frequency required. This latest development promises improved models in the not too distant future.

Dr. George Michio Hatoyama and his atomic clock.

WASHINGTON REPORT

Herbert H. Rosen

Wanted: Research Ideas For Tubes and Parts

A $34 million program is about to be initiated by the Department of Defense aimed at improving electron tubes and electronic parts. Chief coordinator for the program is the Director for Electronics, J. M. Bridges, in the Office of the Assistant Secretary of Defense for Research and Engineering. The contracts for the separate projects will be awarded by the military services. Below is shown how the funds, in millions, are apportioned among the three services.

	Army	Navy	Air Force
Tubes:	$3.536	$1.631	$2.093
Parts:	1.915	1.770	1.840

Bridges' office is seeking new ideas for tubes and parts. A thorough study is being conducted of existing projects by the advisory groups on electron tubes and electronic parts. These advisory groups will make the next-to-final decision on projects submitted to them by the military services or by private companies with ideas needing support. Final approval for each project, of course, rests with Bridges and his staff.

This program has only recently been augmented by $12.8 million from the Defense Secretary's emergency fund. However, if proven as successful as anticipated, similar amounts of money—$34 million, total—will be budgeted for the next five years. Therefore, year-end progress reports will figure heavily in the future of the whole program.

Tacan for Civilian Planes Opposed

Opposition to the costliness of Tacan was officially voiced recently by the Air Transport Association, spokesman for the scheduled airlines. AIA has come out strongly for a combination of VOR and a system called DMET—distance measuring equipment with certain Tacan capability. The association contends that DMET is considerably less expensive because it eliminates the need for the azimuth antenna in the Tacan system.

ATM claims that by taking this position it is informing the manufacturers of short range navigation equipment of the future requirements of the airlines. However, being opposed to something, in this case, does not make ATA *for* something else. Its technical staff is still seeking the "ideal" navigation system. They will welcome any suggestions, whether they be doppler or conventional radar navigational aids.

Meanwhile, the major R & D agency concerned with the problem, the Air Modernization Board, continues its search for new ideas and equipment. Development contracts for terminal and enroute equipment systems have gone to General Equipment Laboratories. And the AGACS—air-ground-air communications system—contract has been awarded to RCA. Twelve other companies share in $12.6 million worth of AMB contracts. Very shortly another contract will be awarded for the development of a system to aid in ground approach and touch down of civil airplanes.

One company very much interested in this area is Bell Aircraft. This company has successfully demonstrated the use of its automatic landing system with a Boeing 707 jet transport. Previous tests with the Navy have led to the tentative acceptance of the Bell system for carrier aircraft.

Obviously, an all-weather automatic landing system is possible with the technical capability at hand. Even back in 1949, the CAA demonstrated capability with its ILS. But simple economics may impose obstacles that will not be as easy to hurdle.

AMB estimates that the $6 billion airways we have today are closed down 15 per cent of the time because of bad weather. It costs the airlines about $6 million each year because of resulting cancellations.

However, it would cost about $900 million to equip all of the air terminals with all-weather equipment. On top of this figure are added the costs for brick and mortar.

ARPA Discloses Projects

Roy Johnson, Director of the Advanced Research Projects Agency, recently announced the types of programs his agency hopes to carry and the money allotted to each. Among these are: Anti-ICBM, $157 million. The Nike Zeus portion of the project is budgeted for $57 million. Communications, $9 million. Navigation, $1 million. Components development, $10 million. Satellite tracking, $17 million. Lunar probes and associated ground scanning equipment, $14 million. Reconnaisance satellites, $186 million. Solid propellants development, $20 million. Exploratory research in related fields, $13 million. Maximizing payload capability, $6 million. And man-in-space experiments, $50 million.

LETTERS

Psychiatrists Plagued by "Read Papers", Too

Editor, *The American Journal of Psychiatry*

"Listening to papers" is one of the many trials and tribulations of a psychiatrist—by far not the least; and the pages of professional magazines are customarily reserved for the very same people who "read papers." Time and again I have sworn to myself never to attend another meeting or convention and never to listen to another paper—ever! But I end up like the man who stated: "To stop smoking is the easiest thing in the world—I have done it hundreds of times." And so, sooner or later, I find myself at the receiving end of a "paper."

I always enjoy listening to a man who has something to say. But if a speaker has something to say—why does he not just go ahead and say it—why has he "to read a paper?" Psychiatrists who habitually inquire into the "why?" of human behavior seem to shun inquiries into the motivation of "paper-reading"—a rather amazing fact if one considers the usual intensity of their professional curiosity.

"Speaking" is one thing, "reading a paper" is something else. The former has its place as a valuable experience in interpersonal relationship; the latter is a rather irrational act, considering that the listeners are most likely all able to read themselves quite well, illiteracy being rare among psychiatrists. If the "reader of a paper" had the voice and the skill of a Charles Laughton, listening might be pleasurable. More likely, however, the reading is a stammering, fumbling, or monotonous production of complicated sentences, constructed for careful reading in one's own studio, but not intelligible at the high speed at which they are thrown at us at the meetings.

A few papers are rich in value—most of them are not. I have listened to many papers of considerable length, the pertinent content of which could have been summarized in a few sentences . . .

Others leave us with the strong impression that the speaker had "to give a paper" for some reason

or other, so that the reading of the paper is an end in itself and no longer serving any other purpose.

What does the listener get out of his attendance? A short while ago I attended a lecture given to teach techniques in group therapy. After the lecture one of my co-listeners, duly impressed by the famous name of the speaker, felt moved to give vent to his admiration of the performance. Since I myself felt disappointed I raised the question "what, if anything, did we learn?" Only then did several others dare to show their own disappointment. Only then did one after the other object that we had heard nothing but well known generalizations. The eulogist withdrew behind the statement, that he had enjoyed the strong feeling: "Here is a man who is a master of a difficult technique!" I felt I did not have to come from far away to convince myself that some men master a technique well—I was aware of that fact. I came to learn . . .

Rarely do we meet a speaker who "speaks." If that happens it is an enjoyable experience—provided he has something to say. Even if he occasionally should get mixed up in his syntactical constructions, if he has occasionally to stop and think for a moment, or to check his short notes before going on, even if he has sometimes difficulty to find the right word, I still prefer him a thousand times to the reader of a smooth paper; and so I think would most of us. For spoken language is the natural means of oral communication, as written language is designed to be read. Thoughts that a man can express in free speech can usually be understood by attentive listening; papers sometimes remain obscure even when one reads them slowly.

Why then are such "speakers" so rare? It seems that few men can handle their anxiety in facing an audience and that a rigidly fixed and prepared manuscript is their only defense.

There is no doubt a corner in Heaven reserved for us, the listeners, a corner where no papers are allowed to be read . . .

Dr. Hans S. Unger
Supervising Psychiatrist
Buffalo State Hospital
Buffalo, N.Y.

▶ Shortly after our editorial decrying the inefficiency of paper reading at conventions, we chanced to see the Convention issue of *The American Journal of Psychiatry* and Dr. Unger's discerning comments. We asked permission to reproduce them. In granting permission, Editor Farrar included this quote by the late science historian, George Sarton: "In my opinion, the reading aloud of a written paper is a cardinal sin as deplorable as meretricious writing; it is a wicked procedure, utterly contemptuous of the audience and unfair to it."

MEETINGS

Calender of Events

Sept.

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

15-19 Instrument-Automation Conf., Phila., Penna.
22-24 Symposium on Telemetering, Miami Beach, Fla.
24-25 Industrial Electronics Conf., Detroit, Mich.
29-Oct. 4 New York High Fidelity Show, New York Trade Show Building

Oct.

S	M	T	W	T	F	S
					3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

1-2 Conf. on Radio Interference Reduction, Chicago
1-2 Engineering Writing and Speech Symp., N.Y.C.
6-8 Symp. on Extended Range and Space Transmission, Washington, D. C.
8-10 IRE Canadian Convention, Toronto
13-15 National Electronics Conference, Chicago, Ill.
20-22 Symp. on Aeronautical Communications, Utica, N. Y.
27-29 IRE Radio Fall Meeting, Rochester, New York
27-29 East Coast Aero. & Nav. Elec. Conf., Baltimore
30-31 Electron Devices Meeting, Washington, D. C.

Nov.

S	M	T	W	T	F	S
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9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

17-18 IRE Region 3 Convention, Atlanta, Georgia
17-20 Conf. on Magnetism and Magnetic Materials, Phila., Penna.
19-21 Elec. Tech. in Med. and Biology, Minneapolis

Dec.

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

2-4 Reliable Electrical Connections, Dallas
3-5 Eastern Joint Computer Conf., Phila., Penna.
3-5 Symp. on Global Communications, Florida

Sept. 24-25: 7th Annual Symposium on Industrial Electronics

Rackham Memorial Auditorium, Detroit, Mich. Sponsored by PGIE and AIEE. Address queries to Willam R. Thurston, General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Sept. 29-Oct. 3: ASTE Semi-Annual Meeting and Western Tool Show

Shine Exposition Hall, Los Angeles, Calif. Sponsored by American Society of Tool Engineers.

Theme will be "Tooling for the Space Age." For more information write ASTE, 10700 Puritan Ave., Detroit, Mich.

Sept. 29-Oct. 3: Audio Engineering Society Trade Exhibit

Hotel New Yorker, New York, N.Y. Sponsored by the Society at its tenth Annual Convention. New devices and methods for the use of professional sound equipment under proper conditions for engineering appraisal. For more information get in touch with Sumner Hall, Amityville, N.Y.

Oct. 1-2: 2nd Annual Symposium on Engineering Writing and Speech

New York City. Sponsored by the IRE, PGEW.

Oct. 8-10: Canadian IRE 1958 Convention and Exposition

Toronto, Ont. Twenty-five sessions covering medical electronics and education, cosmic rays and microwave systems. Exhibits featuring nucleonic and electronic projects, products, and components will be displayed.

Oct. 13-15: National Electronics Conference

Hotel Sherman, Chicago, Ill. Tentative program includes sessions on transistors, servomechanisms, antennas, audio, filter design, solid state, microwaves, instrumentation, network theory, engineering writing and speech, computers, radar and radio navigation, magnetic amplifiers, engineering management, industrial electronics, television and communications. More information can be obtained from National Electronics Conference, Inc., 84 East Randolph St., Chicago 1, Ill.

Oct. 20-21: 4th National Aero-Com Symposium

Hotel Utica, Utica, N.Y. Sponsored by the IRE Professional Group on Communications Systems. It will stress the requirements, progress and challenge of communications in all its phases.

Oct. 20-22: URSI Fall Meeting

Pennsylvania State University, University Park, Pa. Co-sponsors are IRE professional groups on information theory and antennas and propaga-

MEETINGS

tion. Write U.S.A. National Committee, URSI, 2101 Constitution Ave., N. W., Washington 25, D.C., for more information.

Oct. 22-24: Fifth National Symposium on Vacuum Technology

Sir Francis Drake Hotel, San Francisco, Calif. Sponsored by American Vacuum Society. For more information write American Vacuum Society, Box 1282, Boston, Mass.

Oct. 29-30: 5th Annual Computer Applications Symposium

Morrison Hotel, Chicago, Ill. Sponsored by Armour Research Foundation of Illinois Institute of Technology. Topics to be included cover new concepts in large scale data processing. Send inquiries to Dr. Frederick Bock, Electrical Engineering Research Dept., Armour Res. Foundation of Ill. Institute of Technology, 10 W. 35 St., Chicago 16, Ill.

Nov. 19-20: Northeast Electronics Research and Engineering Meeting

Mechanics Hall, Boston, Mass. Sponsored jointly by the Boston, Connecticut, and Western Massachusetts Sections of the IRE. R. R. Leonard, Datamatic Div., Minneapolis Honeywell Regulator Co., Newton Highlands, Mass., has more information.

Nov. 19-21: 11th Annual Conference on Electrical Techniques in Medicine and Biology

Nicollet Hotel, Minneapolis, Minn. Sponsored by IRE, AIEE, and ISA. The theme this year is Biology and Computers. Sessions will cover possible applications of electronic computers in the fields of electrocardiography, electroencephalography, and biological logic. Further information from Mr. Robert Erskine, Minneapolis Honeywell, 2753 Fourth Ave. South, Minneapolis, Minn.

Feb. 12-13, 1959: 1959 Solid State Circuits Conference

Philadelphia, Pa. Sponsored by IRE, AIEE, and Univ. of Pennsylvania. Devoted to transistor circuit technology, applications and circuit techniques of a variety of solid state devices.

EDITORIAL

Can We Learn from the Russians?

If you've written anything of engineering importance, the chances are the Russians have read it—or will. They don't burden themselves with qualms about using only original thinking. If your design, your innovation, or your research can help them—they won't bother duplicating your efforts. And, if you've written a darned good textbook, they'll use that, too.

This is not accidental. It is the deliberate undertaking of a nation which, in a little over 40 years, has zoomed from semi-feudalism to the status of a leading world power. The All-Union Institute of Scientific and Technical Information of the Russian Academy of Sciences abstracts important scientific and technical papers from all over the world. It has some 2000 translators at work. They turn out an average of 10,000 abstracts a week, and translate the most important articles in full.

It is generally conceded that Russia's policy of monitoring the scientific and engineering output of the world in general, and the United States, in particular, has paid off.

Until Sputnik I, most people didn't feel it was at all important to check Russian developments. The possibility of our learning anything from the Russians was considered remote, if not absurd. But now, government and industry have become increasingly concerned with what the Russians are writing.

First Full Book Translation

We, too, have been concerned. Since 1955, we've been publishing abstracts of articles in leading Russian electronics journals. Now, for the first time, we present a full translation of a new Russian book, in serial form. Part 1 begins on page 126.

Nonlinear and Parametric Phenomena in Radio Engineering should help many engineers who view nonlinearity as an unavoidable evil which must be corrected for. These engineers design only on a linear basis, and correct for nonlinearities later. But there are many circuits which depend on nonlinearity—multivibrators, oscillators, switching circuits, etc. And nonlinear elements can actually *improve* linear system performance.

Where the few previous books on the subject reached for the system designer, the advanced researcher, or the mathematician—this one aims squarely at the electronic design engineer—and speaks his language. Information on nonlinear electronics has been available before—in scattered paragraphs, chapters, conference papers—but never in such unified and compact form.

We think this book is a fine introduction, and it helps answer the question, "Can we learn from the Russians?"

George D. Rostay

How to design

Electronically Controllable Bandpass For I-F Amplifiers

G. W. Clevenger
Bendix Radio
Baltimore, Maryland

You can now change the bandwidth of an i-f amplifier merely by varying the bias of a single tube. The change in bandpass can be as high as 20 to 1 in a 30 mc i-f strip. Nor is the on-frequency gain affected. The bandpass shape assumes all intermediate shapes associated with the sharp single tuned and the flat topped, critically coupled cases. And as you will see, the circuit is easy to design.

HERE IS A variable bandpass that simplifies the design of radar and communication networks. The filter can be used in a number of circuits where the bandwidth has to be varied symmetrically around the center frequency. Obvious applications are:

- In a radar set having a choice of two or more pulse widths;
- As a replacement for mechanical devices used in certain communications receivers to vary i-f bandwidth;
- In a search receiver which must search a given band as rapidly as possible, find the desired signal, and afterwards be insensitive to nearby distracting signals.

Operating Characteristics

A simplified schematic of the variable bandwidth amplifier is shown in Fig. 1, along with a vector diagram of the phase relationships which hold at the various points.

In the vector diagram, e_1 is used as the reference. Assume a frequency which is on resonance for the two tuned circuits. We find e_2 lagging e_1 by 90 deg and attenuated by the factor G_1. The voltage at the plate of V_1 is then 180 deg out of phase with e_2 or at +90 deg. The effect of the second phase shifter is to cause e_4 to lag e_3 by 90 deg, or make e_4 again in phase with voltage e_1. The current i_{fb} which is caused to flow in the direction indicated, byt the presence of e_4 on the grid of V_3, constitutes a dynamic pure resistive loading across tank circuit Z_1. The solid lined vectors indicate only the resonance condition.

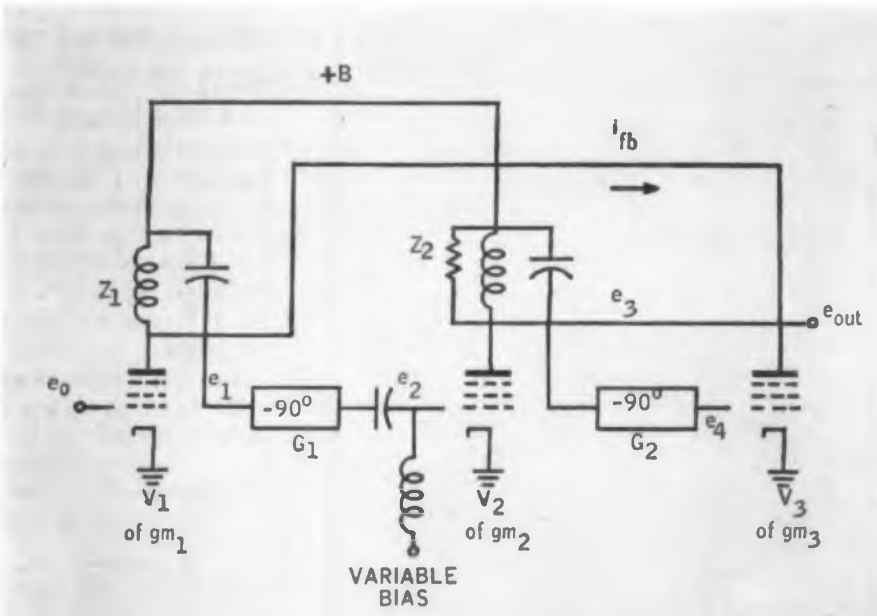
Assume a frequency above the natural resonance of circuits Z_1 and Z_2. The tank circuit Z_2 is now capacitive. Therefore, e_3 lags its former position by the angle ϕ, causing a corresponding lag of e_4 behind its former position. The effect of the lagging current i_{fb} is as if a dynamic resistance and a dynamic inductance had been connected across tank circuit Z_1.

As circuit Z_1 is also capacitive, since a frequency higher than resonance was assumed, the sign of the inductive susceptance is correct to retune the circuit Z_1 to the new higher frequency. This is the same effect as the tuned secondary interaction with the primary previously noted in the coupled circuit case. Furthermore, i_{fb} is controllable in amplitude by carrying the gain within the feedback loop, that is, by varying transconductance of V_2. The variation of gain within the feedback loop is analogous to mechanically varying the coefficient of coupling between two tuned circuits.

One other feature of the circuit is worthy of mention. The Q of the first coil (Z_1) sets the minimum bandwidth. Its Q should be made as high as possible, if wide excursions of bandwidth are desired. It is preferable to unload Z_1 as much as possible by inserting a cathode follower between Z_1 and the RC phase shifter G_1. Adding a small capacitor from cathode to ground on the cathode follower allows slightly more than 90 deg phase shift in G_1, to compensate for the slightly less than 90 deg shift in the simple RC shifter G_2.

Care must be exercised not to exceed the stable gain of V_1. As the bandwidth is narrowed, dynamic loading across Z_1 decreases until V_2 is cut off.

The performance of the variable bandwidth i-f amplifier is given in Fig. 2 in terms of bandwidth versus bias on V_2. Fig. 3 is a multiple exposure photograph of the bandpass of the circuit with several values of bias on V_2.



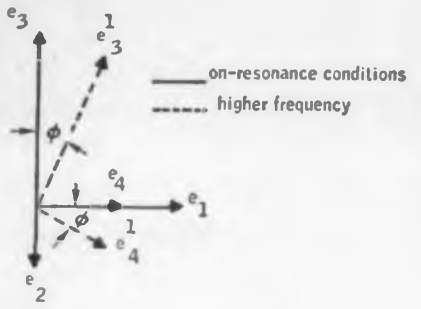


Fig. 1. Schematic of variable bandwidth amplifier. The phase relationships at different points of the circuit are shown in the vector diagram.

Constant Gain Feature

Referring to Fig. 1, we can immediately write the expression for the impedance paralleling Z_1 due to feedback,

$$Z_{fb} = \frac{1}{G_1 G_2 G_{m_2} G_{m_3} Z_2}$$

The parallel impedance of Z_1 and $Z_{fb} = Z_{1p}$

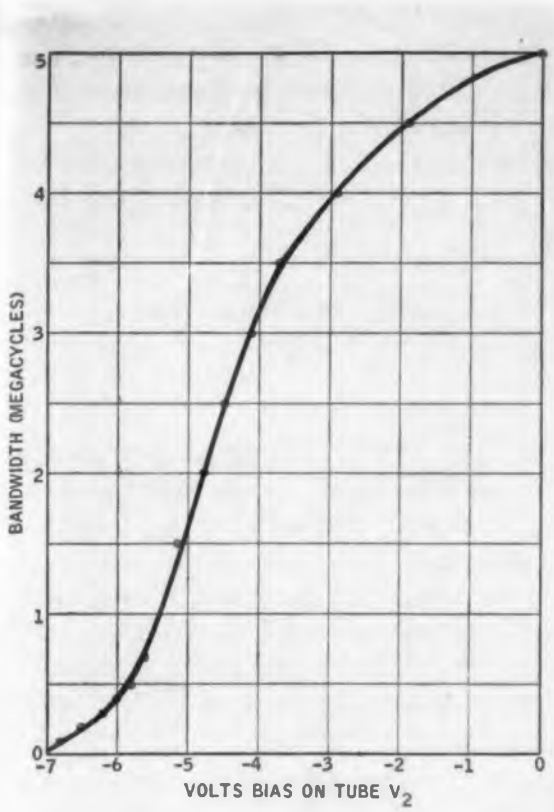


Fig. 2. Bandwidth of i-f amplifier versus bias on tube V_2.

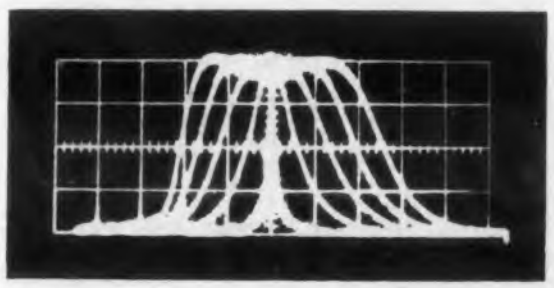


Fig. 3. Oscilloscope pattern of i-f amplifier output, showing wide bandwidth variation with little gain variation.

$$Z_{1p} = \frac{Z_1 Z_{fb}}{Z_1 + Z_{fb}}$$

$$Z_{1p} = \frac{Z_1}{Z_1 G_1 G_2 G_{m_2} G_{m_3} Z_2}$$

The gain through the variable bandwidth portion of the i-f amplifier $\left(\frac{e_3}{e_0}\right)$ can now be written

$$\frac{e_3}{e_0} = G_{VB} = j G_{m_1} Z_{1p} G_1 G_{m_2} Z_2$$

$$= \frac{j G_{m_1} G_1 Z_1 G_{m_2} Z_2}{Z_1 G_1 G_2 G_{m_2} G_{m_3} Z_2 + 1} \qquad (1)$$

If we now assign some values to the terms in-

dicated in eq 1 and assume only on-resonance operation so that Z_1 and Z_2 stay resistive, a curve of gain G_{VB} versus changing transconductance of tube V_2 (G_{m2}) can be plotted.

Assume

$Z_1 = 27$ K

$Z_2 = 3.3$ K

$G_{m_1} = G_{m_3} = 9000$ μmhos

$G_1 = G_2 = 0.2$

G_{m_2} varies from 0 to 9000 μmhos

The computed values of gain at resonance when G_{m2} is varied, Fig. 4, shows that the gain approaches 5 asymptotically as G_{m2} approaches large values.

Another important result is that even with the transconductance reduced to 100 μmhos, the gain through the variable bandwidth circuit has dropped only 3.81 or not quite 3 db. This result is not surprising because what is actually happening is a gain variation within a negative feedback loop.

It is desirable to vary the transconductance of the tube V_2 to take advantage of the constant gain feature. If, however, the choice has been made to vary both G_{m2} and G_{m3} in a similar manner, eq 1 reduces to an analogous equation describing the action of two tuned, coupled circuits with a continuously variable mutual inductance.

Transfer Impedance

To make a comparison between this circuit and a double tuned circuit, the concept of transfer impedance is introduced. Transfer impedance in the latter case is defined as that impedance which, when subjected to the current which flows in the tuned primary, gives a voltage equal to that which appears across the tuned secondary.

The equivalent transfer impedance from Z_1 to Z_2 is gotten from eq 1, by dividing out G_{m1} and substituting impedance forms. Then

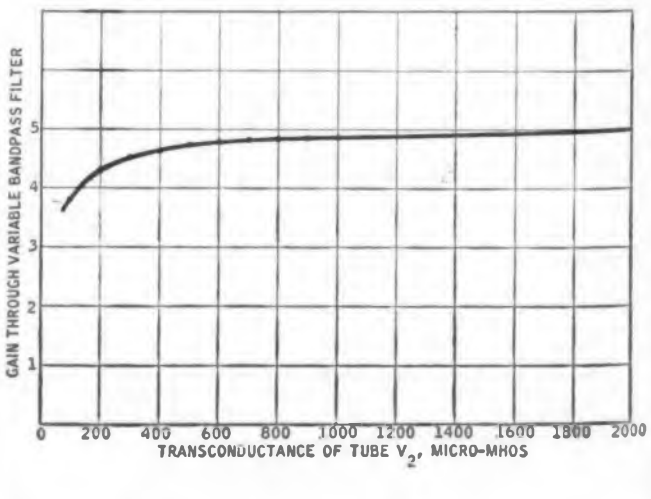


Fig. 4. Computed variation of gain versus bias on tube V_2.

$$Z_{12} = \frac{G_1 G_{m_2} R_1 R_2}{G_1 G_{m_2} G_{m_3} R_1 R_2 + 1 + j\,(Q_1+Q_2)n - (Q_1 Q_2)\, n^2} \qquad (2)$$

The transfer impedance Z_{12} of a double tuned coupled bandpass circuit is[2]

$$Z_{12} = \frac{jS\sqrt{R_1 R_2}}{(1 + S^2) + jv\sqrt{b+2} + (jv)^2} \qquad (3)$$

where

$$S = K\sqrt{Q_1 Q_2} \qquad K = \frac{M}{\sqrt{L_1 L_2}}$$

$$b = \frac{Q_1}{Q_2} + \frac{Q_2}{Q_1}$$

$$v = \sqrt{Q_1 Q_2}\left(\frac{W}{W_o} - \frac{W_o}{W}\right)$$

$$v = \sqrt{Q_1 Q_2}\left(\frac{w}{w_o} - \frac{w_o}{w}\right)$$

For convenience we let $n = \left(\frac{w}{w_o} - \frac{w_o}{w}\right)$.

Therefore,

$$n = \frac{v}{\sqrt{Q_1 Q_2}}$$

and the third term in the denominator of eq. 2 may be written as $jv\,(Q_1 + Q_2)$, which in turn is equal to $jv\sqrt{b+2}$ in eq. 3.

Similarly, by substituting the expression for v in the last term in the denominator of eq 2 we can write it as either $-v^2$ or $+(jv)$.[2]

If we now assume a correspondence of S to $G_{m2}\,G_1$ in eq 2 by restricting G_1 to equal G_2, and G_{m2} to equal G_{m3}, we can rewrite eq 2 in the same way as eq 3. It should be noted that S in eq 3 is the only term containing K, the coefficient of coupling, assumed variable. Similarly the equivalent term, $G\,G_m\sqrt{R_1 R_2}$ is the only one with a variable term, namely G_m. We have therefore shown that by varying transconductances only, the exactly equivalent function to varying the coefficient of coupling between two coils has been performed. As was previously noted, however, the advantage of constant gain with varying bandwidth when only G_{m2} is varied, makes this desirable, as shown in Fig. 3.

References

1. C. B. Aiken, *Vacuum Tube Amplifiers*, p 168, Valley and Wallman.
2. C. B. Aiken, Two-Mesh Tuned Coupled-Circuit Filters, *Proc. IRE*, Feb. 1937.

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Design Curves for Stabilizing Transistors With Thermistors

T. R. Nisbet
Electronic Research Engineer
Lockheed Missile Systems Development
Palo Alto, Calif.

A popular contributor to ELECTRONIC DESIGN, Mr. Nisbet again demonstrates his ability to make life easier for designers with another set of invaluable design curves. Here is a handy means of rapidly selecting thermistor values for transistor temperature stabilization.

TEMPERATURE compensation of transistors can readily be accomplished with thermistors. It is often a problem however, to select the appropriate thermistor values for the desired compensation. Using a series of curves presented here, derivation of thermistor values to counteract the variation in saturation current (I_{co}) of germanium transistors becomes a simple matter. Silicon transistors can be accommodated to some extent in the same design curves. The thermistor curves can also be used for the compensation of many calculated or experimentally determined variations.

Variation of collector current I_{co} with temperature for a transistor (either germanium or silicon) is given by

$$I_{co\,(T_1)} = I_{co\,(T_o)}\, \epsilon^{0.075\,(T_1 - T_o)}$$

Thermistor resistance is expressed by

$$R_{TH\,(T_1)} = R_{TH\,(T_o)}\, \epsilon^{-\beta\left(\frac{1}{T_o} - \frac{1}{T_1}\right)}$$

where temperatures are in deg K and β is a constant of the material, usually valued between 3400 and 4000.

The two exponentials are of different orders, and cannot be directly matched. It can be shown, however, that if the thermistor is placed between the base of the transistor and ground in Fig. 1, a resistance parallel with R_{TH} is required—both comprising R—but no series resistance. Some bleed current (I_{bl}) is assumed.

The family of curves, Fig. 2, 3a and 3b permits a suitable combination of current and resistance ratios to be found so that the base is maintained at constant voltage, V, throughout the required temperature range. The current curves depict the combined current $I_{bl} + I_{co}$ when I_{bl} is a specific multiple of I_{co} at 25 C. The thermistor curves show the combined conductance of the thermistor and shunt when the thermistor at 25 C is a specific multiple of the shunt resistance. The curves are all normalized at different levels (to facilitate comparison) and drawn on logarithmic ordinate scales, with a common temperature scale of abscissae.

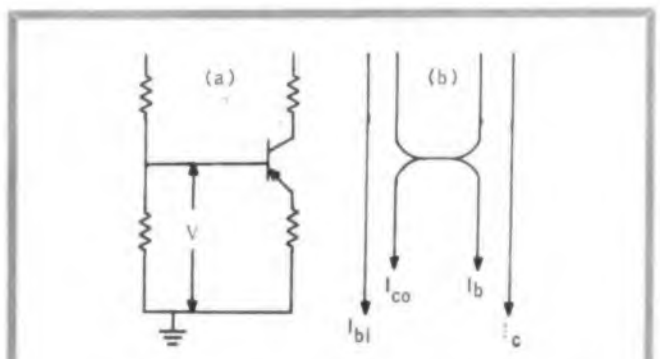


Fig. 1. The thermistor forms part of R. Currents flow as in (b), so that the current in R is $I_{bs} + I_{co}$

Since the logarithm of current minus that of conductance equals that of voltage, the curves can be matched directly against each other. The matching process consists of placing the thermistor curves (or a tracing of the curve of interest) on top of the current curves and moving them up and down, keeping the temperature scales coincident, until a pair is found which match each other over the desired temperature range. From the ratio I_{bl}/I_{co}, the current in the branch can be determined, and from the voltage across the branch (V, Fig. 1) the combined resistance can be calculated. The thermistor ratio R_{TH}/R_S then enables the precise values of thermistor and shunt resistance to be stated.

Example 1. A 2N43 amplifier (Fig. 4) with $I_{co} = 7$ μa at 25 C is to be stabilized from —30 C to +80 C. Comparison of the curves shows a reasonable match occurring between $R_{TH} = 10\ R_S$ and $I_{bl} = 50\ I_{co}$, as shown in Fig. 5. The current I_{bl} plus I_{co} (Fig. 4) at +25 C is therefore 51 x 7 μa. If a voltage of 4 v is to be maintained across the parallel branch of R_{TH} and R_S, a combined resistance of $4/357 \times 10^{-6}$ ohms is required. With $R_{TH} = 10\ R_S$, a shunt of 10.2 k Ω and a thermistor of $\beta = 3450$ K and $R_{TH} = 102$ k Ω at 25 C are obtained.

Before calculation of specific values is actually carried out, several important details can be estimated directly from the curves if desired. By measuring the deviation against the scale on the left of Figs. 2 and 3, the matching, as shown in Fig. 5, is seen to be 10 per cent off at —30 C and +80 C, correct at 32 and 70 C, 3 per cent off at 25 C and 7 percent off at 52 C. The total current $I_{bl} + I_{co}$ has risen at +80 C to 1.6 times its room temperature value, or 560 μa. (It is assumed that the variation of V_{be} is negligible in this example.)

Effect of Mismatch

In the circuit of Fig. 4, it is probable that between base and ground the estimated voltage mismatch of ±10 per cent could be tolerated. The same might not be true, however, if the emitter-to-ground voltage is fixed, since the mismatch could result in almost ±10 per cent of $[I_{bl} + I_{co}]$ variation in I_b. From Fig. 5, this variation can be estimated at ±0.1 x 1.6 x 7 x 51, or ±56 μa change in base current. While the nature of the mismatch is a function of the associated circuitry, its magnitude can be assessed directly from the graphs by measuring the mismatch against the logarithmic vertical scale on the left of both Figs. 2 and 3.

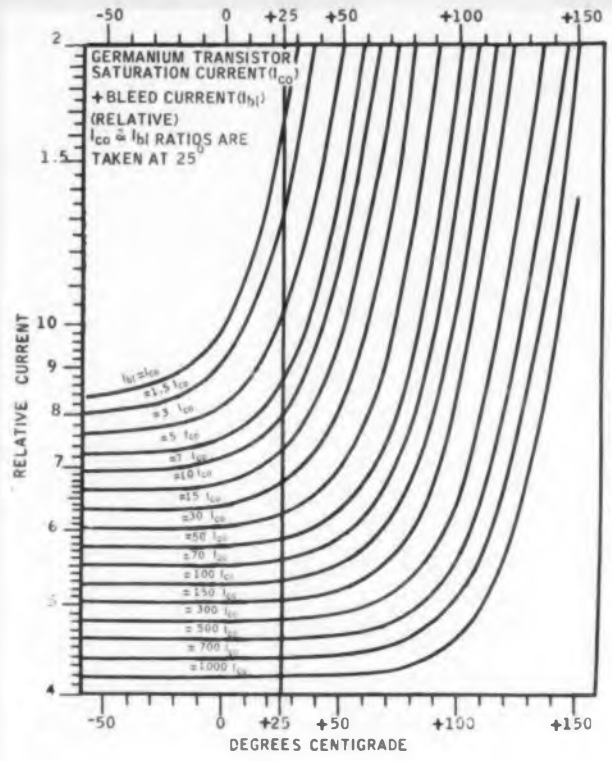


Fig. 2. Current curves which are superimposed on the thermistor curves (Fig. 3) to enable a matching pair to be selected for the required temperature range. Selected ratio of I_{be}/I_{co}, together with V, Fig. 1, give the 25 C value of the current in branch R of Fig. 1.

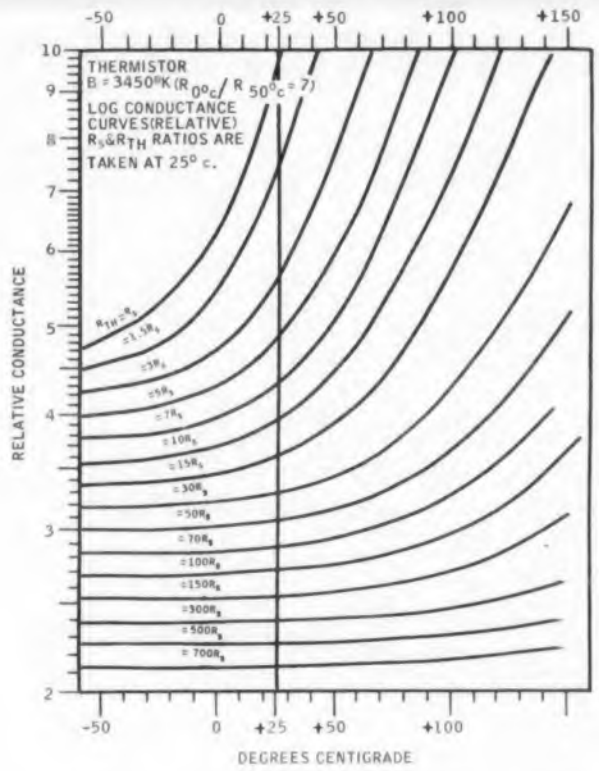


Fig. 3(a) Curves for thermistors of $\beta = 3450$ ($R_o/R_{50\,C} = 7$). The selected curve gives the ratio R_{th}/R_s at 25 C; their parallel value is already known (Fig. 2) and their individual values can therefore be calculated.

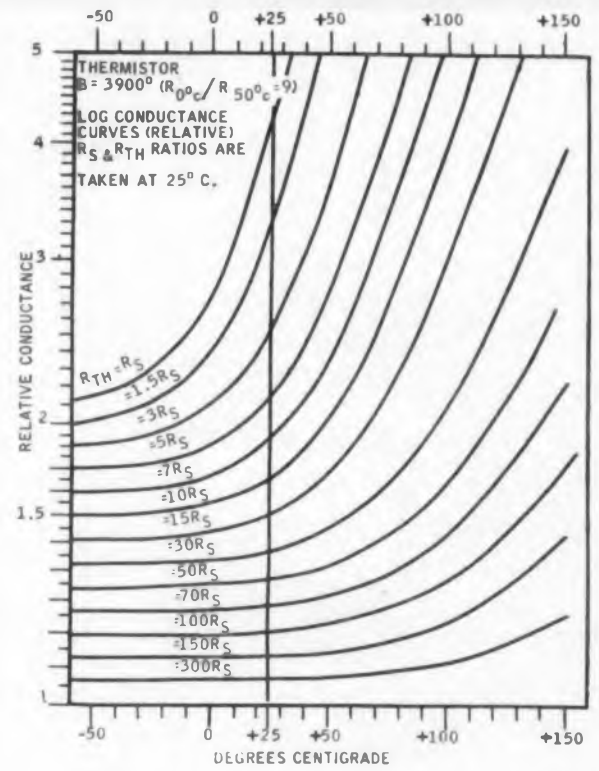


Fig. 3(b) Curves for thermistors of $\beta = 3900$, i.e. whose resistance at +50 C is 9 times the resistance at 0 C.

Production Spread

In the majority of germanium transistors, the production spread of I_{co} is quite broad. In a typical case, the 2N43, I_{co} may equal anywhere from 1 μa to 15 μa at 25 C. Plainly, the best possible temperature compensation in such a case will leave a possible error of almost half the value that I_{co} may reach at the upper limit of temperature. A wide range of thermistor values can be found which give adequate compensation.

If, by selection or through the use of a low collector voltage, the spread of I_{co} can be restricted (in this example, say 3.7 to 7.5 μa at 25 C), thermistor compensation improves.

Eight Rules for Using Graphs

The rules which follow refer to the construction and interpretation of a matching graph such as that for Example 2, Fig. 6 (below).

(1) As a preliminary guide, use the geometric mean of the production spread of I_{co} at 25 C, i.e. the square root of the product of high and low limits.

(2) By tracing or by visual simulation, superimpose the family of thermistor curves upon the current curves, keeping the 25 C verticals coincident, and find a pair which approximately match over the required temperature range. Note the ratios I_{bl}/I_{co} and R_{TH}/R_S. Calculate I_{bl}.

(3) As in Fig. 4, trace the portion of the temperature scale which is of interest, extending it if necessary to the left to include —30 C or the temperature at which both thermistor and current curves become horizontal. Draw the verticals representing 25 C and the upper and lower temperature limits.

(4) Using I_{bl} as calculated in (2), find the ratio of I_{bl}/I_{co} at the upper and lower limits of the production spread of I_{co}. Draw these in the tracing, using an arbitrary horizontal line (AB, Figs. 5 and 6) to represent the common convergence of the two curves. The area between the two curves may be shaded, as in Fig. 6, to represent all possible values of I_{co} over the temperature range.

(5) Decide from circuit considerations to what extent the permissible variation should be taken up as an increase and decrease respectively in I_b, and translate this into terms of the desired point of perfect match at high temperature. In most cases, the geometric mean, half way between the upper and lower limits in the tracing (see Fig. 6), will be used, so that the matching error for a transistor at one limit of the production spread will be the same as that for one at the other limit.

(6) With 25 C verticals coincident, trace the thermistor curve (see (2) above) so that it passes through the point of perfect match at high temperature.

(7) Place the tracing over the log scale of Fig. 2, and, with one point at the scalemark 1, measure in a vertical direction the mismatch ratio at any temperature of interest. The mismatch at cold temperatures will normally be much less than that at high temperatures. Note that a new value of R_{TH}/R_S may be selected, if desired, provided that the mismatch at the cold temperature limit does not exceed that at the high temperature limit.

(8) If desired, use the horizontal line of convergence of the current curves (AB) to represent I_{bl}, and set the logarithmic vertical scale to coincide with it. This gives a current scale, as illustrated in Fig. 6, from which $I_{bl} + I_{co}$ can be read for any desired temperature.

Example 2. The transistor of Example 1 is to be matched over 0 C to +110 C for an I_{co} spread of 3.7 to 7.5 μa. Referring to the rules enumerated above, (1) $\sqrt{3.7 \times 7.5} = 5.3$ μa; (2) $R_{TH} = 50\ R_S$ $I_{bl} = 700\ I_{co}$; (3) $I_{bl} = 3710$ μa; (4) $I_{bl} = 1000\ I_{co}$ and $I_{bl} = 500\ I_{co}$. The curve is constructed as in Fig. 6. Mismatch ratios are measured by placing

the tracing over the log scale on the left. It can be seen that R_{TH} lying between approximately 35 R_S and 65 R_S, the percentage error throughout the temperature range is equal to or less than that at +110 C. (Note: 110 C, though beyond the temperature rating of the 2N43, was used in order to facilitate illustration of this example.) For 4 v base-to-ground, at 25 C, $R_{TH} \,||\, R_S = 4/3.705$ k Ω, and from (2) $R_S = 1080 \times 31/30 = 1117$ Ω. $R_{TH} =$ 32.5 k Ω at 25 C.

Because of the inherent probable mismatch at the upper temperature, the precise ratio of thermistor to shunt resistance in circuits such as Fig. 1 is seldom very critical. However, for matching a transistor of known I_{co}, or for matching to a lower temperature than the 114 C used in Example 2, Fig. 5, the graphical method can supply the appropriate degree of accuracy.

Silicon Transistors

In silicon transistors, I_{co} is generally of a low value, but an additional significant temperature variation takes place in the base-to-emitter voltage. The graphs are not intended for use with silicon transistors, but if the base-to-emitter voltage change is taken into account, the same curves may be used.

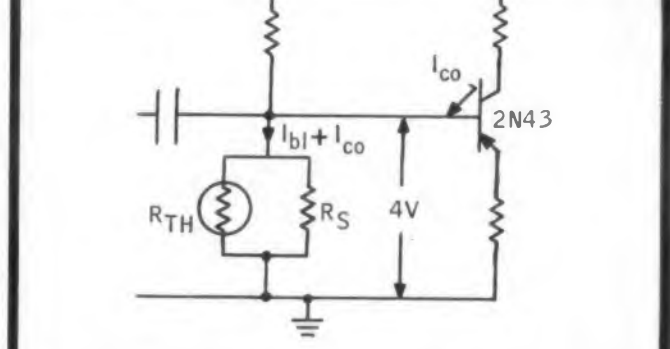


Fig. 4. Typical temperature stabilization problem (see Example 1).

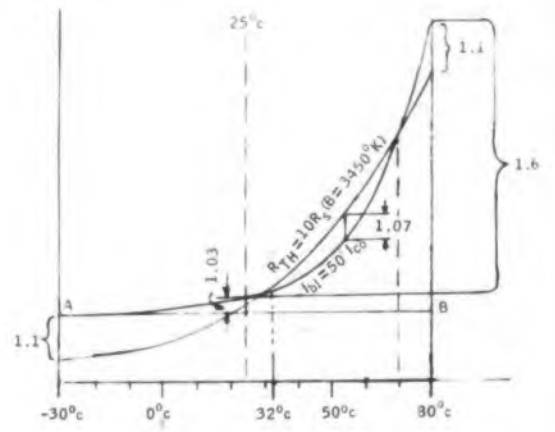


Fig. 5. The selected design curves, superimposed, give a picture of the matching of Example 1. The extent of the mismatch is measured on the vertical log scales of Figs. 2 or 3.

General Use of Thermistor Curves

Calculated or experimentally derived resistance values over a temperature range can frequently be synthesized using the thermistor curves of Fig. 3. In a typical circuit, it was found that, across a 2 k Ω resistor, compensation ranging from α to 10 k Ω was required in parallel, over a temperature range from —20 C to +80 C. The conductance of the combined 2 k Ω and required parallel resistance at 10 C intervals was plotted on the same scales as Fig. 3(a). Sliding the plot vertically across Fig. 3(a), and keeping the temperature scales coincident, gave the nearest suitable ratio of thermistor to shunt resistance.

Experience with these curves indicates that for most transistor work, the use of a resistor in series with the thermistor is not desirable. Its effect would be to flatten the conductance vs. temperature curves at the upper temperature limits. This fact should be kept in mind for any application which may require a modification of this type.

For a free reprint of this article turn to Reader-Service card and circle 389.

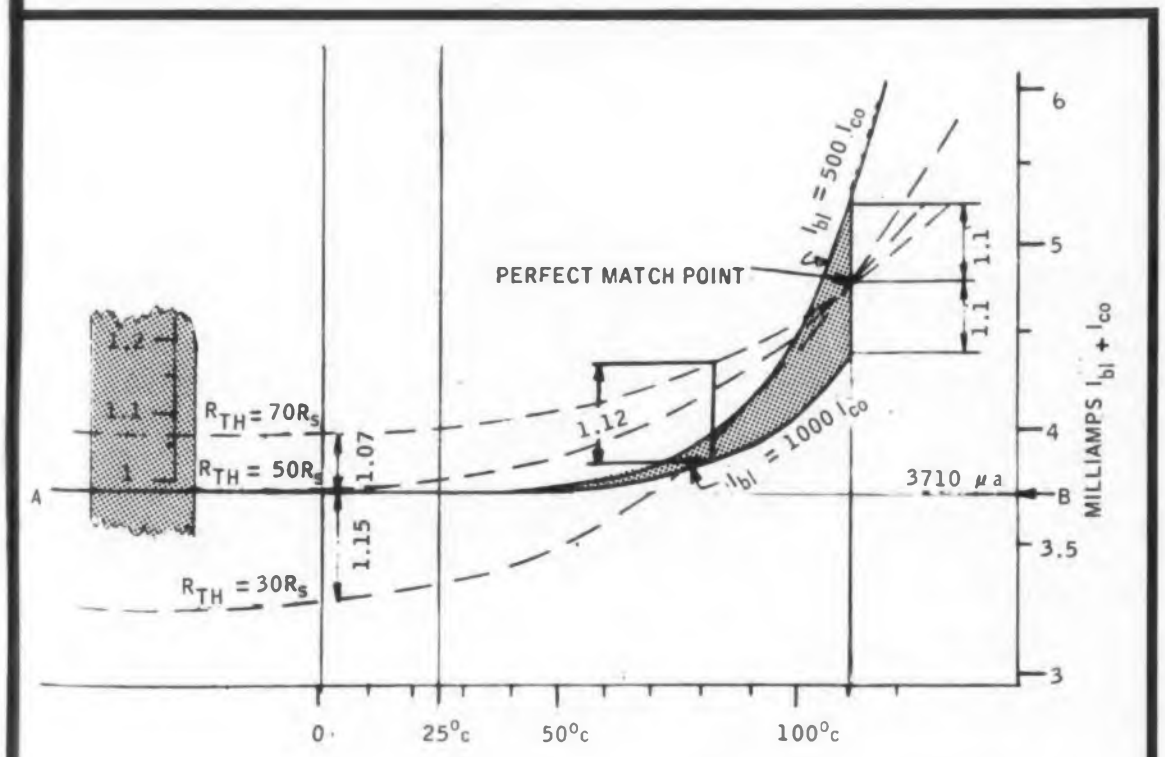


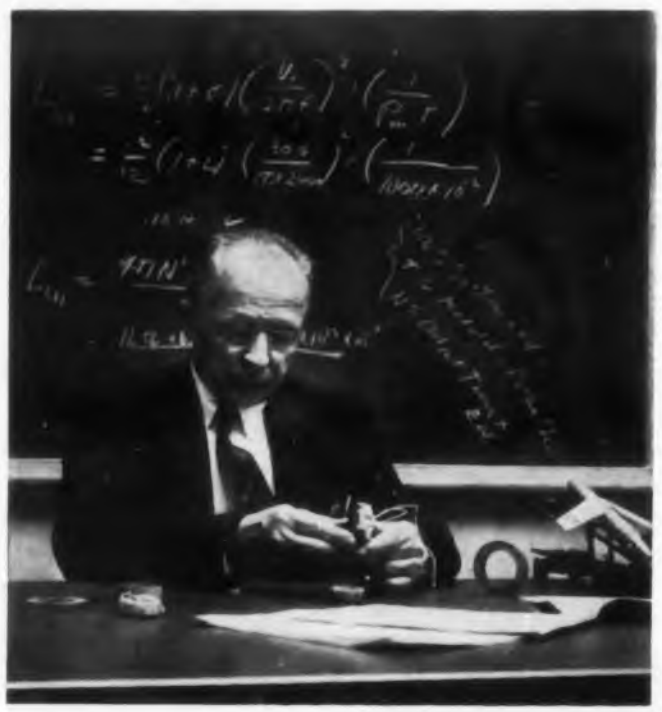
Fig. 6. Two values of I_{co} are used (Example 2) representing upper and lower limits of production spread as the boundaries of the shaded a rea. A point of perfect match is selected to minimize the error at the upper temperature limit. On the left is shown part of the log scale of Fig. 3(b) which was used in assessing the magnitude of the matching error.

How To Use
Pulsactors, Thyractors and Transactors

Harry E. Thomas
Federal Telecommunication Labs
A Division of IT&T
Nutley, N.J.

Pulsactors, thyractors, and transactors are gaining widespread use in pulse magnetics. A pulsactor is another name for a thyractor, which derives its name from "thyratron" and "reactor" for it combines properties of both. The transactor is a transformer, formed by adding another signal carrying winding to a pulsactor.

These devices are efficient and very reliable in pulse generators, multiplex circuits, radar modulators, and computers. They are simple. They are small. They have no moving parts and require no power supply. And they are available to handle milliwatts to megawatts.



Harry Thomas's wide experience seems to have shaped him for his present specialty—the design of magnetic components and allied equipment. His previous experience included design of deflection components and TV studio equipment, and prior to that, receiver circuits.

THE PULSACTOR is a special type of saturable reactor—not quite like conventional ones. It may look like a transformer or toroid winding, and may have a similar schematic symbol, as shown in Fig. 1, but it's different.

In conventional saturable reactors, impedance changes are controlled by dc currents in a separate winding, and are used to vary currents in series connected loads. The pulsactor, on the other hand, provides a triple molded action during each cycle of operation.

How The Pulsactor Works

The pulsactor starts as a variable low frequency reactor. Then it becomes a switch. Finally it becomes a very small inductance in a high frequency resonant circuit.

This three moded type of operation can best be visualized with the equivalent switch diagrams in Fig. 2. Here, the pulsactor's low frequency (unsaturated) inductance is called L_u, its high frequency (saturated) inductance L_s, and its switching from L_u to L_s is pictured by single or double pole switches.

Fig. 2A pictures the pulsactor becoming a two-pole single-throw switch with series inductance in each of the switch blades. In the switch position shown, L_u operates normally as a high inductance. With the switch thrown to the left, the circuit inductance between terminals *1* and *2* becomes L_s, which is much smaller than L_u.

Fig. 2B shows L_s as an inductive switch. With the blades closed, L_u produces negligible shunting across L_s because it is so large a parallel inductance.

Fig. 3 shows the action in a simple pulsactor circuit. Sine waves excite an input resonant circuit consisting of L_o and C_1 to a peak voltage. L_o is a linear charging reactor, followed by pulsactor L_{u1} which, when unsaturated, does not load the input tuned circuit.

At the point of peak voltage across C_1, the pulsactor becomes saturated and discharges the capacitor to produce a steep-sided voltage pulse. If C_2 were replaced with a pure resistance, the voltage waveforms would continue with positive and negative charging and switching excursions as shown in Fig. 3C.

But the switching action shocks a tuned circuit into oscillation. This tuned circuit consists of pulsactor L_{s1} (now in its saturated state) and the equivalent series capacitance of C_1 and C_2 which are connected across it. After switching, the pulsactor becomes a very small inductance. It resonates with C_1 and C_2 at a frequency much higher than the frequency of the input sine wave.

The unsaturated inductance may be 1000 times the saturated inductance, so the ringing frequency may be 30 times the initial sine wave resonant frequency of L_o and C_1.

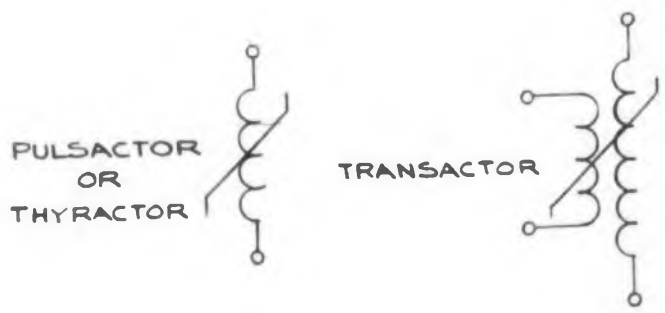


Fig. 1. Schematic symbols for the pulsactor (thyractor) and the transactor.

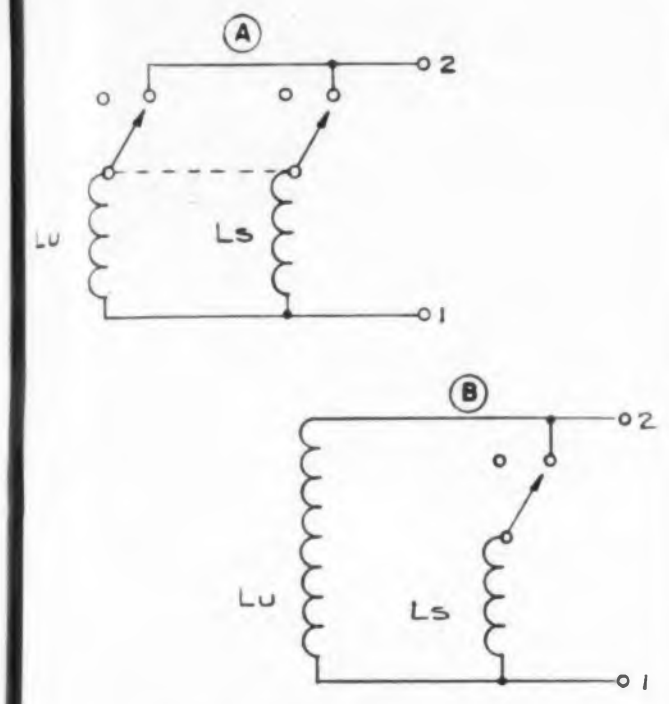


Fig. 2. Pulsactor equivalent circuits. **A**—as a DPST switch; **B**—as an SPST switch.

The circuit would continue to ring as shown in the dotted waveforms in Fig. 3E but its first positive excursion applies a sine wave across L_{u2}. This ringing voltage in turn, actuates a resonant circuit consisting of L_{u2} and C_2.

As the voltage rises across C_2, and L_{u2} becomes saturated, another discharge cycle takes place in cascade with the first, so C_2 is discharged into R by the switching action of the second pulsactor in its unsaturated conditions. The waveforms at Fig. 3E show the increased steepness of this pulse compared with the one after the first stage.

These oscillations (dotted) would continue at a higher frequency than in the first part of the circuit if they were not damped by the load resistance. The output pulse across R_L is shown in Fig. 3F. It occurs later than the input sine wave and the first switching excursion. Since the coils associated with the initial resonance and with the first switching have returned to their unsaturated states, their effect on later circuits and their voltage pulses cannot pass through to the output.

Similar switching cycles can be repeated in successive pulsactor stages, the last of which can be made to deliver high amplitude, very narrow pulses. This compression is accomplished with constant voltage across the charging capacitors C_1 and C_2 and with increasingly narrow and higher amplitude pulses.

This current pulse compression ratio may be as high as 10 to 20 in a single stage. Thus, starting with a 2000 cycle sine wave, one half wave of which is 250 microseconds long, one may develop a 25 μsec excursion after the first switching cycle, a 2.5 μsec pulse after the second, and a .25 μsec pulse at the output.

(Continued on following page)

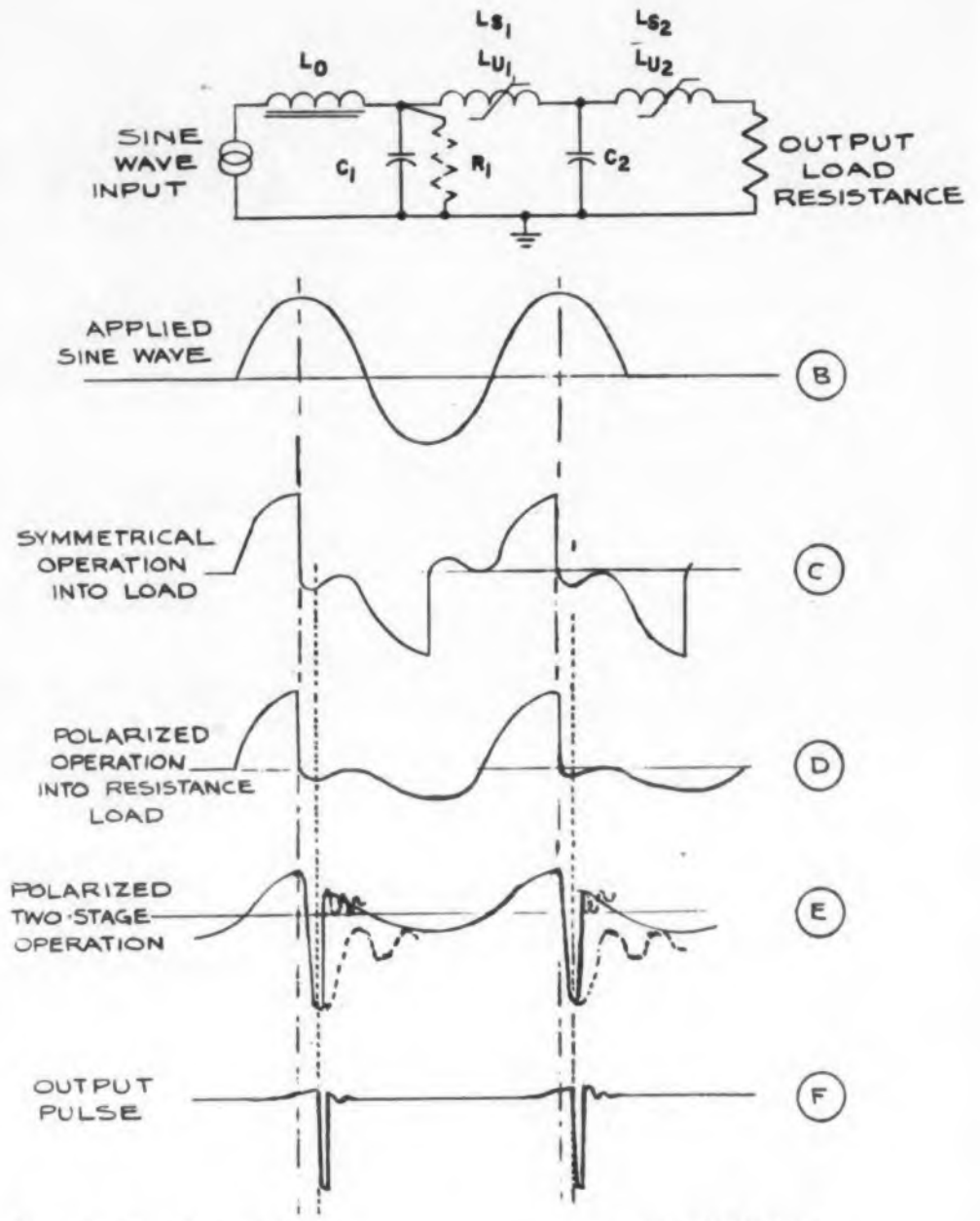


Fig. 3. Simplified pulsactor operation.

Circuit Details

There are many other circuit applications and practical details surrounding the operation. The most important of these use polarizing fields to restrict the switching action in each stage to a single polarity. In Fig. 3 for example, a dc polarizing current can be sent through a separate winding on the main coil of L_{u1}. This would restrict the voltage swings in the negative direction to leave relatively unidirectional output pulses, as shown in Fig. 3D. The circuits can be arranged so switching takes place at the peak of applied voltage swings.

Switching Characteristics

The pulsactor's inductance goes through a tremendous change due to the rapid change in slope of its *B-H* curve. Its permeability (μ) expressed as the slope $\Delta B/\Delta H$ is extremely high compared with that of ordinary transformer iron. This can be seen in Fig. 4.

The transition from unsaturated to saturated conditions is much faster for pulsactor steel (point *C* to *D*) than for ordinary transformer

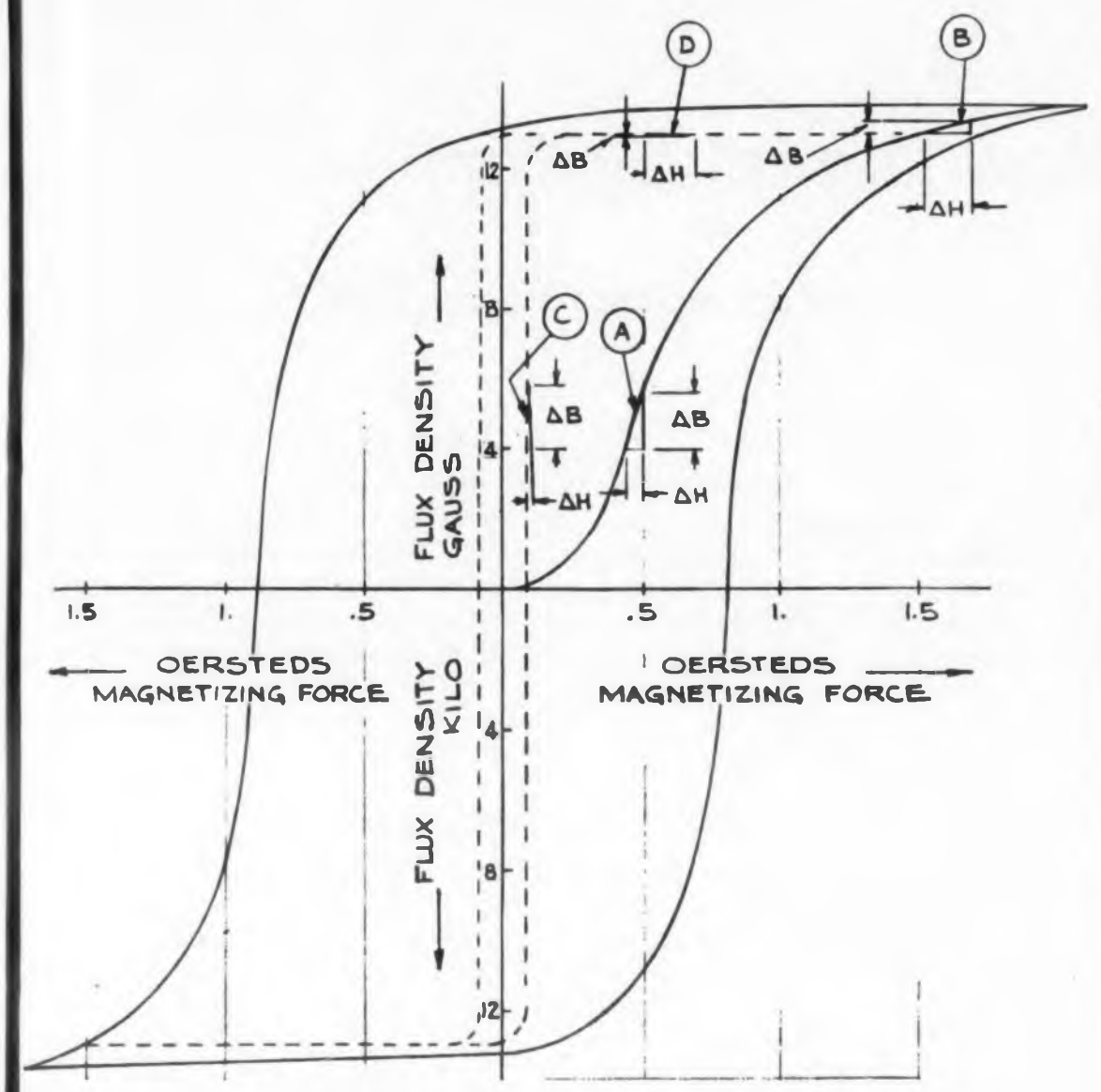


Fig. 4. Magnetization characteristics and permeability of high permeability iron (dotted line) and standard transformer iron (solid).

steel (*A* to *B*). The improvement in switching is obvious.

The ratio of the steepness of the unsaturated part of the dotted curve in a typical high permeability iron compared with its flatness in the saturated region may be as high as 2000:1 compared with 20 or 40 to 1 for ordinary iron.

These high permeabilities make for better pulse performance and lower heating losses. Better pulse performance results from the fact that with high unsaturated inductance, the pulsactor coil may be kept small. At the same time the high frequency range of a coil is extended since it has fewer turns.

The lowered heating losses are a result of the narrow, steep-sided hysteresis curve. The small area of the loop indicates that the core generates less heat in high frequency applications. These losses are further reduced by using very thin laminations and forming the iron into very thin tape wound cores.

Many complex metal treating processes and a vast array of alloys are required to produce these high permeability irons.

New Digital System

solves problems in a "TRICE"

HERE'S THE fastest digital differential equation computer in the world. It solves problems in real time. The basic pulse repetition is 3 mc. Word length is 30 bits. Iteration is 100,000/sec, *regardless of problem length.*

Stable sine waves up to 8000 cps have been generated by this computer, comparing with order-of-magnitude one cps for previous digital devices. In this way TRICE is the first digital computer to operate at analog speeds. And where analog computers may produce an output of 20 cps with one per cent accuracy, the new computer has an 0.1 per cent accuracy at its 8 kc. Reliable, too. As part of the checkout procedure e^{π} was run for two hours at 10^5 iterations per sec—and at the end of that time no error was discernible.

TRICE—the Transistorized Realtime Incremental Computer, Expandable—

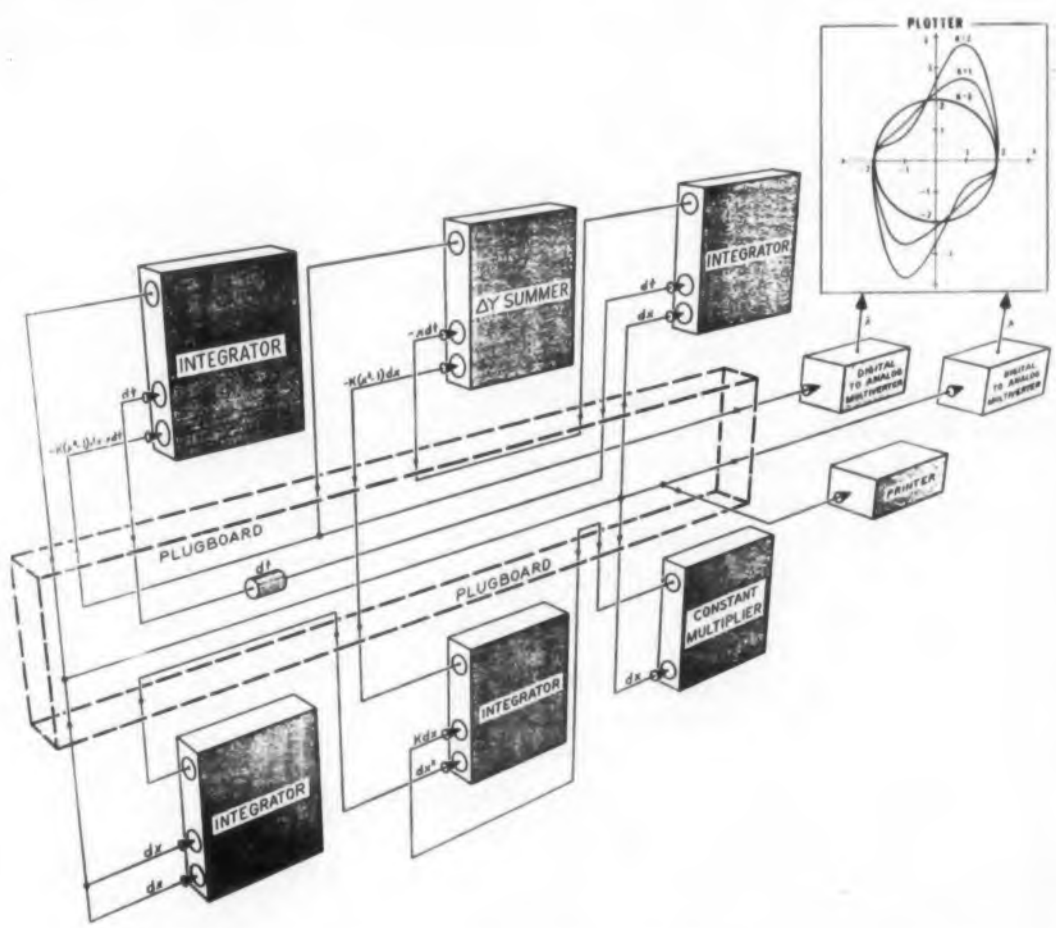


Fig. 1. Interrelation of segments of hardware required to solve Van der Pol's equation. The equation, $x'' + K(x^2 - 1)x' + x = O$, $dx' = -K(x^2 - 1)dx - xdt$, represents a voltage loop in an oscillator circuit. The resistance term is $K(x^2 - 1)$. Energy in the loop is increased when the resistance is negative, decreased when it is positive. Each stable solution will form a loop. The equation has a stable oscillatory solution with the energy gains and losses cancelled for each value of K.

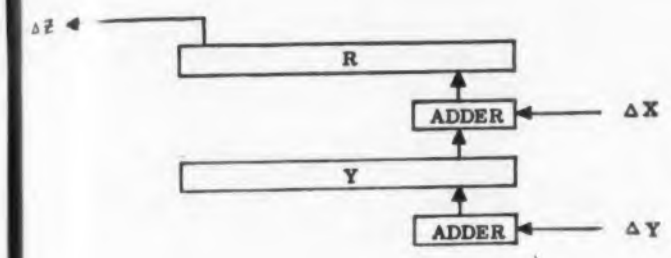


Fig. 2. Simplest form of integrator. Δx and Δy are added to give yΔx; Δz output is result.

manufactured by Packard-Bell Computer Corp., 11766 W. Pico Blvd., Los Angeles 64, Calif., can be used as a design tool or as a special purpose computer for an operational system. For general computation and simulation it will solve problems in aerodynamic stability, missile trajectory studies, control system stability, and the like. Used as a system computer, it will make missile impact predictions, perform coordinate transformation for target acquisition, stable platform calculation, airborne guidance and control.

How It Works

TRICE operates in parallel. This is how its great speed is possible. It is programmed by plugging independent computing elements into a board, like an analog computer. The size of the computer is dependent on the size of the equations to be solved.

An incremental computer, TRICE has as its basic element an integrator, which receives two incremental inputs, Δx and Δy. An incremental output that is an approximation of Ydx is generated. If the increments are summed, the result is a number.

$$Z \approx \int Ydx$$

over the number of Δx's that have been used. Note that the independent variable can be any function, not necessarily *time*, a limitation of analog computers.

A simple form of integrator is shown in Fig. 2. A Δy is added to the first register to change the value of Y. When a Δx pulse comes in, $Y\Delta x$ is added to R, which value becomes ΣYdx.

Instead of accumulating this entire sum, the integral portion becomes a series of incremental outputs—Δz—which can be used as a Δx or Δy input to other integrators.

To generate e^x, Δz is fed right back in, as Δy. If the value in the Y register, e^x, is integrated with respect to X, the result is $e^x dx$, or $d(e^x)$. But of course this represents the increments which yield e^x when summed. So the answer is used as the Δy of the integrator itself, closing the loop. If the Y value is started at some initial condition, the integrator will generate e^x.

Computer Elements

As mentioned above, the TRICE's basic element is an *integrator*. This unit consists of three recirculating 30-bit electrical delay line registers: Y, R and I. The I register stores initial conditions. Three adders are used to add $y + x$, $y + R$ and to make the necessary trapezoidal correction. Output is stored in two flipflops that show the sign and existence of the output. If an overflow occurs, showing that the integrand has exceeded its preassigned full scale value, a light goes on and everything stops.

A *digital servo* generates an output whenever $-1/2 \leq Y < +1/2$. Output sign is determined by the product of the signs of Y and X. It has six input lines and three outputs. An initial condition register is provided.

The *variable multiplier* needs five delay lines for X, Y, R and the two initial conditions; and four adders for summing $X + \Delta x$, $Y + \Delta y$, $X + R$ and $Y + R$.

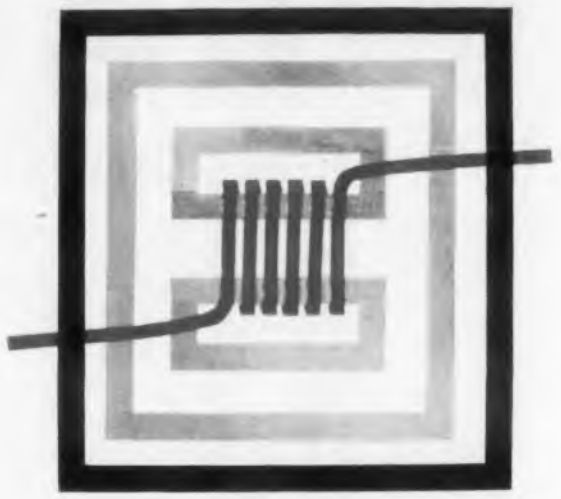
A clock generator with a crystal-controlled 3 mc frequency, a timing counter, control flipflops and an overflow detector are packaged together as the *control unit*. *Constant multipliers* and *Δy summers* are also included as TRICE plug-in units.

The integrator package measures 12-1/4 x 1-3/4 x 20 in. Forty packages and their power supplies will fit in a 6 ft 19 in. relay rack. There are 110 transistors and 400 diodes in each integrator; 10 w are consumed. Thirty bits are stored in each line by a standard delay cable.

Dimensions for the digital servo are the same as for the integrator. However, it uses only seventy-five per cent as many components.

For further information on this digital differential-equation computer, turn to the Reader-Service card and circle **101.**

Making Transformers Smaller with . . .



Fluorochemical Cooling

An ELECTRONIC DESIGN interview with

L. K. Kilham, Jr., Ralph R. Ursch, J. Francis Ahearn

Raytheon Mfg. Co.

Waltham, Mass.

Until now, satisfactory reduction in transformer size could not be achieved because of limitations in conventional cooling liquids. Fluorochemicals, because of their thermal stability and good dielectric properties, have led to considerable reductions in size. Considerations in utilizing fluorochemicals for this purpose are discussed in this article.

How do the fluorochemicals compare with conventional cooling liquids?

Transformer oil, silicone oil, and fluorochemicals have all been proved compatible with materials commonly used in the manufacture of transformers. One of the outstanding characteristics of fluorochemical liquids is their ability to transfer heat from a solid surface. They are approximately twice as efficient as transformer oils in natural convection, (Fig. 1). Also, the heat transfer coefficient of boiling fluorochemicals is about ten times as great as the liquid or twenty times as great as the transformer oils in natural cooling techniques.

Fluorochemicals also have a property of self-healing after arc-over. Other transformer oils do not.

At one atmosphere, conventional oils and the fluorochemical vapors have equal dielectric strength. This means that it is not necessary to completely immerse a transformer coil in a fluorochemical liquid. If the liquid boils, the portion of the unit exposed to the vapor is protected against dielectric breakdown to the same extent as one completely under the liquid.

The plot of temperature gradient versus transformer losses, (Fig. 2), illustrates a comparison of cooling capabilities of various transformer coolants. Silicone oil, for instance, has a very high temperature gradient. For the same losses incurred in a transformer, transformer oil has a lower temperature gradient, and the transformer will operate at a lower temperature.

How do they compare electrically?

Perfluoro compounds compare favorably with the silicone oil and transformer oil.

The dielectric constants, for instance, are about 1.90 for the fluorocoolants. The conventional coolants have a dielectric constant of about 2.5. Power factors at 100 cps range about 0.0025 to 0.016 for perfluoro compounds. Transformer oils have power factors of about 0.012 at the same frequency. Resistivities, in ohms per cm^3, are approximately 6.3×10^{14} for fluorocoolants and conventional oils. Both perfluoro compounds have dielectric strengths of 40 kv. Conventional oils have dielectric strengths of 30 kv.

Would you explain how a coolant is decided?

Fluorochemical dielectric materials range in boiling point from —78 to 177 C. The selected

ABOUT THE AUTHORS:

R. R. Ursch (left) attended Washington University, St. Louis, from 1946 to 1949, where he received his B.S. in Electrical Engineering. Since 1951 he has been with Raytheon at Waltham, Mass., where he has been engaged in engineering design and development of magnetic components.

J. F. Ahearn (center) has a long and productive career as a physical chemist. In 1953 he joined Raytheon as a physical chemist in the design and development of magnetic components. Mr. Ahearn's papers and lectures on heat transfer have won him recognition as an authority in this field.

L. F. Kilham, Jr. (right) graduated from Tufts University in 1939 with a B.S.E.E. Since 1942 he has been employed by Submarine Signal Co. of Boston and by its successor, Raytheon. Mr. Kilham has been Chief Engineer of Magnetic Components since 1949.

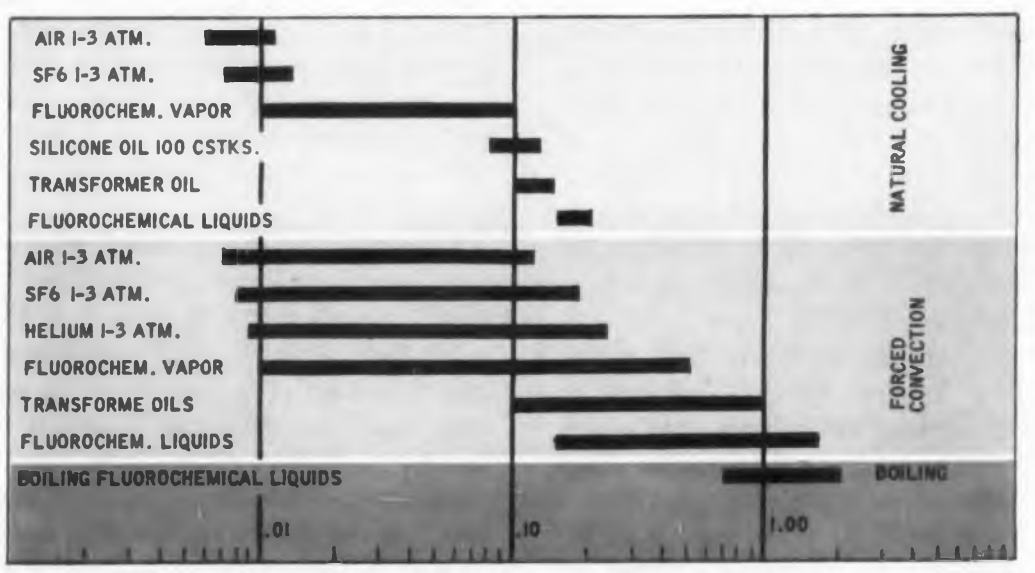


Fig. 1. Heat-transfer coefficient obtainable with various cooling fluids.

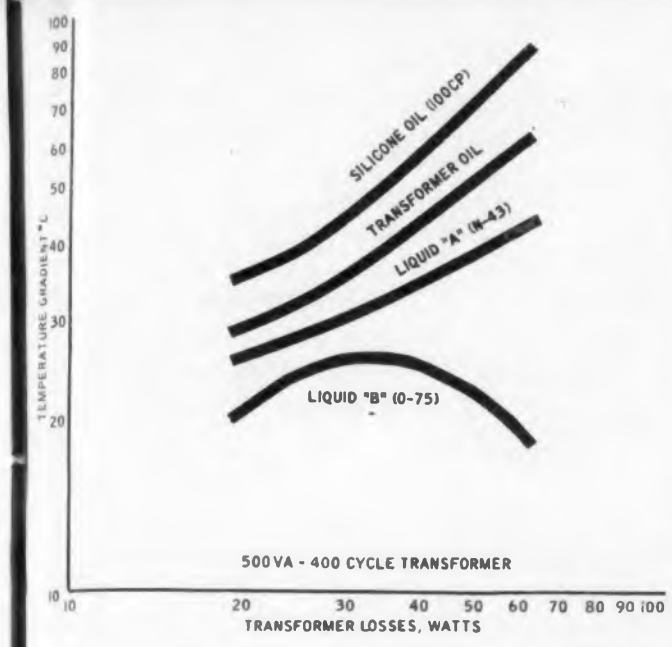


Fig. 2. Comparison of coil-temperature rise above the container temperature with various dielectric liquids.

coolant depends on the requirements of the system. Ordinarily it is necessary to use a combination of low boiling materials and high boiling materials. The low boiling coolant insures protection at low temperatures. The high boiling perfluoro compound is employed for effective heat transfer. Operating ranges from —50 to 200 C have been achieved to meet certain military specifications. Combining a gas and a liquid has the advantage of saving weight while still providing dielectric protection and heat transfer.

Besides liquid and gas combinations there are two other categories of cooling employed which should be mentioned.

- The first method is the use of a complete gas cell. This method is applicable where thermal problems are not encountered and the voltage does not exceed 5 kv.
- Another method is a complete liquid fill. This system can be used where extremely high voltages are involved, 10 kv and up, and where high temperatures are reached.

Are there any special considerations taken in enclosing transformers that contain fluorochemical coolants?

Because of the presence of vapors, it becomes necessary to make the containers as leaktight as possible. The materials, of course, must not react with the coolant. This is no problem, because fluorochemicals are one of nature's most inert compounds. They are compatible with silicone resins, varnishes, and other materials used for insulation.

Since these transformers can operate in the 200 C region, low temperature solder must be avoided. High temperature solder and brazing techniques, which are impervious to gasses, must be utilized throughout the construction.

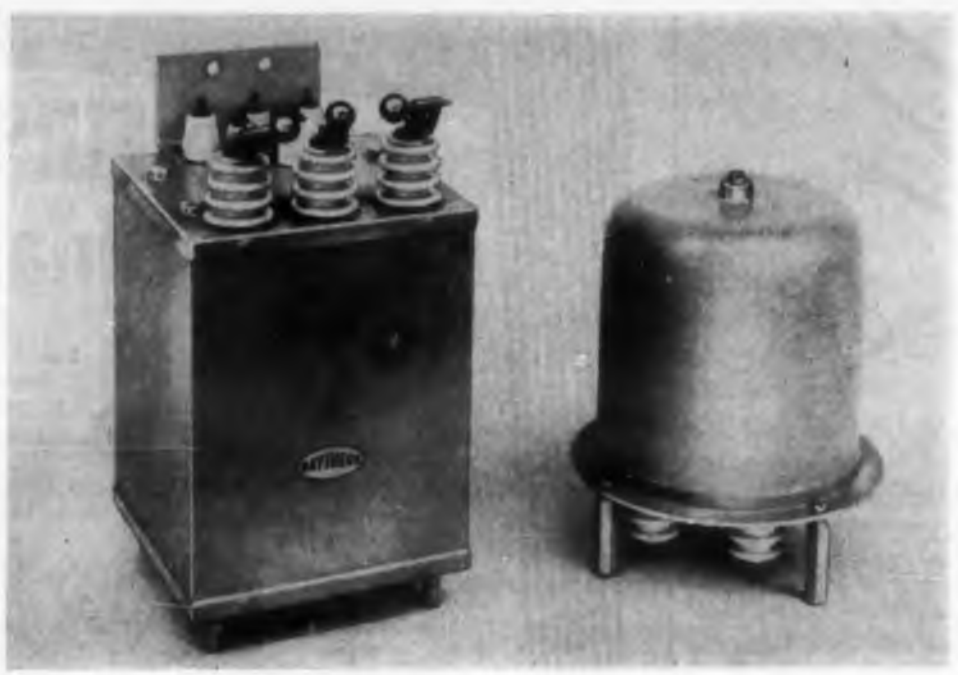


Fig. 3. Standard audio-output transformer (left), reduced by about one-half in size and weight (right).

Are there any limitations in using fluorochemicals for magnetic component or transformer design?

There is one pronounced limitation. This is that generalization must be avoided. To achieve a substantial reduction in size and weight of a transformer, the problems involved must be treated individually and in their entirety. This means each new transformer must have both its dielectric and its mechanical problem solved. The mechanical problem includes heat transfer with such aspects as the heat sink, which is the mechanism to help remove heat. If the heat sink is designed for optimum heat transfer, the magnetic component can be made for maximum miniaturization.

What are the conditions for best heat transfer?

The ultimate in heat transfer and the condition that permits maximum miniaturization is when the vapor, produced by the liquid near the core and the coil, condenses on the heat sinks and the walls of the transformer. The condensed liquid is then returned to the system. This technique is about 100 times as effective as natural circulation.

How do fluorochemical coolants effect reliability?

Utilization of these coolants increases the reliability of transformers in a number of ways.

- They are completely non-flammable so there is no danger of fire upon rupture as with the use of conventional hydrocarbon coolants.
- Fluorochemicals have excellent corona inhibiting properties. Coronas generated with these coolants are considerably less than other high temperature coolants.
- Fluorochemical coolants effectively reduce internal radiance in the components, which reduces the maximum operating temperature. Since equipment life is limited by its operating temperature, a reduction in the temperature increases the life and reliability.

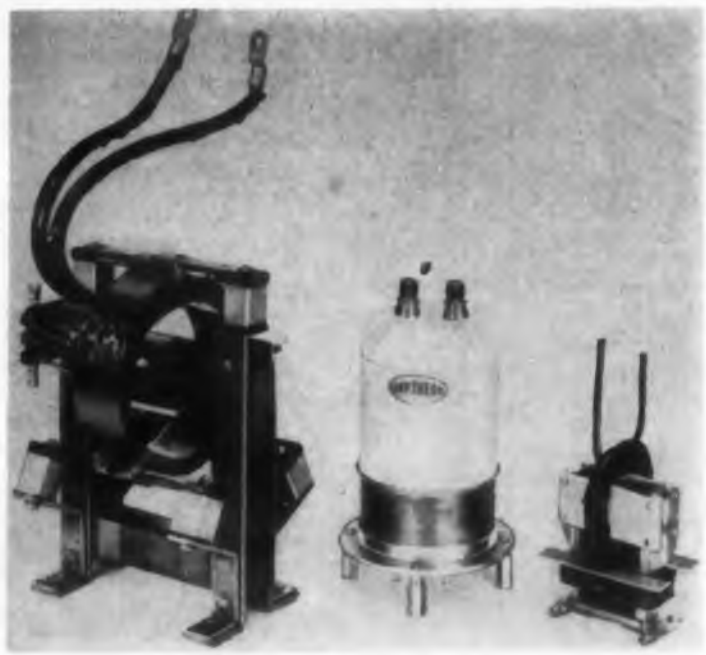


Fig. 4. Construction details show reduction of standard transformer (left) to one-quarter size (right).

▪ The Penetration properties of fluorocoolants also increase reliability. Because of their capillary action properties, the fluorocoolants may rise as much as four or five inches against gravity. This permits wetting of nearly all the voids in the coil and core.

What precautions must be taken in handling these coolants?

Because the cost of these coolants can become ominous, the first precaution is not to use more than a design demands.

Fluorochemicals are very volatile and must be kept in closed containers. The chemicals are non-toxic, non-flammable, inert, and will not absorb moisture; therefore, they present no problems from these standpoints.

Fluorochemicals will be non-corrosive to metals if the system is dry. The equipment should be thoroughly dried before filling and filled preferably under a vacuum.

What is the relative cost of fluorocoolants as compared to conventional oils for cooling transformers?

No generalization can be made on this point. Under certain conditions, the cost of fluorocooling is less than that of a conventional method. For instance, a case where vapors are completely utilized, the cost can be as low as $3.00 per gallon. Silicone oil costs $28.00 per gallon. If on the other hand, the transformer were completely filled with a liquid fluorocoolant, its cost would greatly exceed that of conventional materials.

Would you give some examples where transformers using conventional coolants were miniaturized or improved by the use of fluorocoolants?

One specific example that comes to mind with respect to this was an epoxy unit which operated at relatively high voltage. Because the design was pressed for extreme miniaturization the corona level was high. This contributed to field failures. The problem was: How can a reliable unit be made in the same amount of space? Vaporative cooling fluorochemical techniques were applied. Because of their corona inhibiting properties, the transformer was made more reliable and still maintained its miniature size.

Examples of reduction in size are:

▪ A standard output transformer was reduced to better than one-half in size and from 20-7/8 lb to 15-1/2 lb. This was performed through the use of a combination of heat-conducting copper shields and tabs with a liquid fill of FC43 and FC75, (Fig. 3).

▪ Another transformer was reduced to about one quarter size through the combined low dielectric constant and good dielectric strength of fluorochemical FC43, (Fig. 4).

Variable Speed Tape Drive Works without Capstan

HERE IS A tape mechanism that can search through a reel of tape faster than most computers can digest information. It allows a computer to locate information blocks at any speed, and includes high-speed search at 920 in. per sec (ips). Read and write speeds of 30 to 100 ips are reached in 1/2 to 1-1/2 sec.

But most interesting are the design features of this tape system:

- The transport does not use a constant speed capstan. Two conventional three-phase motors pull the tape in either direction.
- The control system varies the speed by modifying the torque on driving motors after comparing the timing track bit rate with the desired bit rate. By this means, the computer can select an appropriate speed for recording data in real-time over prolonged periods.
- A separate channel of block marks enables the computer to locate information at variable speeds.
- A permanent, constant-density timing track on the tape provides the speed reference for the control circuits. This makes possible fixed position addressing and a variable rate of information transfer.

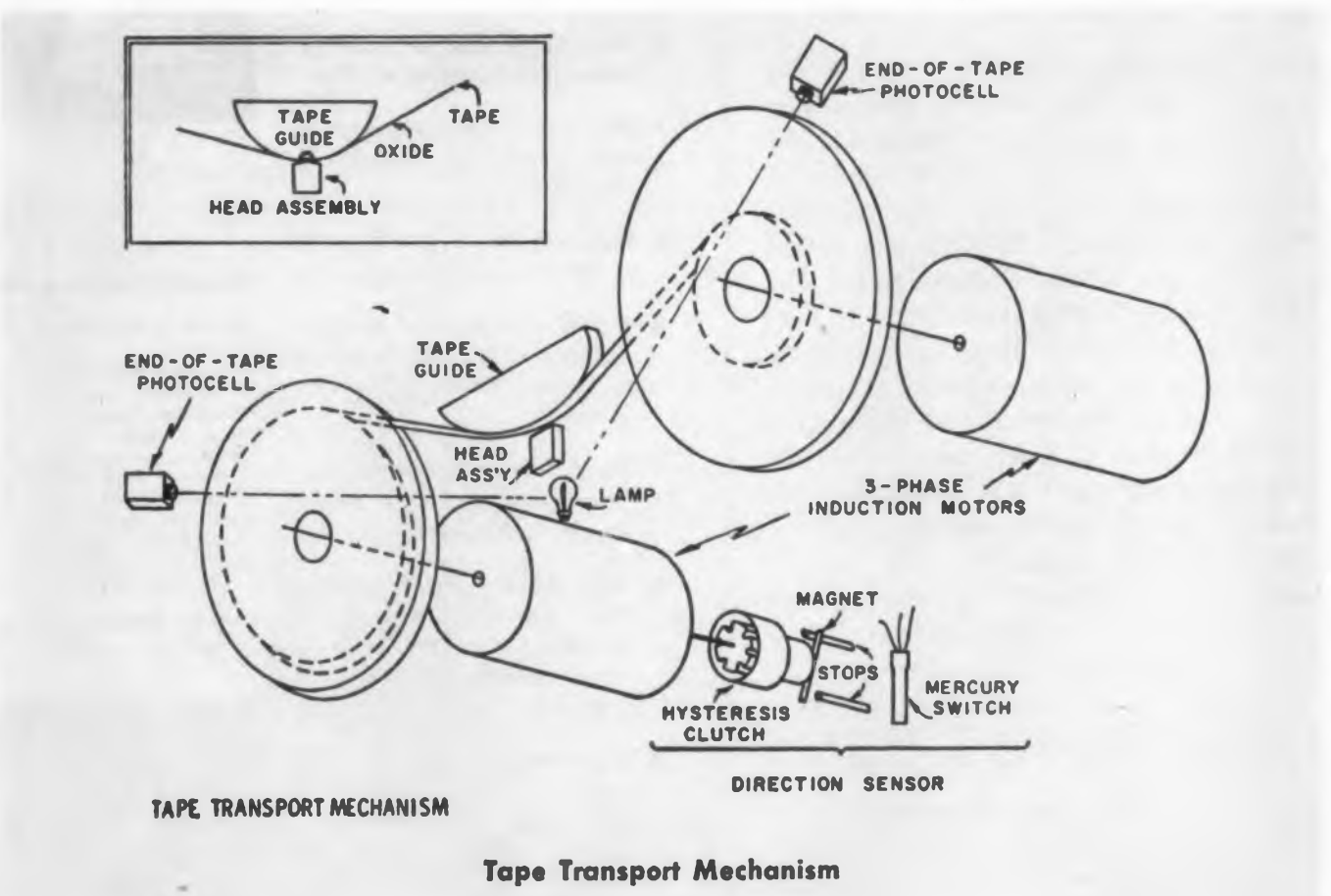
The tape transports were developed at Lincoln Laboratory, MIT, by R. L. Best and T. C. Stockebrand. It was designed for use with the TX-2 computer, which has a core memory of 2.5 million bits.

How It's Designed

The tape transports used in this system are as simple and fool-proof as possible. They consist of a read-write head assembly, two reels, two drive motors, and a tape guide. The drive mechanism has no capstan. A good deal of mechanical complexity is therefore eliminated, which makes possible a wide range of tape speeds. Fast starts and stops are precluded, however: 1/2 sec and 7-1/2 in. of tape are required to reach 30 ips.

The figure shows the transport mechanism. The motors are flange mounted. Typical three-phase induction motors, they are rated at 1800 rpm, 1/8 hp, and have roughly constant torque characteristics when operating well below synchronous speed. The hp rating, and therefore the torque, is as high as possible, limited by the tensile strength of the tape. These motors, each driven by a magnetic amplifier, provide the proper torque to operate 10 in. reels mounted directly on the motor shaft. The reels are loaded with polyester tape, 0.001 in. thick and 0.5 in. wide.

The head assembly and guide are shown in the insert of the figure. The large, constant



Tape Transport Mechanism

radius of the guide reduces the pressure between tape and guide. At speeds above 20 ips the tape floats on an air cushion and is easy to edge guide. Skew, caused by non-uniform tape tension across the width of the tape and by variations in tape width, is minimized. There is no wrap around the head. Variations in tape tension (which are large in this transport) do not, therefore, cause excessive pressures on the head and wear is reduced. Because only short wave lengths (0.0025 and 0.005 in.) are used in the system, the area of tape-head contact need not be large.

The direction in which the transport is moving is determined by a sensing device mounted on the rear shaft extension of one motor. The sensor consists of an iron cup dragged against one of a pair of stops by hysteresis from a star shaped permanent magnet on the motor shaft. The cup operates a mercury switch by rotating an attached magnet. This scheme gives positive direction information even at the slowest tape speed. A mercury wetted contact switch provides computer-level signals to the control without contact bounce and with good reliability.

How Tape Speed Is Controlled

Each motor can generate torque in only one direction to pull the tape from one reel to the other. The control of the motors is therefore simpler than if torque had to be reversed. Since tension is limited by tape strength, acceleration is relatively slow. A sudden change of torque, which might allow a loop to form, is prevented by a long time constant in the control windings of the motor magnetic amplifier.

To stop the tape, full torque is first applied by the trailing motor until the tape speed falls below 20 ips. At that point dc applied to the trailing motor, brings the tape to a smooth stop. The direction sensor indicates which motor is trailing. With dc in the motor field winding the rotor will resist applied torque even at zero velocity due to the hysteresis in the rotor. Voltage is never completely removed from either motor. Some tape tension is always maintained. The end of the tape is sensed by a photoelectric call which receives light through transparent leaders at each end of the tape. The timing track is continued on the edges of the 100-ft transparent strips. This lets the control element know when the tape has fallen below 20 ips.

Feedback is included to provide close control of minimum torque. Too much minimum torque fails to overcome static friction, and doesn't allow a loop of tape to form. The feedback prevents large variations in the output current of the magnetic amplifier which would be caused by unbalanced line voltage or small variations in reactor control current. This is especially true when the amplifiers are cut off.

Messrs. Carl (left) and O'Connor. G. R. Carl, a graduate of Bradley University has been with GE for 8 years; 5 as a transformer designer and the last 3 as a sales engineer. Mr. O'Connor has been designing pulse, audio and power transformers for GE these last 7 years. He graduated Case Institute of Technology in '49 with a BSEE.

Airborne Electronic Transformers

G. R. Carl

R. A. O'Connor

General Electric Co.
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Aside from the usual parameters associated with general transformer design—frequency range, regulation, duty cycle, capacity, etc.—two additional considerations are necessary when designing transformers for airborne applications. The authors offer a terse and lucid definition of these additional parameters which should prove helpful in the design of highly reliable airborne transformers with higher operating temperature and life ratings.

TWO DESIGN parameters, not normally associated with ground based applications, must be considered when determining the size and weight of encapsulated transformers for airborne applications. These parameters are:

- Life expectancy rating
- Maximum altitude rating.

By clearly defining these ratings, the circuit designer can obtain a transformer having the proper balance between reliability and minimum size and weight.

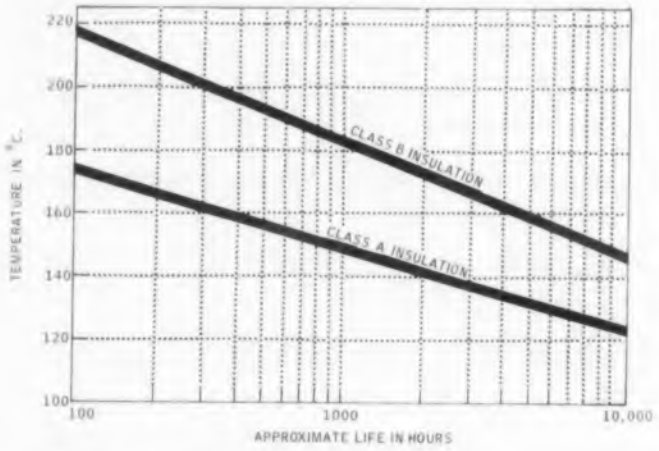

Fig. 1. Logarithmic plot of operating temperature and life of insulation system.

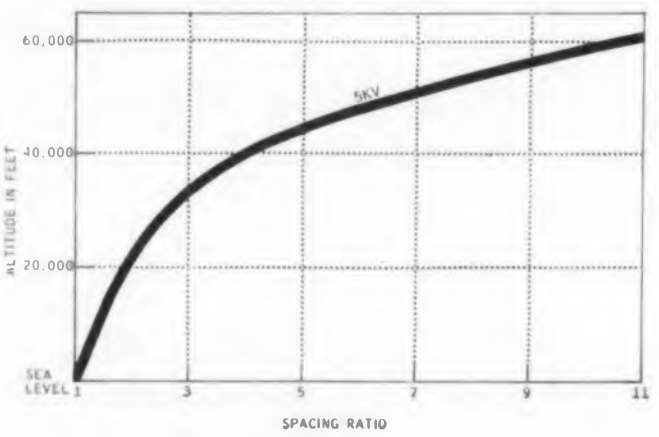

Fig. 3. Altitude plotted against spacing ratio.

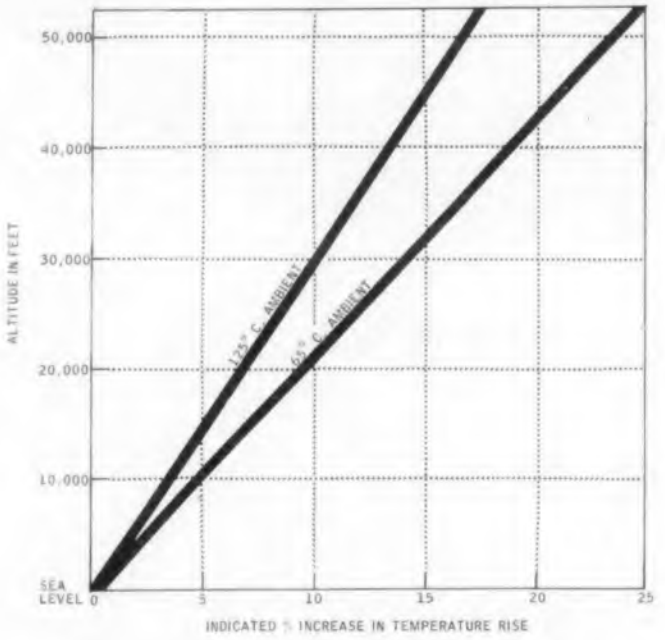

Fig. 2. Altitude plotted against per cent increase in temperature rise for two different ambients.

Life Expectancy

Recognition of life ratings has proved extremely beneficial in reducing size and weight of airborne transformers. Manufacturers are able to take advantage of the fact that the logarithm of life of an insulation system is approximately an inverse function of the operating temperature of the system (Fig. 1).

Thus, depending on the minimum life required, a single transformer insulation system may be qualified at various operating temperatures. Actual savings depend on both the maxi-

mum ambient temperature and the allowable ultimate temperature. Since military specifications call out two classes of transformers having 105 C and 30 C maximum ultimate temperature, a transformer rated for a 95 C maximum ambient has much more to gain by having its ultimate operating temperature increased from 105 C to 130 C (250 per cent increase in allowable temperature rise) than a similar unit rated for a 65 C maximum ambient (62 per cent increase in allowable temperature rise).

No exact relationship has been established for encapsulated transformer size reduction resulting from various percentage increases in allowable temperature rise. However, it is estimated that doubling the temperature rise will reduce the size by approximately one-third.

Maximum Altitude

While short life expectancy ratings tend to decrease the size and weight of airborne transformers, maximum altitude ratings have an opposite effect. As altitude is increased the radiation and convection coefficients for heat transfer from the transformer to the ambient air are adversely affected. A transformer designed for a specified temperature rise at sea level conditions will have a higher temperature rise when operated at increased altitudes (Fig. 2).

Transformer life could be downgraded from any prolonged period of operation at the combined conditions of maximum altitude and maximum ambient temperature. In most instances such a condition will not exist since ambient temperature tends to decrease with increased altitude. The circuit designed should determine and specify the maximum ambient temperature that exists at maximum altitude. Transformer designers can then design optimum transformers based on realistic conditions rather than provide safety factors to insure reliable operation at conditions which may never exist.

Altitude will also affect dielectric breakdown. As air density decreases, its dielectric strength also decreases. Transformers must be designed to provide sufficient spacing between terminals and between terminals and ground to prevent arc-overs or flash-overs under the conditions of maximum altitude and maximum working voltage.

The designed spacing must allow for a reasonable decrease in spacing resulting from the equipment manufacturer's lead connections. An indication of required increases in spacing due to altitude is shown in Fig. 3. At times the combination of working voltage and altitude requirements becomes the limiting feature of a transformer design. In these cases the required spacing rather than the volt-ampere rating determines the size of the unit.

Power Dissipation In Class B Circuitry

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In a discussion of complementary symmetry audio amplifiers (*ED*, Aug. 6), the author showed how this principle can be applied to the design of a Class B system. This article analyzes in greater detail transistor dissipation in Class B operation.

WHEN A power amplifier is designed or tested, the most severe operating condition for the output stage is often considered to be "full drive." Under some abnormal conditions this assumption is true. With regard to dissipation, however, the assumption is erroneous.

The fallacy is obvious for a class A output stage because the output subtracts from the fixed power supplied, thereby reducing dissipation as the power output increases. For class B operation, however, the actual condition is not nearly so obvious.

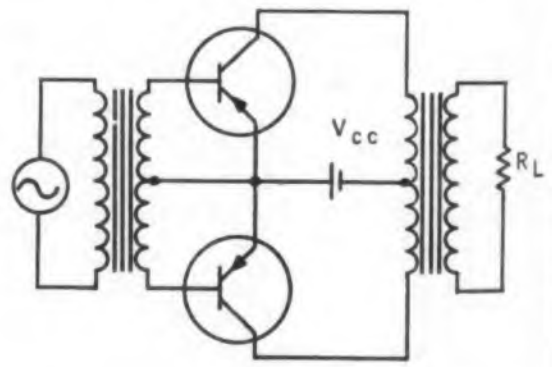

Fig. 1. In this basic circuit, assume ideal transformers and linear transistors.

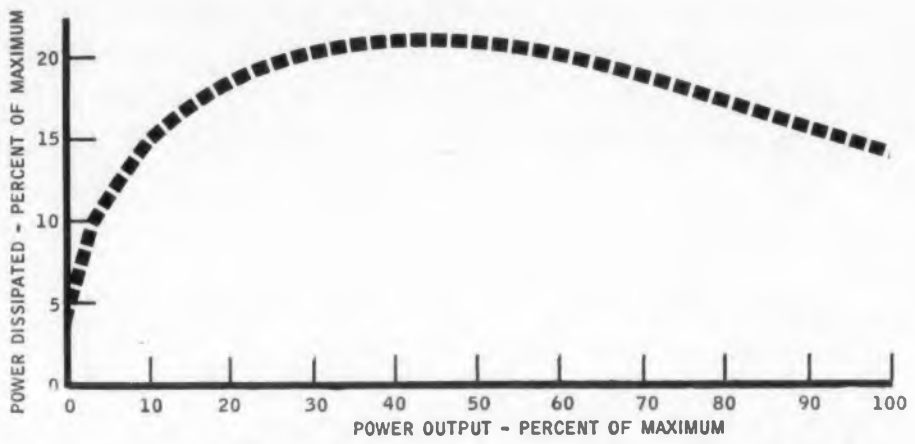

Fig. 2. How dissipation for each transistor varies with power output.

This article shows that the dissipation in a class B stage operating at 10 per cent of rated power output is greater than that at full power output (sine-wave excitation). The maximum dissipation occurs at approximately 40 per cent of rated power output.

For purposes of discussion, transistors are referred to as the output devices. However, the analysis applies equally well to electron tubes. In practice, transistors approach the assumption of zero saturation voltage more closely than electron tubes (relatively speaking) and, therefore, will agree more closely with the theory.

In the circuit of Fig. 1, it is assumed that the quiescent current of the transistors is zero and that the saturation voltage of the transistors is zero. Ideal transformers are also assumed, as well as linear transistors.

The collector voltage on a given transistor is given by:

$$v_c = V_{cc}\,(1 - A \sin \omega t) \qquad (1)$$

The collector current is given by:

$$i_c = \frac{V_{cc}\,A}{R_L} \sin \omega t \text{ from } 0 \text{ to } \pi \qquad (2)$$

$$i_c = 0 \text{ from } \pi \text{ to } 2\,\pi \qquad (3)$$

Dissipation for each transistor, therefore, is:

$$P_c = \frac{1}{2\,\pi} \int_0^{\pi} (V_{cc})\,(1 - a \sin \omega t)$$

$$\frac{(V_{cc}\,A)}{R_L} (\sin \omega t)\, d\omega t \qquad (4)$$

$$= \frac{V_{cc}^2\,A}{\pi R_L} \left[1 - \frac{A\,\pi}{4}\right] \qquad (5)$$

The max dissipation can be determined as a function of A from the following relation:

$$\frac{dP_c}{dA} = \frac{V_{cc}^2}{\pi R_L} - \frac{V_{cc}^2\,A}{2\,R_L} = 0 \qquad (6)$$

Max dissipation occurs when:

$$A = \frac{2}{\pi} = 0.636 \qquad (7)$$

The max dissipation, therefore, is given by:

$$Pc_{max} = \frac{V_{cc}^2}{\pi^2\,R_L} \qquad (8)$$

which may be normalized with respect to the theoretical max power output:

$$\left(P_0 = \frac{V_{cc}^2}{2\,R_L}\right), \text{ as follows:} \qquad (9)$$

$$P_{c_{max}} = \frac{2P_0}{\pi_2} = 0.203\,P_0 \cong \frac{P_0}{5} \qquad (10)$$

The dissipation of a transistor as a function of power output is shown in Fig. 2. The power-output scale is plotted in per cent of

$$\frac{V_{cc}^2}{2\,R_L}.$$

When a quiescent current flows, it may be shown that the max collector dissipation is given by:

$$P_{c_{max}} \leq \frac{2P_0}{\pi^2} + V_{cc}\,I_0 \qquad (11)$$

The efficiency of the output pair may be determined to equal:

$$\eta = \frac{\pi\,A}{4} \qquad (12)$$

BACKGROUND FOR DESIGNERS

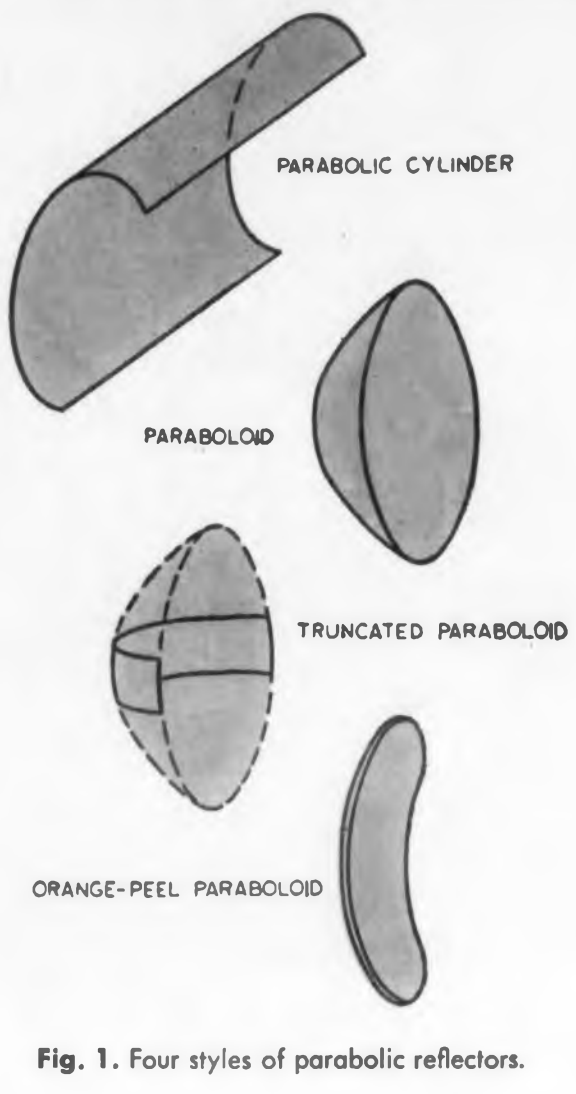

Fig. 1. Four styles of parabolic reflectors.

All energy emitted from a point source at the focus of a parabola will be reflected from the surface in rays parallel to the axis of the parabola. This characteristic makes the parabolic reflector especially useful in long-range high-frequency communication. Some basic design considerations necessary to achieve this result are presented in this article.

Elements of design of . . .

Parabolic Reflectors

Arthur S. Kramer
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ABOUT THE AUTHOR:

Art Kramer is the Engineering Analyst of the Research Administration Department at Du Mont. He is primarily responsible for the coordination of the estimating and pricing of all the R & D proposals which require this service. Art received his BS in EE from Brooklyn Polytechnic Institute and has been with Press Wireless Co., Crosby Laboratories, Curtiss-Wright and Air Associates. While at Du Mont he has specialized in the design of horn antennas and parabolic reflectors. He also assisted in the Forward Scatter project and was responsible for various measurement aspects of this system.

PROPERLY focused and energized parabolic reflectors are equivalent to a very large number of dipoles, all polarized in the same plane and energized in phase. Fink[1] refers to this effect as "current sheet of in-phase dipoles." And this effect gives the reflector its highly directional properties.

To assure good performance, these factors must be considered in design:

- Type
- Feed Methods
- Illumination
- Gain
- Radiation Pattern
- Mechanical Adjustments
- Reflector Material
- Manufacturing Tolerances

Types of Parabolic Reflectors

Parabolic reflectors come in several forms. Most common are the circular parabola, the orange peel parabola, the parabolic cylinder and the square or truncated parabola (Fig. 1). Characteristics of these various forms of paraboloid are discussed by Reintjes and Coate.[2] Most attention will be given here to the circular paraboloid or "parabola of revolution."

Methods of Feeding

Feed methods for parabolic reflectors can be divided into two general classes: (1) rear feeds, and (2) front feeds. Of the various rear feeds, the half-wave dipole and the "Cutler"[3] ring-focus feed are the most commonly used. Front feeds are usually accomplished by using some form of electromagnetic horn. These horns are usually either rectangular or of the square "diplexer" type in shape. The aperture of regular front feed horns is so dimensioned that a certain "taper" of illumination across the face of the parabolic reflector is achieved. Magnitude of this "taper" has an important effect on the radiation pattern of the dish.

Illumination

Besides a smoothly tapered illumination, several other illuminations are of interest, even though some of them are unobtainable. Uniform illumination, of course, gives not only maximum gain and minimum main-lobe beam width, but also maximum side-lobes. Reintjes and Coate[2] have calculated curves showing beam width and side-lobe suppression for several illuminations. Another interesting method[4] is called "Illumination in Accordance with Binomial Coefficients." No side-lobes whatsoever occur.

Most authorities agree that an illumination which is smoothly tapered from the center of the parabola to its rim, and which has an amplitude at the rim 10 to 15 db below that at the center will give a good compromise between gain, beam width, and side-lobe suppression. If a condition of "phase incoherence," (when the various components are not in phase across the dish diameter) exists in the illumination, changes will take place in major and minor lobes of the pattern.

Gain

Getting the maximum gain from any reflector is extremely important. Fig. 2 shows a power level chart for a typical tropospheric scatter propagation circuit.

A number of formulas and nomograms for quickly calculating the gain of a parabolic dish are given in the literature. Although they differ in details, it is clear that the area of the aperture is the governing factor for gain.

Gerks,[5] RCA,[6] and "Reference Data for Radio Engineers,[7] all give equations for gain, the results of which differ only slightly.

The easiest method of measuring the gain of a parabolic dish in the field is by comparing its performance over a short unobstructed path with that of a "gain-standard" or reference horn, the gain of which has been carefully measured under ideal laboratory conditions.

Radiation Pattern

Two of the most important aspects of the radiation pattern of a parabolic dish are the 3 db (half-power) beam width and the side-lobe suppression. These two quantities jointly determine the width of the beam in the tropospheric medium, and the maximum bandwidth. Generally, the greater the beamwidth the greater the multipath effect, and the greater the multipath the more restricted is the bandwidth of the microwave circuit. For these reasons, every effort should be made to get narrow beam widths and high values of side-lobe suppression.

Richmond[8] has done some work on the techniques of calculating patterns of horn antennas, which function in a manner similar to that of a parabola, both being aperture type antennas. He indicates that far-field patterns can be calculated through the main lobe in less than one hour on a desk calculating machine. It is safe to say that calculating the full pattern would be a very laborious job. It can be done, however, if an electronic computer and the services of a trained mathematician are available.

Mechanical Adjustments

Several adjustments are available to the engineer so that a good compromise may be obtained

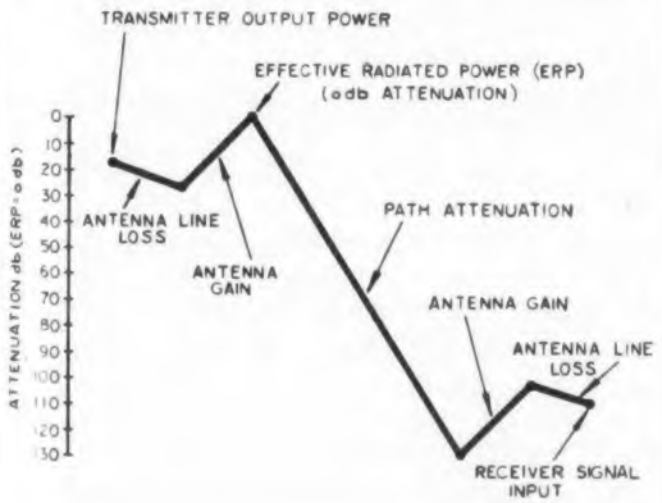
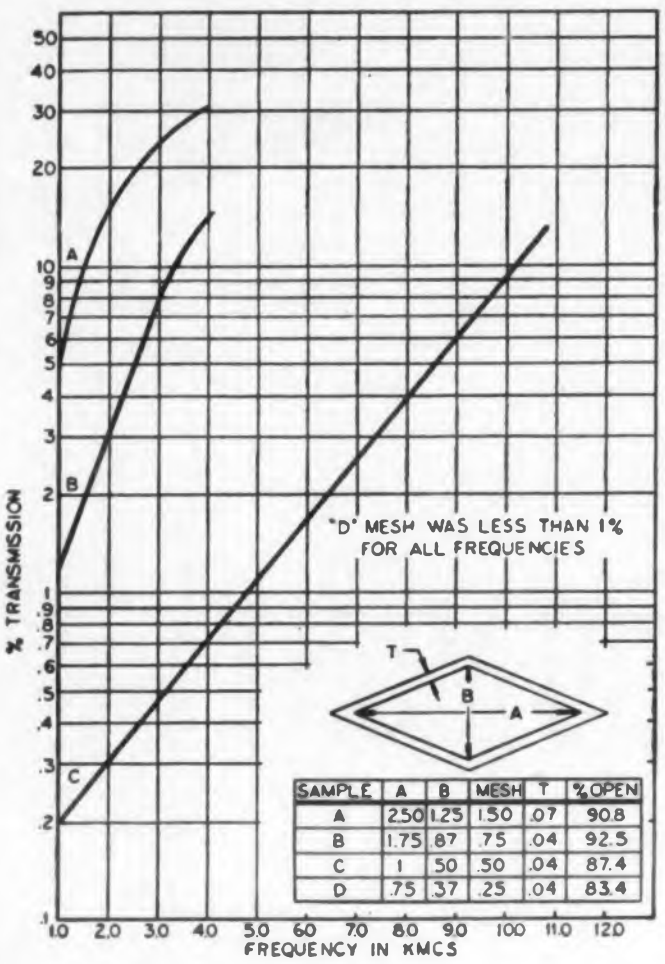
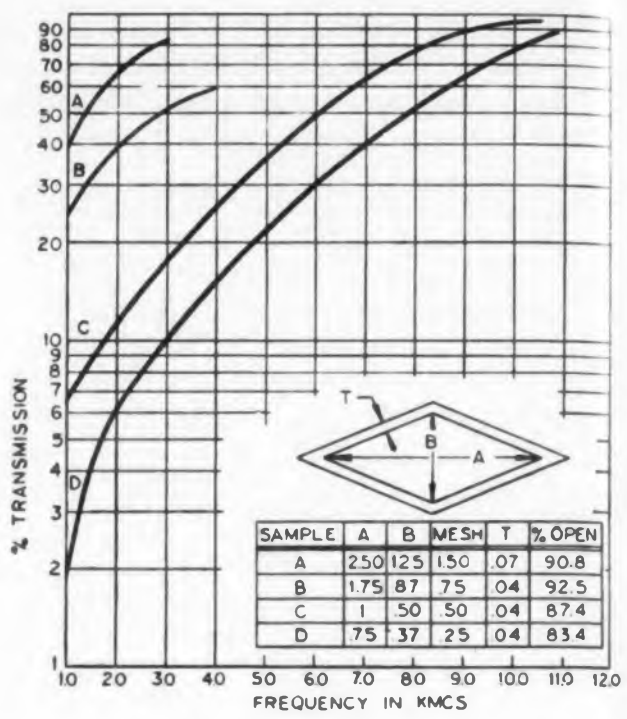


Fig. 2. Relative attenuation from transmitter to receiver.



SAMPLE	A	B	MESH	T	% OPEN
A	2.50	1.25	1.50	.07	90.8
B	1.75	.87	.75	.04	92.5
C	1	.50	.50	.04	87.4
D	.75	.37	.25	.04	83.4

(a)



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B	1.75	.87	.75	.04	92.5
C	1	.50	.50	.04	87.4
D	.75	.37	.25	.04	83.4

(b)

Fig. 3. Reflecting properties of expanded metal parabola. Polarization parallel to long dimension (a), and polarization perpendicular to long dimension (b).

between gain, beam width, and side-lobe suppression. One is illumination taper which can be varied by using front feed horns of different aperture dimensions until the best conditions are obtained. Another adjustment is the focal distance. It has been found that the best way to adjust the focal distance is to start out with the calculated value and vary it until the best compromise is found. Several different feed horns with different apertures can be tested and the best combination selected for permanent use.

Materials Used in Construction

Several methods of construction are available to the designer of parabolic reflectors:

- Solid sheet metal reflecting surface, assembled together as sectoral pieces.
- Metal foil over plywood base. Somewhat lighter and cheaper to fabricate than the solid sheet-metal type. But plywood has a tendency to warp, causing a gradual deterioration in the parabolic surface. Side-lobe suppression and beam width suffer. Found only in parabolas of about 10 ft and smaller. An excellent way of making small, low-gain, inexpensive dishes which are easy to mount and feed.
- Open-mesh construction. Reflecting surface may be made of thin sections of expanded metal or parallel bars assembled to give an equivalent parabolic surface. Open mesh construction has the advantages of: (1) low wind resistance; (2) low cost; (3) ease of fabrication and assembly; and (4) ability to conform to parabolic shape. But: (1) gain is reduced; (2) cross-talk may be increased; (3) intensity of side-lobes with respect to main lobe may be increased, and there may be

a loss in isolation between the two cross-polarized feeds of a diplexer-type feed horn.

Curves (Fig. 3) showing transmission through an expanded-metal reflecting surface for both planes of polarization and for four sizes of screen mesh have been evolved by Richards and Devane.[9] Harris[10] claims that the open-grid or parallel-bar type of parabolic reflector is the equal gain-wise of a solid spun aluminum dish in the 6 and 10 ft sizes at 900 megacycles.

So far as can be determined, the relative resistivity of the reflecting surface has little or no effect on the gain and efficiency of a parabolic reflector. For this reason, at least from an electromagnetic standpoint, it is reasonable to believe that reflecting surfaces made from copper, untreated aluminum, anodized aluminum or stainless steel will perform equally satisfactorily.

An interesting recent development consists of an air-inflated fabric balloon with parabolic contour. One surface is coated with aluminum particles to reflect electromagnetic energy. A 30 ft dia model weighs only 1700 lbs as compared to 10,000 lbs for a conventional dish of the same size. The 30 foot model can be held to a tolerance of 1/16 inch over the entire surface. In use, the inflated dish is housed in a plastic radome.

Tolerances in Manufacture and Adjustment

Friis[11] claims that an error of Δ in the reflecting surface of the parabolic reflector will result in an error of about 2Δ in the phase front. He recommends that the maximum tolerance to be allowed in the reflecting surface should be held to $\pm\lambda/16$. The primary feed should be placed as close as possible to the focal point of the dish. Defocussing will result in a circular curvature of the phase.

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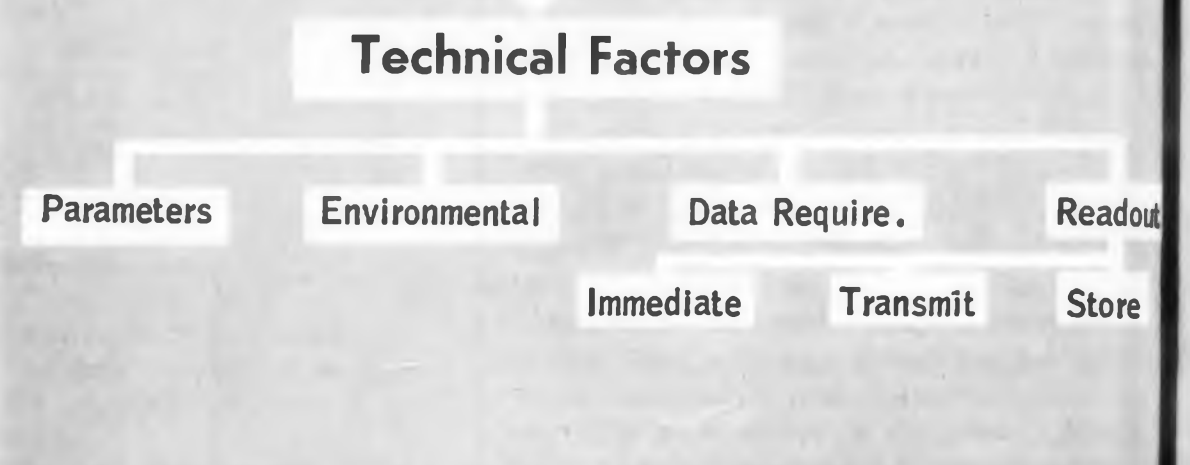
10. Designing Open Grid Parabolic Antennas, Harris, p. 60, *Tele-Tech*, November, 1956.
11. Friis and Lewis, *The Bell System Technical Journal*, April, 1947, p. 219.

Instrumentation S

Earl F. Kierna

Physic Me



DATA REQUIRED by the systems design engineer are in general the same as those needed by any design function plus a quantity of additional information which is generally considered as falling outside the technical domain. Considerable amount of coordination is, of course, necessary, inasmuch as a variety of items must be joined together to produce an operational ensemble. This joining process involves not only the hardware but also includes a meeting of the minds of all those concerned in the operation.

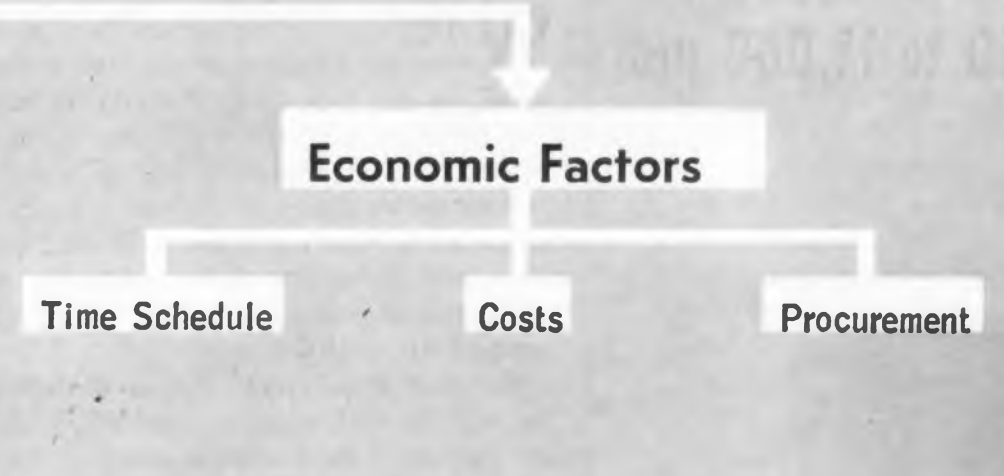
The various phases of system design—technical and economic—are blocked out in the diagram. Assuming that the parameters to be instrumented are physical, such as acceleration, pressure, temperature, it is first necessary to know what is to be measured; where it is to be measured; and when the data is to be utilized. Here at the very start, coordination enters the picture. This involves a series of meetings and conferences to establish priorities of time and importance, i.e., who needs what and which comes first. The question of data requirements enters at this point. The resolution of such a situation may require weeks before a duly authorized instrumentation list is issued. This list may be subject to modification from time to time as the system design progresses. The items listed will spell out such things as the name of the parameter to be measured (coded as to system relationship), the excursion range of the parameter, the units in which it is designated, the accuracy desired, priority, etc. Once a reasonably firm instrumentation list has been established, the systems engineer probably has a pretty fair idea concerning the economic factors indicated on the chart.

With the instrumentation list in hand, the next question involves environment; where are the transducers to be located? Here again, if the system involves aircraft or a missile, the instrumentation list may call out a frame and a sector number. In any case, detailed information must be acquired as to the exact mounting point (if possible) and the method of attachment. The matter of fastening a

System Design

Menlo Park, Calif.

Measurements



transducer to the structure of a thin-skinned missile may become quite involved. It may be that a suitable transducer is not procurable. If such is the case, a development program may be instigated within the company, or bids may be requested from other concerns.

Assuming that suitable transducers are available, detailed data on accuracy, repeatability, linearity, hysteresis, etc., must be analyzed. This particular phase of design may develop into a highly involved process. There is a universal lack of uniformity in the definitions of terms. In one particular instance involving a million dollars or more worth of transducers, a vendor is said to have spent two hundred fifty thousand dollars on standardization adjustments before the situation was resolved. The controversy stemmed from differences in term definitions.

Having selected a suitable transducer, arrangements must be made to present the data therefrom in a form most suitable for the purpose in mind. Quite often the readout must provide a quick look as well as transmittal and storage. The quick look may involve a meter or a strip chart. Transmission may involve radio linkage if the pickup is moving, or simply a transmission line with suitable terminations, as in ground support installations. In both airborne and ground installations, magnetic tape and/or photographic film may be used for storage purposes.

The economic aspects of the problem may loom very large depending upon the time schedule and the urgency involved. If the program is on a crash basis, with no holds barred, costs can be ignored and procurement facilitated at least as far as purchasing is concerned.

Then again if the urgency is not quite so great, a target date, subject to revision may be established with specified limits on overtime, premium cost payments, etc.

Finally, the more normal approach is involved when a decision is made to develop a certain system with the schedule fitted into the programmed activities of a department.

DESIGN FORUM

Unusual output circuitry, an ultrasonic carrier, and combined feedback, help make a very stable, efficient power supply

WHEN a power supply can provide zero, or even negative output impedance—that's unusual. In our July 1, 1957 issue, we described the performance of this supply, its excellent regulation, its negligible drift, and its fast response.

Now we want to describe how it works. Manufactured by Optimized Devices, Inc., of White Plains, N. Y., the power supply uses negative voltage and positive current feed-back, and a modulated ultrasonic carrier.

It's well known how output impedance can be reduced with negative feedback, as in Fig. 1, by increasing the feedback-gain product, in the expression $Z_{out} = Z_{int}/(1-\beta K)$. But βK would have to be infinite to provide zero output impedance and large βK values can introduce

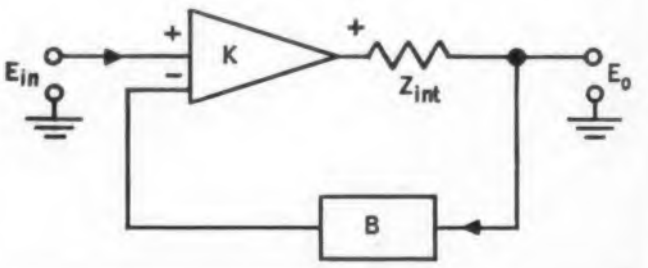


Fig. 1. Basic arrangement for negative voltage feedback.

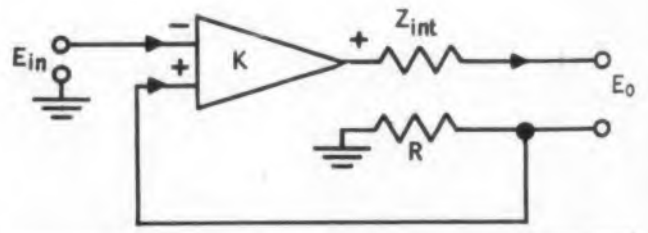
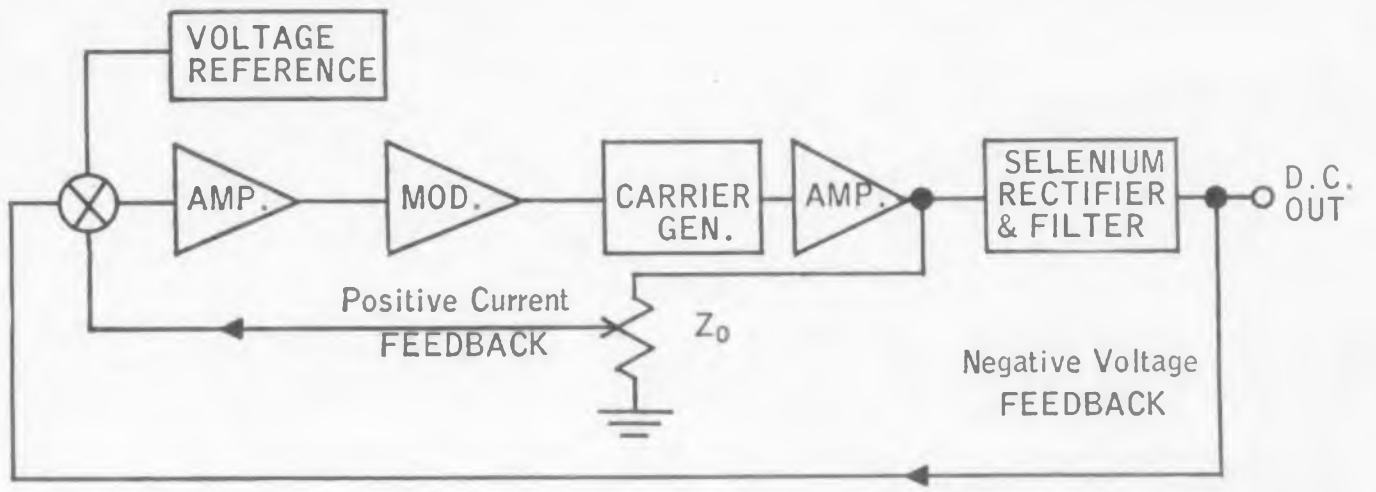


Fig. 2. Basic arrangement for positive current feedback.

Fig. 3. Power supply block diagram showing the two feedback paths.



with . . .

Output Impedance—Zero

serious instability.

And that's where positive current feedback enters the picture. The output impedance in Fig. 2 is $Z_{out} = R(1-K) + Z_{int}$. With this scheme, R can be varied to make Z_{out} zero or negative.

The power supply block diagram of Fig. 3 and the schematic in Fig. 4 show how the combination feedback is used. This low voltage supply is a closed loop system with two main feedback paths.

The negative feedback is from the output, through $R1$ to the second grid of the differential input amplifier $V1$. This feedback helps reduce the output impedance and noise, and regulates the output voltage. The "Z_o" control provides positive feedback to reduce the output impedance further to zero or small negative values. "Z_o" taps off the output driver where there is a square wave voltage proportional to the load current. The 0.1 μfd capacitor across "Z_o" averages the square wave to provide dc.

The coarse and fine controls deliver a reference voltage from an OB2 105 v VR tube, while the $R2,3,4$, combination supplies a line regulation compensating voltage.

The dual cathode bias arrangements in both $V1$ and $V2$, a second differential amplifier, help stabilize the output against the effects of filament voltage variations and tube aging.

$V2$ modulates $V3$, a free running multi-vibrator whose frequency varies inversely wtih load current from 20 to 50 kc. Thus, with light loads, this carrier frequency is high, resulting in very low ripple. The frequency drops with heavier loads, resulting in increased selenium rectifier efficiency.

$V4$ amplifies the ultrasonic carrier and drives the output tube. The unusual drive circuitry and power output circuitry ($V5$) make for a highly efficient power amplifier. It can deliver high power output with an 80 per cent theoretical plate efficiency. Yet $V5$ dissipates very little power when lightly driven. Its average bias as a switch is proportional to the driving signal, with the tube operated as a switch (either saturated or cut off). Hence no fixed or cathode bias.

For more information turn to the Reader-Service card and circle **100.**

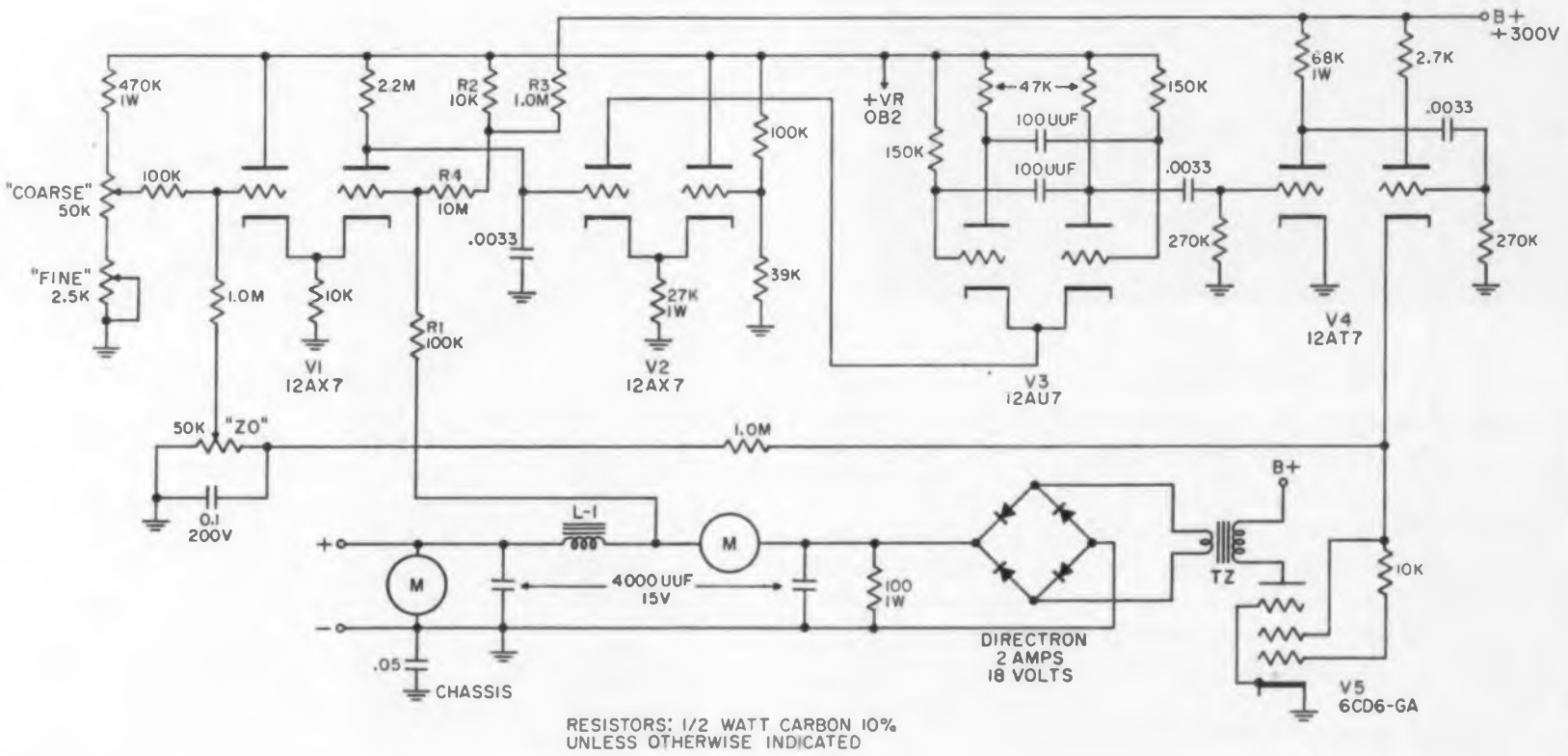
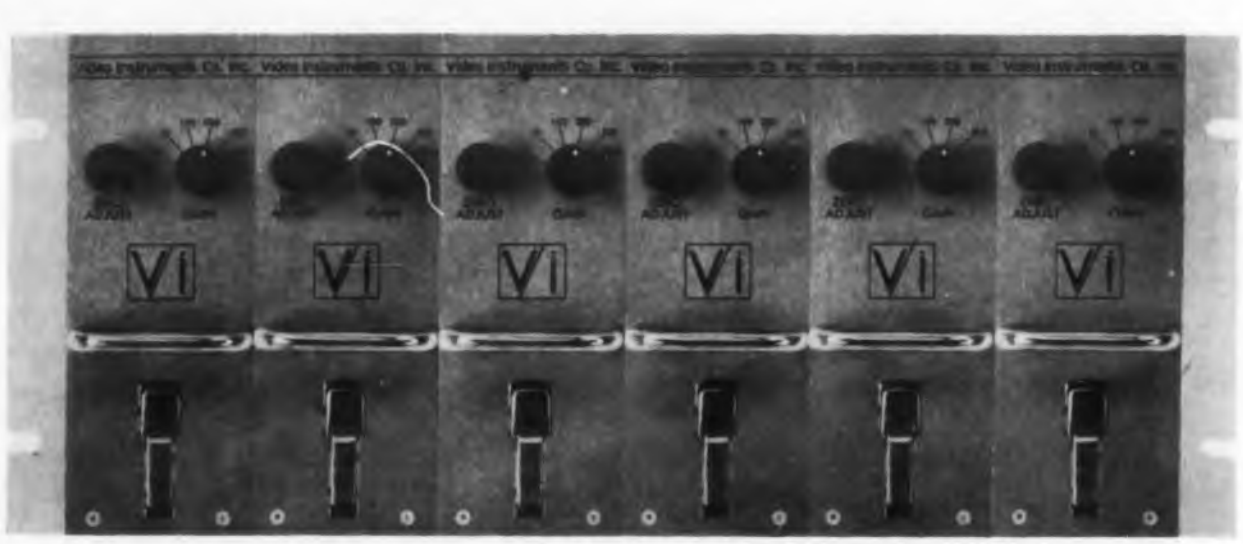


Fig. 4. This low voltage power supply uses negative voltage feedback, positive current feedback, line regulation, and a very unusual output stage. (Internal power supply not shown, uses traditional circuitry).

NEW PRODUCTS

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

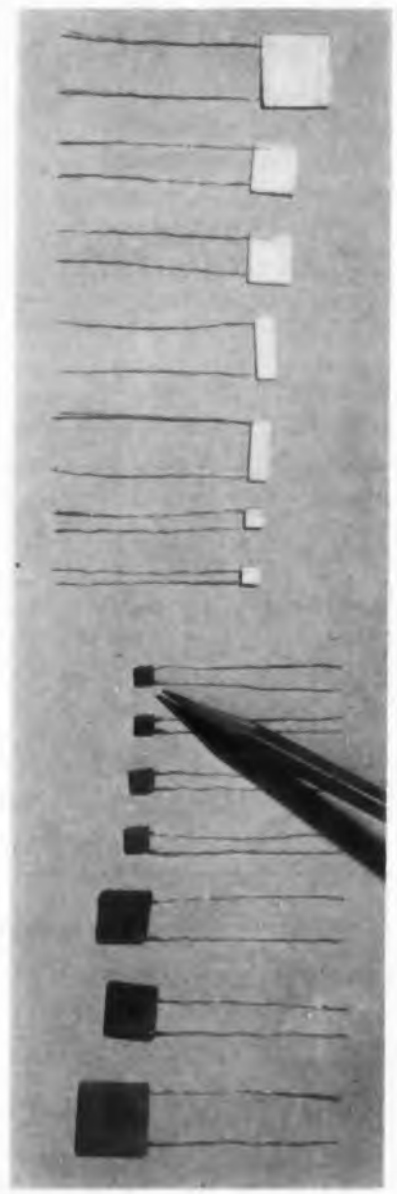


DC AMPLIFIER

A solid state chopper, consisting of a magnetostriction driven capacitor, is featured in the model 74 dc amplifier. The chopper provides μv per day stability. Chopper frequency is 8 kc, well outside the 1-kc bandwidth of the amplifier, and therefore chopper intermodulation is prevented. Input is differential, with infinite impedance to dc, and it is entirely isolated from ground. Either side of the floating output may be grounded. Common mode rejection is 100,000:1 for common mode signals of 100 v.

Video Instruments Co., Inc., Dept. ED, 3002 Pennsylvania Ave., Santa Monica, Calif.

CIRCLE 42 ON READER-SERVICE CARD



CERAMIC CAPACITORS

Designed for 225 C operation, the Hi-T series of glass-coated ceramic capacitors have passed 1000 hour life tests at this temperature at twice rated voltage. The capacitors have an insulation resistance of 10,000 meg at +25 C and 100 v dc. Maximum capacity ratings range from 0.1 μf, 70 wv dc, to 0.035 μf, 500 wv dc.

Gulton Industries, Inc., Dept. ED, 212 Durham Ave., Metuchen, N.J.

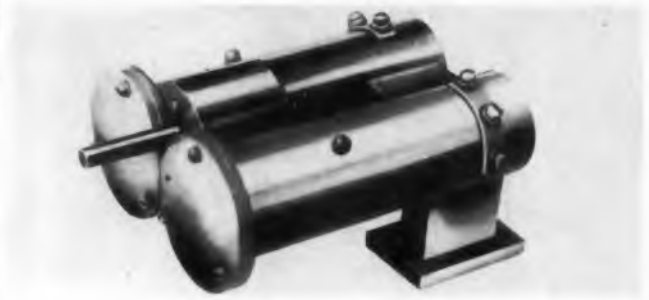
CIRCLE 43 ON READER-SERVICE CARD

ZENER DIODE

This double anode silicon zener is rated at 600 mw and designed for printed circuits. The unit provides symmetrical dynamic clipping characteristics for such applications as rate feedback limiting in servo control systems, maintaining the output of a gyro pickoff at a prescribed level, oscilliscope calibration, and similar functions. Available in zener voltage ranges of 4.3 to 30 v, the unit is also suitable for arc suppression and circuit protection uses. The device consists of two matched silicon zener junction diodes connected by a common cathode.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

CIRCLE 44 ON READER-SERVICE CARD



MICROWAVE FILTER

This two-section preselector filter has high selectivity and wide range. The filter is useful in broadband image rejection or front-end selectivity applications requiring minimum size and weight. The unit illustrated tunes from 7500 to 8500 mc, with an insertion loss not exceeding 2.0 db for a 25 mc bandwidth.

Airtron, Inc., Dept. ED, 1096 West Elizabeth Ave., Linden, N.J.

CIRCLE 45 ON READER-SERVICE CARD

NEW PRODUCTS

Transistorized Circuit Packaging

High package densities

Semiconductor and passive circuitry packaging densities of 40 to 74 per cent are achieved with this cast instrument stick. Individual modules can be replaced or repaired. Used with printed circuit boards, the method permits three dimensional wiring.

Lind Corp., Dept. ED, 1181 Hughes Dr., Trenton 90, N.J.

CIRCLE 48 ON READER-SERVICE CARD

RF Coil

For automatic assembly

The X-L is a patented rf coil and transformer assembly for printed circuit board insertion. The coil has adjustable tuning and one or two windings. Inductive drift is 50 ppm per degree centigrade.

Essex Electronics, Dept. ED, 550 Springfield Ave., Berkeley Heights, N.J.

CIRCLE 49 ON READER-SERVICE CARD

Voltmeter

10 cps to 1 mc frequency range

The 21A voltmeter measures ac voltages over a 10 cps to 1 mc fre-

CIRCLE 47 ON READER-SERVICE CARD

quency range. Full scale accuracy is ±2 per cent from 15 cps to 200 kc at 25 C and ±4 per cent from 10 cps to 1 mc from −10 to +55 C. Stability is ±1 per cent over line voltage variations of 105 to 125 v.

The Daven Co., Dept. ED, Livingston, N.J.

CIRCLE 50 ON READER-SERVICE CARD

Electrometer

Has wide frequency response

The 201A electrometer amplifier combines wide frequency response with low current ranges. On the lowest range, 3 x 10^{-14} amp, response time of under 0.1 sec are available, including the effects of capacity which may be introduced by input cables.

E-H Research Labs, Dept. ED, 2161 Shattuck Ave., Berkeley 4, Calif.

CIRCLE 51 ON READER-SERVICE CARD

Digital Shaft-Angle Encoder

Has built-in alignment cell

A 13-digit shaft-angle encoder, the DV-13A has a built-in alignment cell to establish optical-mechanical concentricity precise to 110 ppm. Reading accuracy is better than ±2.5 minutes of arc, and maximum reading rate is 100 digital words per second. Without brushes or moving contacts, the Dychroverter instantly encodes the angular position of high-speed rotating shafts.

Dychro Corp., Dept. ED, 125 Mt. Auburn St., Watertown 72, Mass.

CIRCLE 52 ON READER-SERVICE CARD

CIRCLE 53 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Pancake Clutch

For close coupled operations

Half as long as its mounting diameter, the model PC-8 precision clutch has encapsulated coils, fixed terminals, 1.000 servo mounting diameter, and guaranteed torque of 16 oz in.

Autotronics Inc., Dept. ED, Rt. 1, Box 812, Florissant, Mo.

CIRCLE 55 ON READER-SERVICE CARD

Precision Power Resistors

Rated to 275 C

Available in 2 to 10 w units, miniature Techsilohm precision power resistors are rated to 275 C. Temperature coefficient is 20 ppm per degree C.

Tech-Ohm Resistor Corp., Dept. ED, 36-11 33rd St., Long Island City, N.Y.

CIRCLE 56 ON READER-SERVICE CARD

Vibration Mounts

Have all-metal stabilizer unit

These metal mounts are designed for high, narrow-axis equipment subject to shock and vibration. They feature an all-metal stabilizer unit.

Ralph E. Cooper Co., Dept. ED, 233 S. Clinton St., Dayton 3, Ohio.

CIRCLE 57 ON READER-SERVICE CARD

Potentiometer

Infinite resolution

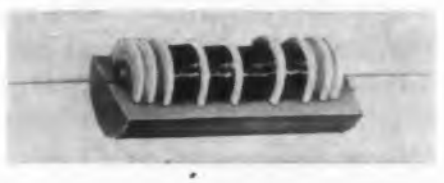
Model 85175 potentiometer is available with either three or ten turns. It has resistances ranging from 2 to 250 ohms.

G. M. Giannini & Co., Inc., Dept. ED, Pasadena, Calif.

CIRCLE 58 ON READER-SERVICE CARD

Wirewound Resistor

Not derated at 200 C



In values from 1 ohm to 750 K, type 1400 wire wound resistors are rated at 0.5 w to 200 C, derating to 0 at 225 C. Temperature coefficient is ±30 ppm per deg C from −50 to +200 C. Available in ±1, ±0.5, and ±0.1 per cent tolerances.

The Daven Co., Dept. ED, Livingston, N.J.

CIRCLE 59 ON READER-SERVIC CARDE

Altitude Switch

Operates from 2000 to 70,000 ft

At any preset height from 2000 to 70,000 ft, this 3-oz altitude switch will close or open contact. It operates from −65 to +250 F. Accuracy is 2 per cent of setting.

Aero Mechanism, Inc., Dept. ED, 8938 Lindblade St., Culver City, Calif.

CIRCLE 60 ON READER-SERVICE CARD

CIRCLE 61 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Pressurizing Window

1.12 maximum vswr

The BL 777 K_u-band pressurizing window has a maximum vswr of 1.12 over a frequency range of 12.4 to 18.0 kmc. The BL 777 can be pressurized to a maximum pressure differential of 30 psi and will operate up to 100 kw maximum.

Bomac Labs., Inc., Dept. ED, Salem Rd., Beverly, Mass.

CIRCLE 63 ON READER-SERVICE CARD

Ceramic Capacitor

Highly stable

Capacitance change from room temperature to +85 C is less than 2.5 per cent in the C40 miniature ceramic capacitor. Units are available with ratings of 250, 500, and 1000 v.

Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

CIRCLE 64 ON READER-SERVICE CARD

Temperature Indicator

Uses thermistor sensing elements

Using thermistor sensing elements, the model 109 temperature indicator covers a range of 60 to 90 C. It indicates temperature at ten different points to 0.1 deg C accuracy.

Fenwal Electronics, Inc., Dept. ED, Mellen St., Framingham, Mass.

CIRCLE 65 ON READER-SERVICE CARD

VTVM

Logarithmic meter movement

Model 400L vtvm has a logarithmic meter designed to eliminate optical confusion and provide an accuracy which is a constant percentage of the reading. This was accomplished by expanding the lower portions of the voltage scale and by providing a linear decibel scale which spreads 12 db over the full scale length. The unit has two voltage scales ranging from 0.8 to 3.2 and from 2.5 to 1. It measures any voltage from 0.3 mv to 300 v in the 10 cps to 4 mc range.

Hewlett-Packard Co., Dept. ED, 275 Page Mill Rd., Palo Alto, Calif.

CIRCLE 66 ON READER-SERVICE CARD

Electronic Timer

±1 msec accuracy

For measuring time intervals between opening and closing of contacts on almost any instrument or control, the Dynatimer electronic stopwatch has ±1 msec accuracy. Contact time intervals range from 2 msec to 10 sec. The unit comes with glow counter tube or Nixie readout.

Dynapar Corp., Dept. ED, 5150 Church St., Skokie, Ill.

CIRCLE 67 ON READER-SERVICE CARD

CIRCLE 68 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Regulated DC Power Supply

Magnetic amplifier control

This regulated silicon dc power supply features magnetic amplifier control with ferro-magnetic overload protection circuit. Ratings are: 115 v; single phase 60 cps ac; output 5 to 30 v 40 amp dc. Regulation is ±12 per cent; ripple 1 per cent.

Gates Electronic Co., Dept. ED, 2090 Barnes Ave., Bronx 62, N.Y.

CIRCLE 70 ON READER-SERVICE CARD

Microwave Amplifier

For use with traveling wave tubes

A self-contained low-noise microwave amplifier, the TWT-10 CM incorporates the RCA MW-4900 solenoid and is suited to the use of several RCA low-noise wideband traveling wave tubes. Frequency coverage is in the 1.1 to 4.3 kmc region; noise figures ranges from 6.5 to 7.5 db; and maximum output is about 1 mw with gains of 20 db or more.

Lel, Inc., Dept. ED, 380 Oak St., Copague, N.Y.

CIRCLE 71 ON READER-SERVICE CARD

Function Generator

Card-programmed

The MC-670 diode function generator is programmed from punched paper cards inserted in the front of the instrument. For use with analog computers and data handling systems, the unit is equipped to provide 20 segments of diode-break-

point function generation. The slope of the curve at any particular breakpoint is adjusted by means of binary coded information punched into the card. Zero offset and slope scale are also card-programmed. Set-up can be effected in seconds independent of the generator proper. Repeatability is ±0.02 per cent; accuracy, ±0.1 per cent.

Mid-Century Instrumatic Corp., Dept. ED, 611 Broadway, New York 12, N.Y.

CIRCLE 72 ON READER-SERVICE CARD

Multi-Contact Relay

Dissipates 1.2 w dc or 2 va ac

The KF can be supplied to operate on ac or dc voltage. It is a continuous duty relay that dissipates 1.2 w dc or 2 va ac, and it can be adapted for 5pdt or 7pst arrangements. The relay is designed with the movable contacts and relay frame electrically common.

Potter & Brumfield, Inc., Dept. ED, Princeton, Ind.

CIRCLE 73 ON READER-SERVICE CARD

Metallized Paper Capacitors

Have double insulation

Type 118P difilm metallized capacitors have both metallized paper and polyester film insulation. Screw-neck mounting styles have large threaded neck mountings in case diameters 0.562 in. and above to improve performance under severe vibration. Type 121P capacitors are available for use where high insulation resistance is not required.

Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

CIRCLE 74 ON READER-SERVICE CARD

NEW PRODUCTS

Rivet Standoff

Variety of shank lengths

For mounting to terminal boards or panels, the X1246 rivet standoff comes in shank lengths to accommodate panel thickness from 1/32 to 1/4 in., and in eight mounted heights above the board, from 1/8 to 1 in. Internally threaded, the rivet standoffs are finished with 0.003 in. cadmium plate.

Cambridge Thermionic Corp., Dept. ED, 445 Concord Ave., Cambridge 38, Mass.

CIRCLE 77 ON READER-SERVICE CARD

Relay

Featuring large degree of wipe

This relay utilizes a novel contact configuration for maximum over travel and a large degree of wipe. Type BR8 exceeds applicable military specifications for miniature relays: 30 g, 10-2000 cps. operate and release less than 5 msec, with pull-in power 200 mw for dpdt and 80 mw for spdt relays.

Babcock Relays, Inc., Dept. ED, 1640 Monrovia Ave., P.O. Box 344, Costa Mesa, Calif.

CIRCLE 78 ON READER-SERVICE CARD

Diode Tester

Tests forward and reverse characteristics

A combination diode tester, model 997 tests both forward and reverse characteristics of germanium or silicon semiconductors. Forward characteristics: voltage range, 0 to 5 v; current range, 0 to 1 amp; meter ranges, 0 to 10 to 0 to

1000 ma. Reverse characteristics: voltage range, 0 to 1000 v; current range, 0 to 10 to 0 to 1000 mμa.

Trans Electronics, Inc., Dept. ED, 7349 Canoga Ave., Canoga Park, Calif.

CIRCLE 79 ON READER-SERVICE CARD

Capacitors

Miniaturized

Miniaturized capacitors designed to save up to 80 per cent in space. Working voltages range from 100 to 600 v dc.

Potter Co., Dept. ED, 1950 Sheridan Road, N. Chicago, Ill.

CIRCLE 80 ON READER-SERVICE CARD

Miniaturized Delay Lines

Close tolerances over wide range

These rugged, compact delay lines have close tolerances over a wide range of delays. They have a high delay to rise time ratio for their size and can be supplied in any reasonable specified impedance value.

Globe Industries, Inc., Dept. ED, 525 Main St., Belleville 9, N.J.

CIRCLE 81 ON READER-SERVICE CARD

VHF Multicoupler

90 to 200 mc frequency range

This vhf multicoupler has a frequency range from 90 to 200 mc with maximum efficiency, and from 50 to 200 mc with reduced efficiency. It is available with a plug in preamplifier so that overall gain from input to each of the outputs can be approximately unity.

Westronics, Inc., Dept. ED, 3605 McCart St., Ft. Worth, Tex.

CIRCLE 82 ON READER SERVICE CARD

NEW PRODUCTS

Frequency Meter

Has 21 direct reading scales

Frequency meter T-2 has 14 ranges from 25 cps to 80 kc and 7 ranges from 1250 to 80,000 rpm, all in direct reading scales. Accuracy is 1 per cent. The unit accepts voltages from 10 mv to several hundred volts at high impedance.

Jones-Porter Instrument Co., Dept. ED, Box 302, Millburn, N.J.

CIRCLE 84 ON READER-SERVICE CARD

Crystals

Low frequency

Series ST-70NXS low frequency crystals cover a frequency range of 100 to 250 kc with a frequency tolerance of ±0.015 per cent from −55 to +90 C. They stand 100 g initial shocks and 20 g vibration up to 2000 cps.

Bulova Watch Co., Electronics Div., Dept. ED, Woodside 77, N.Y.

CIRCLE 85 ON READER-SERVICE CARD

Transistor Tester

Measures switching time

The API 300 analyzes the time characteristics of high speed tran-

The G-E Power Tube Microwave Laboratory is located at Stanford Industrial Park, Palo Alto, California where it was one of the Park's pioneer installations. Its staff of scientists and engineers has the advantage of technical exchange with Stanford University faculty and research staffs, as well as with General Electric's own Research and General Engineering Laboratories.

sistors. It measures the switching time of the leading or trailing edge of the output pulse with an error o 3 mμsec in the 3 to 100 mμsec range. The unit has direct mete reading with a presettable go-no-go level.

Atronic Products, Inc., Dept. ED 1 Bala Ave., Bala-Cynwyd, Pa.

CIRCLE 86 ON READER-SERVICE CARD

Transformers

Multiple filament

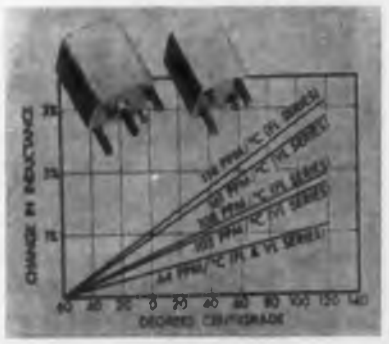
These hermetically sealed, mul tiple filament transformers are built to MIL-T-27A, Grade 4 Class R specifications. Minimum life expectancy is 10,000 hr; maxi mum operating altitude, 10,000 ft

Chicago Standard Transformer Corp., Dept. ED, 3501 Addison St. Chicago 18, Ill.

CIRCLE 87 ON READER-SERVICE CARD

Linear Inductors

Adjustable and fixed



Variation of inductance is linear from —55 to +125 C in this line of fixed and adjustable inductors Temperature coefficients range from 55 to 161 ppm. Q variation is ±10 per cent from —30 to +85 C, and inductance range is 100 μh to 2 h.

Pulse Engineering, Inc., Dept ED, 2657 Spring St., Redwood City, Calif.

CIRCLE 88 ON READER-SERVICE CARD

CIRCLE 89 ON READER-SERVICE CARD

NEW PRODUCTS

Flexible Terminal Blocks

Have self-locking screws

Imported from West Germany, Flex-o-Block terminals are made of unbreakable, nonporous, completely flexible vinyl plastic. Blocks are in strips of 12 that can be cut with a pocket knife. Screws, enclosed in plastic molding, have a tapered head which gives locked-in protection without washers. Resistant to environments, the terminals withstand temperatures from −65 to +100 C. Resistance is 2.5 x 10^{15} per in.; dielectric constant is 3.5 at 60 cps. Units come in 10, 20, 30, and 50 amp capacities.

American Electronic Products Co., Inc., Dept. ED, 202 W. 40th St., New York 18, N.Y.

CIRCLE 91 ON READER-SERVICE CARD

Storage Tube

For radar use

In a fraction of a second, tube WL-7228 memorizes data received by radar and holds it for long periods. The tube stores over 100,000 pieces of information. It has three guns. One to receive and write information, a second to wipe it out, and a third to display it.

Westinghouse Electric Corp., Electronic Tube Div., Dept. ED, Elmira, N.Y.

CIRCLE 92 ON READER-SERVICE CARD

Composite Transistors

High gain

These composite transistors and diodes feature stability, high gain, and the elimination of

ancillary circuitry. The 2N626 npn and ARA-25P pnp power transistors are for use in circuits where high impedance driving sources exist in common emitter, common base, or common collector configurations. The ARA-25N-H pnn and ARA-25P-H npp power transistors are germanium-silicon power hook collector transistors designed to be used in their stable configurations. The ARA-D1528 shunt regulating diode consists of a Zener diode coupled to a high power composite transistor.

Advanced Research Associates, Inc., Dept. ED, P.O. Box 68, 4130 Howard Ave., Kensington, Md.

CIRCLE 93 ON READER-SERVICE CARD

Multivibrator

Vibrator replacement

The Univistor transistorized astable multivibrator is used with an external vibrator transformer to deliver ac power output from dc input. Since the external vibrator transformer is part of the power supply circuit, the Univistor can be interchanged with a vibrator without change in circuitry.

Universal Transistor Products Corp., Dept. ED, 17 Brooklyn Ave., Westbury, N.Y.

CIRCLE 94 ON READER-SERVICE CARD

Transistorized Oscillator

High accuracy to 105 C

This transistorized sinewave oscillator has an adjustable frequency set range of 20 cps to 20 kc. Frequency is stable to ±0.25 per cent, with under 1 per cent distortion from −55 to +105 C. Construction is either plug-in or header type.

General Controls Co., Dept. ED, 801 Allen Ave., Glendale, Calif.

CIRCLE 95 ON READER-SERVICE CARD

NEW PRODUCTS

Telemetry Antenna

Manually operated or remote-controlled

Model MAM-1000 telemetry antenna is for use where the antenna can be manually oriented. It also comes with a remote controlled motor-driven mount. Unit pictured is a 4-turn helical beam antenna with a 50 deg acceptance angle and a 10 db gain over an isotropic source.

Nems-Clarke Co., Dept. ED, 919 Jesup-Blair Dr., Silver Spring, Md.

CIRCLE 98 ON READER-SERVICE CARD

Capacitor

Symmetrical feed-through

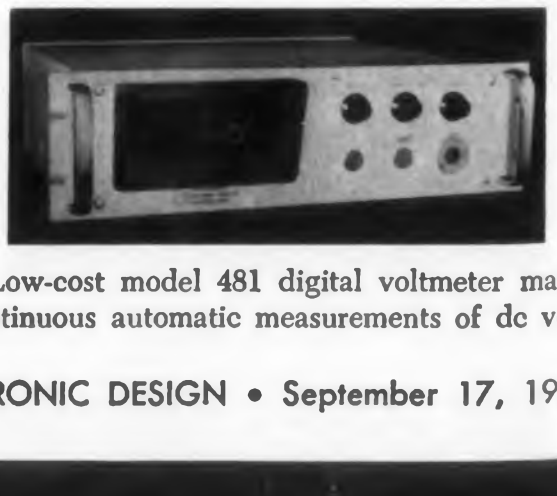
The DA-741 Hi-Kap symmetrical feed-through capacitor can be inserted from either end. There is no capacitance drop-off. The unit withstands 450 F soldering temperatures; comes in capacitance values to 1000 μμf.

Centralab, Div. of Globe-Union, Inc., Dept. ED, 900 E. Keefe Ave., Milwaukee 1, Wis.

CIRCLE 99 ON READER-SERVICE CARD

Digital Voltmeter

Measures dc voltages from 1 mv to 1000 v



Low-cost model 481 digital voltmeter makes continuous automatic measurements of dc volt-

ages from 1 mv to 1000 v with a linearity and scale factor accurate to 0.01 per cent. It has a stabilized reference, and automatic range changing, polarity, and decimal point positioning. Visual presentation only.

Non Linear Systems, Inc., Dept. ED, Del Mar, Calif.

CIRCLE 105 ON READER-SERVICE CARD

Power Supply

Provides 60 ma at 300 v dc

Power supply which occupies 5 cu. in. and supplies 60 ma at 300 v dc from a 115 v, 400 cps ac input source. Ripple is less than 5 per cent at full output rating. Qualified per MIL-T-5422C.

Master Specialties Co., Dept. ED, 956 E. 108th St., Los Angeles 59, Calif.

CIRCLE 106 ON READER-SERVICE CARD

Printed Circuit Connectors

Have straight-through terminals

The UPCC-ML series printed circuit connectors have straight-through terminals on the male member. Terminals are solder dip for 1/16, 1/8, or 1/4 in. boards, or solder eyelet or turret type. Insulation resistance is over 5000 meg, with voltage breakdown over 2500 v ac rms, and current rating 7.5 amp. With 7, 11, 15, 19, and 23 terminals.

U. S. Components, Inc., Dept., ED, 454 E. 148th St., New York 55, N.Y.

CIRCLE 107 ON READER-SERVICE CARD

NEW PRODUCTS

Electrical Impulse Counters

Have four 5-digit counting heads

ZDG series electrical impulse counters may be installed with up to four 5-digit counting heads printing on one tape. Counting time is 25 per sec; printing time, 0.1 sec; and reset time, 0.5 sec. For dc current, 24 and 60 v.

Presin Co., Dept. ED, 12128 W. Pico Blvd., Los Angeles 64, Calif.

CIRCLE 110 ON READER-SERVICE CARD

Potentiometer

Up to 13 taps

Model 200-CEUS 2 in. precision potentiometer may have up to 13 preset taps or it can be tapped in the field by the user. Spacing of terminals facilitates direct attachment of padding resistors to produce nonlinear functions; nonlinear units can be wound to any specified function. All nonferrous parts are anodized or plated. Up to 15 units can be stacked without loss of accuracy.

George Rattray and Co., Dept. ED, 116-08 Myrtle Ave., Richmond Hill 18, N.Y.

CIRCLE 111 ON READER-SERVICE CARD

Metallized-Paper Capacitors

Miniature

Type P83CZK metallized-paper capacitors feature a metallized dielectric which provides both

the electrodes and the dielectric. Power factor is under 1 per cent when measured at 1 kc and 25 C. The miniature units operate to +85 C.

Aerovox Corp., Dept. ED, New Bedford, Mass.

CIRCLE 113 ON READER-SERVICE CARD

Power Relay

Has octal plug-in

In a clear polystyrene enclosure with octal plug-in header, series 26D miniature power relay is available up to 3pdt with contacts rated at 10 amp. It can be wired for double make or break operations, ac or dc coil. Units come with coil resistances to 15 K.

Kurman Electric Co., Dept. ED, 191 Newel St., Brooklyn 22, N.Y.

CIRCLE 114 ON READER-SERVICE CARD

Transformers

Operate to 70,000 ft altitude

These 400 cps transformers are hermetically sealed and meet MIL-T-27A, Grade 4, Class S specifications. They operate at 85 C ambient, 45 C rise. Maximum operating altitude is 70,000 ft and life expectancy is 10,000 hr. Included in the line are 10 power transformers with high voltage secondaries ranging from 40 to 300 dc ma and multiple filament secondaries ranging from 3 to 20 amp. All units have 2500 v rms insulation.

Chicago Standard Transformer Corp., Dept. ED, 3501 Addison St., Chicago 18, Ill.

CIRCLE 115 ON READER-SERVICE CARD

DC Chopper

Low drift

An spdt chopper, the DCM-99K-1 dc modulator has less than 5 μv dc offset. It drifts less than 2 μv over a long period of time. Normal contact dwell time is 55 per cent, held within 2 per cent for the first 1000 hr. Life is 10,000 to 25,000 hr.

Millivac Instruments, Div. of Cohu Electronics, Inc., Dept. ED, P.O. Box 997, Schenectady, N.Y.

CIRCLE 116 ON READER-SERVICE CARD

NEW PRODUCTS

Transistor Building Blocks

For digital systems

A pluggable pin-jack system quickly combines Data Blocs into special test equipment and complete digital systems. The 5 mc transistor building blocks can be used any number of times. Permanent equipment can be specified and built from the experimental block hookup by the use of Data-Pacs, the printed circuit plug-in card equivalent of the Data Blocs.

Harvey-Wells Electronics, Inc., Dept. ED, 5168 Washington St., West Roxbury, Mass.

CIRCLE 119 ON READER-SERVICE CARD

Printed Circuit Relay

Has gold flashed contacts

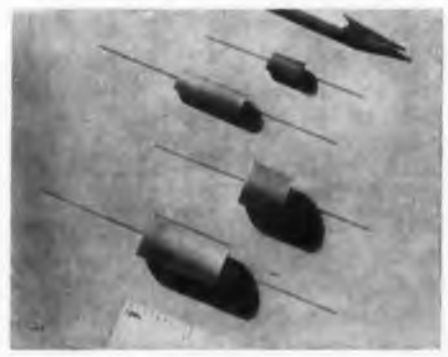
For printed circuits, series MKT relays have gold flashed silver or silver cadmium oxide contacts in arrangements up to 3pdt. Ratings are 5 or 10 amp resistive at 115 v, 60 sps or 26.5 v dc.

Line Electric Co., Dept. ED, 271 S. Sixth St., Newark 3, N.J.

CIRCLE 120 ON READER-SERVICE CARD

Zener Reference Assemblies

Voltage range of 6.2 to 49.6 v



In these Zener reference assemblies, type 1N429 twin anode Zener reference diode is the basic building block. The strings have an operating voltage range from 6.2 to 49.6 v; a maximum

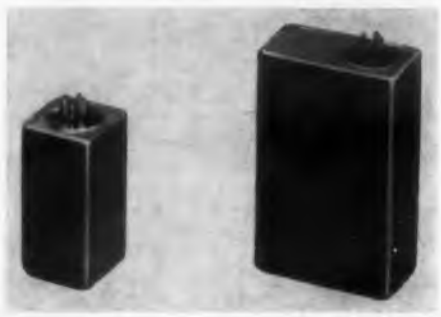
change in voltage in the —55 to +100 C range of 0.05 to 0.2 v; and a maximum dynamic impedance at 7.5 ma from 20 to 180 ohms.

Hoffman Electronics Corp., Semiconductor Div., Dept. ED, 920 Pitner Ave., Evanston, Ill.

CIRCLE 121 ON READER-SERVICE CARD

Telemetering Filters

Cover frequencies from 400 cps to 70 kc



Telemetering band pass filters, group TMN, covers frequencies from 400 cps to 70 kc with ±7.5 per cent bandwidth. Group TMW covers frequencies from 22 kc to 70 kc with ±15 per cent bandwidth. Impedance for all units is 100 K in and out. Insertion loss is less than 6 db.

United Transformer Corp., Dept. ED, 150 Varick St., New York 13, N.Y.

CIRCLE 122 ON READER-SERVICE CARD

Rectilinear Recorder

8 channel

Model 99.003 rectilinear recorder is for use with analog computers. It combines 8 channel capacity, hot-stylus recording, and push button sensitivity selection. It may be controlled from the computer console, or control of the computer itself may be obtained from the recorder.

Electronic Associates, Inc., Dept. ED, Long Branch, N.J.

CIRCLE 123 ON READER-SERVICE CARD

Film Resistor

200 ohm to 1.5 meg range

A low-cost, glass-based resistor bearing a tin oxide metal film, the C-42 has a 200 ohm to 1.5 meg resistance range and operates to 150 C. Power rating is 2 w at 70 C.

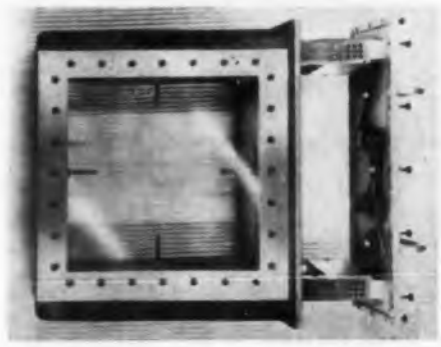
Corning Glass Works, Dept. ED, Corning, N. Y.

CIRCLE 124 ON READER-SERVICE CARD

NEW PRODUCTS

Antenna Anti-Icer

For bipolar feed horns



This heater extension for bipolar feed horns is designed for radar and tropospheric scatter communications systems in the arctic. The anti-icer uses two infrared lamps in the horn extension assembly. The lamps direct radiant energy through the window and heat air around its outer surface.

The Gabriel Co., Gabriel Electronics Div., Dept. ED, Needham Heights 94, Mass.

CIRCLE 127 ON READER-SERVICE CARD

Coaxial Couplers

0.2 db accuracy at 5 frequencies

The couplers cover a 2-1/2 to 1 freq. range with flat coupling and high directivity from 4000 to 10,000 mc. Units include chart providing calibration to 0.2 db accuracy at 5 freq.

Narda Microwave Corp., Dept. ED, 118-160 Herricks Rd., Mineola, N.Y.

CIRCLE 128 ON READER-SERVICE CARD

Rotary Switches

High speed

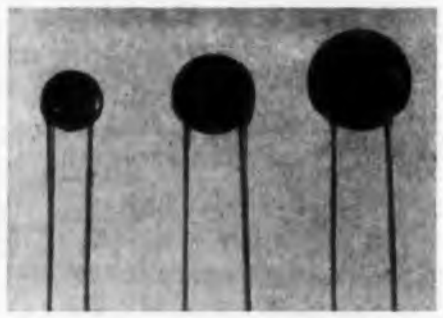
These high speed rotary switches come in a variety of sizes and arrangements. Shown is a double rotor unit with 80 contacts per pole. It operates up to 600 rpm with a life of 1500 hr.

The Daven Co., Dept. ED, Livingston, N.J.

CIRCLE 129 ON READER-SERVICE CARD

Disc Ceramic Capacitors

For printed wiring boards



Cera-Mite disc ceramic capacitors have multiple coating and clean lead wires, yet they seat snugly on printed wiring boards. Suitable for two-sided or plated-through boards, they withstand severe vibration. Units rated to 1000 v are available.

Sprague Electric Co., Dept. ED, North Adams, Mass.

CIRCLE 130 ON READER-SERVICE CARD

Substitution Box

For Zener diode selection

Quick selection of Zener diodes for experimental breadboard circuits is made with the Zeniac substitution box. Choice of 11 basic 1 w silicon Zener diodes covering 3.6 to 30 v range. May be inserted into any breadboard circuit.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

CIRCLE 131 ON READER-SERVICE CARD

Rate Switch

Handles 1.5 amp

With directly-operated switches able to handle a 1.5 amp inductive load, RS01 rate switches come in ranges from 5 to 1000 deg per sec. Differential switch rate is low.

Humphrey, Inc., Dept. ED, 2805 Canon St., San Diego 6, Calif.

CIRCLE 132 ON READER-SERVICE CARD

NEW·PRODUCTS

Ohmmeter

Checks igniters

The model 101-5A ohmmeter safely checks igniters used in solid propellant rockets. Current through the igniter under test cannot exceed 5 ma. The portable circuit tester has an accuracy of ±0.01 ohm the 0 to 5 ohm range, and ±0.02 ohm in the 5 to 30 ohm range.

Allegany Instrument Co., Inc., Dept. ED, 1091 Wills Mountain, Cumberland, Md.

CIRCLE 135 ON READER-SERVICE CARD

Tantalum Capacitors

For hearing aids

Type 160D solid-electrolyte tantalum capacitors are for hearing aid use. Designed to operate from −55 to +65 C.

Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

CIRCLE 136 ON READER-SERVICE CARD

Thermocouple Reference Junction

Long term stability of ±0.15 F

Series R thermocouple reference junction provides maintenance free, constant temperature

oven which encloses the junctions of thermocouple and copper lead wires. Long term stability is ±0.15 F. The unit works in 40 to 120 F ambient temperature range. Nominal temperature set point is 250 F.

Cardinal Instrumentation Corp., Dept. ED, 4201 Redwood Ave., Los Angeles 66, Calif.

CIRCLE 137 ON READER-SERVICE CARD

Test Block Connector

6 or 16 contacts

Right angle pins are designed for dip soldering to a printed circuit board. A choice of 6 or 16 contacts are available for insertion of standard 0.080 test probe. Current rating is 5 amp continuous and 7.5 amp max. Voltage breakdown at sea level is 2200 v rms.

DeJud-Amsco Corp., Electronic Sales Div., Dept. ED, 45-01 Northern Blvd., Long Island City 1, N. Y.

CIRCLE 138 ON READER-SERVICE CARD

Pressure Ratio Control Valve

Sensitive

By means of a sensing mechanism, pressure ratio is measured to within 0.25 per cent over a pressure altitude range of 15 to 1. Type 141VK14 has a rectangular stainless steel diaphragm 0.001 in. thick.

Consolidated Controls Corp., Dept. ED, Bethel, Conn.

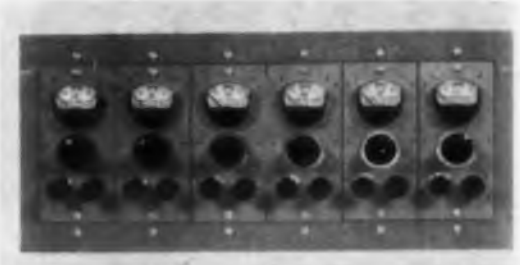
CIRCLE 139 ON READER-SERVICE CARD

* *Quotation from "Designing Electronic Equipment for Maintainability", Machine Design, July 12, 1956.*

NEW PRODUCTS

Sound Level Meter

0 to 15,000 cps frequency range



When used with a complete line of transducers, the DG-600 Dynagage measures sound levels from 50 db to pressures of 100,000 psig over the frequency range from 0 to 15,000 cps. Water cooled transducers can be used from −300 to +6000 F.

Photocon Research Products, Dept. ED, 421 N. Altadena Dr., Pasadena, Calif.

CIRCLE 142 ON READER-SERVICE CARD

Attenuator

Miniature

This miniature attenuator has two switch sections with slip rings and 22 fixed resistors. It withstands vibration up to 2000 cps at 15 g and acceleration of 50 g. Available as 11-position bridged T, 20-position ladder, or 20-position potentiometer. Custom-made in any impedance and attenuation range.

The Daven Co., Dept. ED, Livingston, N.J.

CIRCLE 143 ON READER-SERVICE CARD

Voltage to Frequency Converter

Reading insensitive to noise

Output of 10,000 cps is produced for each dc volt fed into the DY-2210 voltage-to-frequency

converter. Ranges are 1, 10, 100 and 1000 v, at a constant 1-meg inut impedance. The voltage being measured is averaged over the period of a selected counter gate time giving a reading which is insensitive to noise.

Dynac, Inc., Dept. ED, 395 Page Mill Rd., Palo Alto, Calif.

CIRCLE 144 ON READER-SERVICE CARD

Instrument Dryer

Avoids build-up of pressure

Model A-10 dryer conditions 1/2, 1, and 1-1/2 cu ft of air. It maintains pressure equilibrium during altitude changes and prevents dangerous build-up of pressure.

Daco Instrument Co., Dept. ED, Tillary & Prince Sts., Brooklyn 1, N.Y.

CIRCLE 145 ON READER-SERVICE CARD

Miniature Relay

Sensitivities from 20 to 100 mw

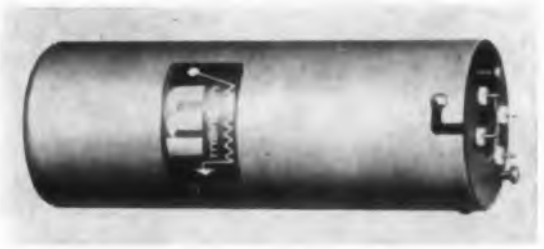
In spdt or dpdt arrangements, type TQ miniature relays are designed to operate on dc coil signals at sensitivities from 20 to 100 mw. Contact rating with resistive load at 28 v dc or 115 v ac is 3 amp with silver contacts, 0.5 amp with palladium or gold alloy contacts.

Comar Electric Co., Dept. ED, 3349 W. Addison St., Chicago 18, Ill.

CIRCLE 146 ON READER-SERVICE CARD

Crystal Oven

Close temperature control



Temperature in the RD-134 crystal oven is kept within ±0.01 deg C at fixed ambient, and ±0.1 C over a 0 to 50 C ambient range. The unit weighs 6 oz and accommodates an HC-6/U crystal holder.

Manson Labs, Inc., Dept. ED, P.O. Box 594, 207 Greenwich Ave., Stamford, Conn.

CIRCLE 311 ON READER-SERVICE CARD

NEW PRODUCTS

Electrolytic Capacitors

Vertically mounted

Type 89D Verti-lytic capacitors are plastic-encased electrolytics for stand-up mounting on printed wiring boards. Terminals are easily identified by the larger size of the negative terminal. Standard ratings range from 1 to 290 μf at 3 v dc to 1 to 25 μf at 50 v dc.

Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

CIRCLE 314 ON READER-SERVICE CARD

Temperature and Pressure Instruments

Indicate, transmit, and control

For indicating, transmitting, and controlling pressure and temperature, series 1450 small-sized instruments are cased in plastic-impregnated fiber glass. Temperature range of the series is −400 to +1000 F; pressure range, 30 in. Hg vacuum to 5000 psi.

Fischer & Porter Co., Dept. ED, 951 Jacksonville Rd., Hatboro, Pa.

CIRCLE 315 ON READER-SERVICE CARD

Vaneaxial Blowers

Single or double stage

Single-stage blower is rated at 7/8 hp at 5600 rpm. It delivers 700 cfm of air at 4 wg static pressure. Two-stage unit has 2-1/4 hp blower and can deliver 400 cfm at 19 wg static pressure.

American-Standard, American Blower Div., Dept. ED, Detroit 32, Mich.

CIRCLE 316 ON READER-SERVICE CARD

Multiple Preset Counters

Up to 30,000 counts per minute

For sequential predetermning, counting, and control, 2020 multiple preset counters can be supplied with various inputs, including photocell, mechanical contacts, or pulses. Units operate up to 30,000 counts a minute.

Freed Transformer Co., Inc., Dept. ED, 1727 Weirfield St., Brooklyn 27, N.Y.

CIRCLE 317 ON READER-SERVICE CARD

Phase Angle Meter

Accuracy of ±1 deg

Model 120 offers direct reading 0 to 360 deg with accuracy ±1 deg, 20 to 20,000 cps, and makes possible continuous, unattended monitoring of phase angle by use of chart recorder.

Control Electronics Co., Inc., Dept. ED, Huntington Station, N.Y.

CIRCLE 318 ON READER-SERVICE CARD

Glass Trimmer Capacitor

0.5 to 5 μμf range

The Atlee direct traverse expanding core variable capacitor has a range of 0.5 to 5 μμf. It stands extreme vibration and shock and has good retrace characteristics. A full-floating piston assures positive mechanical alignment. These trimmer units are available in glass dielectric and silver plated brass.

Atlas E-E Corp., Dept. ED, 47 Prospect St., Woburn, Mass.

CIRCLE 319 ON READER-SERVICE CARD

NEW PRODUCTS

Regenerative Repeater

Reshapes signals

The Model 605C start-stop regenerative repeater is designed for use on telecommunication circuits where it reshapes and retimes distorted incoming signals. All components are packaged as plug-in subassemblies. A plug-in speed tuning network is furnisher for 60, 75, or 100 wpm operation.

Encapsor Products Corp., Dept. ED, 46 S. Bayles Ave., Port Washington, N.Y.

CIRCLE 322 ON READER-SERVICE CARD

Cathode Ray Tube

11 in. from screen to base

For TV receivers, SF short crt's come in two versions: the 17DAP4/SF17 17-in. rectangular tube, less than 11 in. long from screen to base; and the 21EAP4/SF21A 21-in. rectangular tube, less than 13 in. long. Aluminized, the tubes need no ion trap magnet.

Philco Corp., Lansdale Tube Co. Div., Dept. ED, Church Rd., Lansdale, Pa.

CIRCLE 323 ON READER-SERVICE CARD

Clutch-Brake

Operates in 1 msec

This line of clutches and brakes operates within 1 msec. Model C-400 illustrated has a full

torque of 30 oz-in. at 12 v dc input. Torque output is linear with respect to voltage or current input.

Rainbow Engineering Co., Inc., Dept. ED, 7212 New Hampshire Ave., Washington 12, D.C.

CIRCLE 324 ON READER-SERVICE CARD

DC Microvolt-Ammeter

High sensitivity

Model 425A dc microvolt-ammeter measures dc voltages from 1 μv to 1 v and dc currents from 1 μμa to 3 ma. Accuracy is ±3 per cent full scale. Full scale sensitivity is ±10 μv and ±10 μμa. Drift is under μv per hr.

Hewlett-Packard Co., Dept. ED, 275 Page Mill Rd., Palo Alto, Calif.

CIRCLE 325 ON READER-SERVICE CARD

PNP Transistors

Medium and high power switching

Series 2N670 germanium pnp alloy-junction transistors are for use in high-voltage, high-current pulse amplifier and switching circuits. The series is rated at 40 v for emitter-base, collector-base, and collector-emitter breakdown, 2 amp maximum collector current, and continuous maximum power dissipation to 1 w.

Philco Corp., Lansdale Tube Co. Div., Dept. ED, Church Rd., Lansdale, Pa.

CIRCLE 326 ON READER-SERVICE CARD

Adjustable Polystyrene Capacitor

Rated at 200 v dc

Precisely adjustable, this 1 μf polystyrene capacitor may be trimmed ±1.5 per cent from nominal value. Rated voltage is 200 v dc and dissipation factor at 1000 cps is 0.01 to 0.05 per cent. The unit operates from 1 to 65 C.

Corson Electric Mfg. Corp., Dept. ED, 540 39th St., Union, N.J.

CIRCLE 327 ON READER-SERVICE CARD

NEW PRODUCTS

Phasemeter

100 cps to 5 mc

The V-71 phasemeter provides a simple compact and inexpensive measuring and phase calibrating instrument over a very wide frequency spectrum of approximately 100 cps to 5 mc. The instrument offers a 360 deg continuous phase-shifting system utilizing a Variogon phase-shifting transducer.

Nilsen Mfg. Co., Dept. ED, Addison, Ill.

CIRCLE 331 ON READER-SERVICE CARD

Preset Counter

Transistorized

Preset range of this transistorized counter is 0 to 180,000 counts per minute with instantaneous reset. Totalizing speed is 0 to 300,000 counts per minute. The unit features direct reading and long service life.

Dynapar Corp., Dept. ED, 5150 Church St., Skokie, Ill.

CIRCLE 332 ON READER-SERVICE CARD

Oscillograph

Features low price

Model ER-22 low-priced direct-writing oscillograph will record signals from dc to 60 cps. Available

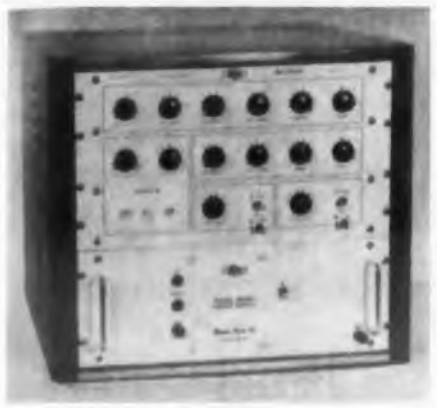
with coil resistances from 215 to 4000 ohms and with a resonant frequency of 30 cps, the pen galvanometer has a spring-leaf flexure and voice-coil design. Coil provides a full scale deflection of 40 mm with 2 per cent linearity.

Mandrel Industrial Instruments, Inc., Dept. ED, 5134 Glenmont Drive, Houston 36, Texas.

CIRCLE 334 ON READER-SERVICE CARD

Double Pulse Generator

200 cps to 2 mc



Model 3460 A double pulse generator provides two separate or mixed rise time outputs at variable repetition rates. Repetition rates are variable in four decade ranges from 200 cps to 2 mc.

Electro-Pulse, Inc., Dept. ED, 11861 Teale Street, Culver City, Calif.

CIRCLE 357 ON READER-SERVICE CARD

Power Supply

300 to 1000 cps output

Model AE-400 power supply is variable from 300 to 1000 cps. It is designed as a power source for testing equipment.

Aeronautical Electronics Sales Co., Dept. ED, 3101 Pico Blvd., Santa Monica, Calif.

CIRCLE 358 ON READER-SERVICE CARD

NEW PRODUCTS

Voltage Monitors

Accuracy within 2 per cent

These voltage monitors are made for any level from 1 mv to 500 v, either ac or dc. Most ranges have accuracy within 2 per cent. More sensitive ranges at reduced accuracy go down to 0.1 mv or 0.2 μa. Ac ranges below 250 mv include a small step-up transformer.

Assembly Products, Inc., Dept. ED, Dillon Rd., Desert Hot Springs, Calif.

CIRCLE 363 ON READER-SERVICE CARD

Dynamometer

Measures small motor torque

For torque measurements on gear trains, potentiometers, and small instrument and servo motors, the 10-B dynamometer has ±3 per cent accuracy. It measures torques between 0.1 and 15 in.-oz. at any speed where power developed is 20 w or less. The adjustable block holds motors up to 3 in. in diameter.

Bischof Die and Engraving Co., Dept. ED. 1405 16th St., Racine, Wis.

CIRCLE 364 ON READER-SERVICE CARD

Miniature Relay

Dielectric strength of 1000 v ac

Unit can withstand temperatures of —65 to 125 C and vibration of 2000 cps at 20 g. Dielectric strength is 1000 v ac, 750 v ac across contact gaps.

Wheelock Signals, Inc., Dept. ED, Long Branch, N.J.

CIRCLE 365 ON READER-SERVICE CARD

Recorder

Takes 4 nonlinear inputs

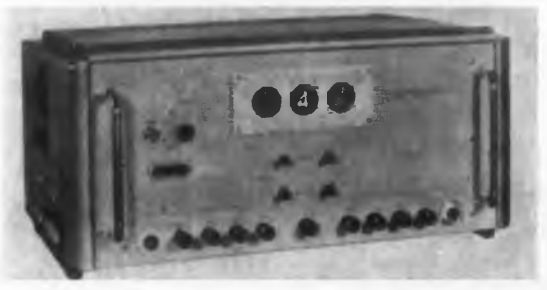
This recorder takes four nonlinear inputs, comes with differential transformer or slidewire type receiver. Four records are possible on one circular chart. Variation for ±20 per cent supply voltage fluctuation is 0.05 per cent.

Hays Corp., Dept. ED, Michigan City, Ind.

CIRCLE 148 ON READER-SERVICE CARD

Resolver

For testing servo components



For testing servo components and systems, the JX746A resolver provides simultaneous identical phase shifts to each phase of a 4-phase reference signal. Input per phase is 10 v rms; output, 10 or 50 v rms at any phase angle from 0 to 360 deg.

Solartron, Inc., Dept. ED, 530-532 Cooper St., Camden 2, N.J.

CIRCLE 149 ON READER-SERVICE CARD

Retractible Cable

Has new type winding

The winding direction is reversed in the middle of this multiconductor retractible cable. When the cable is extended, the twisting forces are transmitted to the reverse point, and there is no strain on the wires where they terminate. A few ounces will extend a cable of 100 wires.

Organic Development Corp., Dept. ED, P.O. Box 415, Garden Grove, Calif.

CIRCLE 150 ON READER-SERVICE CARD

NEW PRODUCTS

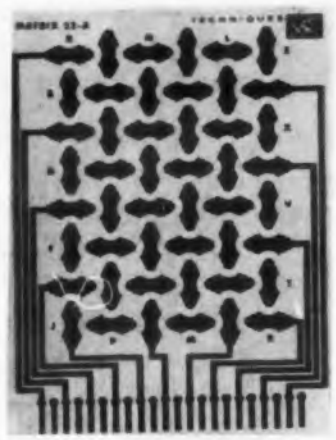
Digital Recorder-Reproducers

Speeds from 7-1/2 to 100 ips

Standard speeds of the 5-680 series digital magnetic tape recorder-reproducers range from 7-1/2 to 100 ips. Speeds of 0.4, 0.8, and 150 ips are also available. Start and stop times are less than 3 msec with 0.05 in. accuracy in both forward and reverse directions.

Consolidated Electrodynamics Corp., Dept. ED, 300 N. Sierra Madre Villa, Pasadena, Calif.

CIRCLE 153 ON READER-SERVICE CARD



Matrix Board

22 terminals

Over 100 circuit elements can be mounted on this printed circuit 22 terminal plug-in board. The No. M-22A board is two-sided and provides for a total of 944 possible connections to a dual printed circuit receptacle. Of XXXP laminate, 1 oz copper, it measures 5-1/2 x 4 x 1/16 in.

Techniques, Dept. ED, 52 Jackson Ave., Hackensack, N.J.

CIRCLE 154 ON READER-SERVICE CARD

Differential Transformer

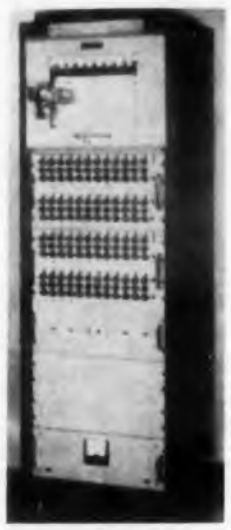
Remote angular position indicator

Model R4BIS rotary variable differential transformer is suitable for continuous measurement and remote indication of the angular position of rotary mechanical elements. It features a fifth terminal pin in the center of the hermetic header. The pin projects about 0.1 in. above the other terminals and is connected to the junction point of

the differential secondaries. The unit is electromagnetically shielded.

Schaevitz Engineering, Dept. ED, P.O. Box 505, Camden 1, N.J.

CIRCLE 156 ON READER-SERVICE CARD



Strain Gage Recording Systems

Modular construction

Strain gage recording systems for balancing, calibrating, controlling, scanning, and recording the output of 24 to 96 channels. Modular construction permits assemblies in multiples of 24 channels. Strain values are recorded directly on multi-point strip chart recorders. Two basic systems are available: the B system which prints strain values in sequence together with channel number, and the C system which plots strains vs load for each channel.

B & F Instruments, Inc., Dept. ED, 3644 N. Lawrence St., Philadelphia 40, Pa.

CIRCLE 157 ON READER-SERVICE CARD

Potentiometer

Provides high power dissipation at 200 C

Miniature model 875T precision potentiometer offers up to 0.06 per cent resolution with a standard linearity of 0.5 per cent. A wirewound, servo mount unit, it provides high power dissipation at temperatures to 200 C. Resistances range from 200 ohms to 100 K per section, and up to four sections can be ganged on a common shaft. Torque is 0.1 oz-in.

G. M. Giannini & Co., Inc., Dept. ED, 918 E. Green St., Pasadena 1, Calif.

CIRCLE 158 ON READER-SERVICE CARD

NEW PRODUCTS

Pulse Transformer Kit

Contains wound core units

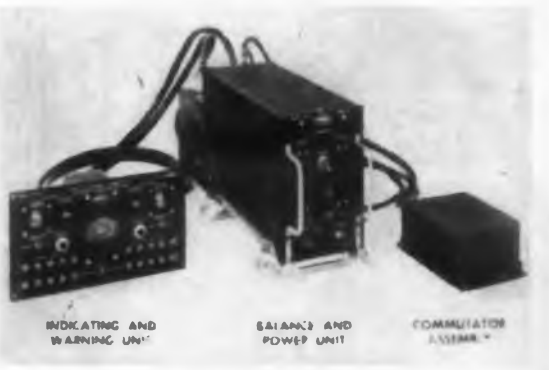
The H-58 kit includes one each of all H-45 through H-58 series pulse transformers. The units are wound core structures suited to service from —70 to +130 C. All 13 transformers are 1:1:1 type with pulse width ranging from 0.05 to 25 μsec. They are hermetically sealed by vacuum molding to meet MIL-T-27A Grade 5 specs.

United Transformer Corp., Dept. ED, 150 Varick St., New York 13, N.Y.

CIRCLE 161 ON READER-SERVICE CARD

Temperature Monitor

Airborne



For monitoring critical temperatures sequentially in as many as 20 places, the CTI-10-2D flight-safety device uses combined magnetic and transistor circuitry. It requires no external amplification of signals. Range can be selected anywhere between 0 and 1600 F. Accuracy is ±2 per cent.

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

CIRCLE 162 ON READER-SERVICE CARD

Radome Boresight-Error System

Measures radar beam deflection

Model 150C radome boresight-error system measures radar beam deflections through aircraft and missile radomes and plots them in milliradians with an accuracy of ±0.1 milliradian. It also measures radome transmission with ±1 per

cent and plots antenna patterns on a linear scale with ±0.5 db accuracy. Measurements meet MIL-R-7705A(ASG) requirements.

California Technical Industries Div. of Textron Inc., Dept. ED, 1421 Old County Rd., Belmont, Calif.

CIRCLE 163 ON READER-SERVICE CARD

Wheatstone Resistance Bridge

0.02 per cent accuracy

For critical resistance measurements, the model 230-R Wheatstone resistance bridge has an accuracy of better than 0.02 per cent for most measurements from 0 to 12,000 megohms. The lowest range has a resolution of 10 micro-ohms per dial division. The unit features improved ratio switching, adjustable ratios, internal guarding, and roving decimal point.

Electro-Measurements, Inc., Dept. ED, Portland, Ore.

CIRCLE 164 ON READER-SERVICE CARD

Tape Recorder

14-channel

Remote speed control, transistorized recording and playback modules, and a tape transport unit with dynamic braking are provided in the C-100 instrumentation tape recorder. With speeds between 3-3/4 and 60 ips, the system handles up to 14 tracks at once.

Minnesota Mining & Mfg. Co., Mincom Div., Dept. ED, 2049 S. Barrington Ave., Los Angeles 25, Calif.

CIRCLE 165 ON READER-SERVICE CARD

NEW PRODUCTS

Readout Oscillograph

Speed Range of 1/2 to 50 ips

This model, the D/R 616, has a recording speed range of from 1/2 to 50 ips with writing speeds above 30,000 ips. Photographic record of the galvanometer require no chemical development. A light beam interrupter type of trace identification has been incorporated into the instrument to provide identification of the galvanometer traces.

Midwestern Instruments, Dept. ED, Tulsa, Okla.

CIRCLE 168 ON READER-SERVICE CARD

Miniature Magnetic Amplifier

Controlled by 5 mw power

With a control source of 5 mw, series 80 toroidal magnetic amplifier components permit control of the power flow from a 400 cps power source to a load of up to 12 w, ac or dc. Standard output voltages range from 30 to 300 v ac or dc. Control voltages are from 0.7 to 20 v dc. The units are 1.5 in. in diameter and 1.25 in. high.

Arnold Magnetics Corp., Dept. ED, 4613 W. Jefferson Blvd., Los Angeles 16, Calif.

CIRCLE 169 ON READER-SERVICE CARD

Connectors

For rf coaxial cable

Designed for microwave service, these small Cub series rf coaxial cable connectors handle frequencies up to 10,000 mc with low vswr. Impedance matched for 50, 75, and 95 ohm cable. There is no change in contact position from −65 to +300 F. Dielectric strength is 2000 v dc at sea level.

Dage Electric Co., Inc., Dept. ED, 67 N. Second St., Beech Grove, Ind.

CIRCLE 170 ON READER-SERVICE CARD

Contact Assemblies

Eliminate soldering and welding

These assemblies, designed for use with printed commutators, potentiometer windings, slip ring assemblies and printed rotary switches, are available in a line of standard molded brush assemblies. Advantages are a complete single or multiple brush assembly and elimination of welding or soldering.

The J. M. Ney Co., Dept. ED, P.O. Box 990, Hartford 1, Conn.

CIRCLE 171 ON READER-SERVICE CARD

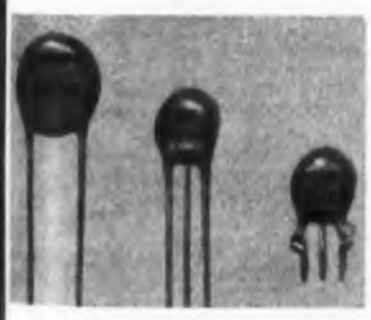
Dual TR Tube

For X-band use

Rated at 200 kw, the MA-338 dual TR tube is for use in radar duplexers over the 8500 to 9600 mc band. Maximum recovery time is 5 μsec and vswr is 1.2 over the entire bandpass. Temperature range is —55 to +85 C.

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

CIRCLE 172 ON READER-SERVICE CARD



R-C Networks

Discs for printed circuit use

The capacitor sections of Multi-Comp R-C printed circuit discs are available in tolerances of +50 and —20 per cent. The resistors in the units have tolerances of ±20 per cent. The discs are rated at 100 v dc and withstand a 250 v dc test for 5 sec. They are designed to operate at a maximum of 85 C.

Sprague Electric Co., Dept. ED, North Adams, Mass.

CIRCLE 173 ON READER-SERVICE CARD

NEW PRODUCTS

Ka-Band Magnetrons

Wide range

Models MA-210A, B, C, magnetrons tune 500 mc segements in the 34.2 to 35.5 kmc band. The tuning range of each tube is as follows: MA-210A 34.2 to 34.7 kmc; MA-210B 34.6 to 35.1 kmc; MA-210C 35.0 to 35.5 kmc.

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

CIRCLE 176 ON READER-SERVICE CARD

Frequency Sensing Cut-off Relay

Provides inverse time response

For protecting electronic equipment against damage from low frequency, model BS-5003 consists of a high-pass filter feeding a thermal sensing relay. Due to the inverse time characteristic of the thermal relay, the unit disconnects equipment only after the low frequency condition has existed long enough to be significant. The relays have time constants from 6 sec to several minutes. Nominal cut-off frequency is 370 cps.

G-V Controls Inc., Dept. ED, 28 Hollywood Plaza, East Orange, N.J.

CIRCLE 177 ON READER-SERVICE CARD

Miniature Crystals

Operative from 300 kc to 125 mc

For operation from 300 kc to 125 mc, this miniature crystal is packaged in an HC 18/u case. The crystal wafer is suspended between the two terminals.

Sherold Crystals, Inc., Dept. ED, 1512 McGee Trafficway, Kansas City, Mo.

CIRCLE 179 ON READER-SERVICE CARD

Silicon Rectifiers

Ratings up to 3 amp at 600 v

This line of silicon rectifiers includes home entertainment and industrial models. The former are rated to 500 ma dc at piv's to 500 v and 100 C ambient. The latter have ratings to 3 amp at 600 v and 150 C ambient.

International Telephone and Telegraph Corp., Dept. ED, 100 Kingsland Rd., Clifton, N.J.

CIRCLE 180 ON READER-SERVICE CARD

Variable DC Power Supply

Transistorized

Model 550 regulated dc power supply provides 3 to 45 v continuously variable at 0 to 5 amp. Output impedance is 0.01 ohm and ripple is less than 8 mv. The unit incorporates overload protection.

Sila-Kon Eng'r Co., Dept. ED, 605 Hoyt Ave., El Monte, Calif.

CIRCLE 181 ON READER-SERVICE CARD

NEW PRODUCTS

Panel Light
Transistorized

Panel display light Type TL-1 can be installed without solder in 30 sec. Using a NE-2E neon lamp, it has a self-contained transistor circuit that needs 3 v signal to control the light. Lamp circuit requires 200 v dc at 0.5 ma.

Transistor Electronics Corp., Dept. ED, 3357 Republic Ave., Minneapolis 26, Minn.

CIRCLE 185 ON READER-SERVICE CARD

Microwave Power Generator
1125 w peak power

An integrated packaged microwave power generator, the PGM-100 has a maximum power output of 800 w cw at 2450 mc. Peak power is 1125 w. The unit operates on 120 cps pulsed or 10 per cent modulated dc.

Raytheon Mfg. Co., Dept. ED, 100 River St., Waltham 54, Mass.

CIRCLE 186 ON READER-SERVICE CARD

Image Orthicon Tube
Meets MIL-E-5272A standards

At 5 g acceleration, 50 to 500 cps, the WL-7198 image orthicon tube shows horizontal resolution of 350 lines with 3 x 10^{-2} ft-c illumination. Per MIL-E-5272A, it operates under 10 g acceleration up to 500 cps.

Westinghouse Electric Corp., Electronic Tube Div., Dept. ED, P.O. Box 284, Elmira, N.Y.

CIRCLE 187 ON READER-SERVICE CARD

Diode Insulator Mounts

Rated to 4000 v

Insulator mounts, rated up to 4000 v, are designed for high altitude operation and efficient heat transfer to chassis or ground. In over-all thermal drop, the mounts are rated better than 1 deg C per watt.

Thermo Materials, Inc., Dept. ED, 4040 Campbell Ave., Menlo Park, Calif.

CIRCLE 188 ON READER-SERVICE CARD

Soldering Iron

Has automatic temperature control

This soldering iron automatically controls its own temperature within ±2 per cent. Its tip contains a special alloy that gains and loses magnetic qualities with changes in temperature, making or breaking contact.

Weller Electric Corp., Dept. ED, Easton, Pa.

CIRCLE 189 ON READER-SERVICE CARD

Rotary Selector Switch

Holds four 12-position wafers

Model BD2E rotary selector switch, actuated by a Ledex 2 solenoid, holds up to four 12-position wafers. Operating voltage, 3 to 300 v dc; minimum pulse length, 20 msec. The unit can be self-stepped or externally impulsed.

G. H. Leland, Inc., Dept. ED, 123 Webster St., Dayton 2, Ohio.

CIRCLE 190 ON READER-SERVICE CARD

NEW PRODUCTS

Linear Accelerometer

Frictionless operation

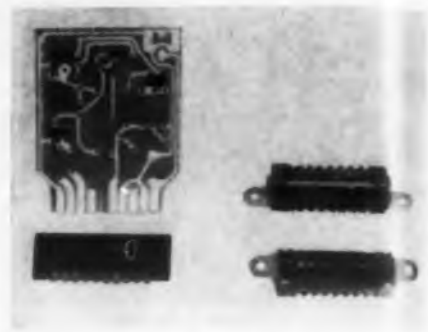
Type LA-600 ac linear accelerometer eliminates friction. A nonpendulous seismic mass on a frictionless spring suspension, it incorporates an ac variable reluctance type pick-off. The unit is insensitive to cross-coupling accelerations both at null and under an acceleration along its sensitive axis. It also has a near-constant damping ratio from −65 to +250 F. Full scale range is ±0.5 to +40 g; full scale output, up to 10 v, 400 cps; threshold, 0.0001 g; cross-axis sensitivity, less than 0.5 per cent.

Minneapolis-Honeywell, Boston Div., Dept. ED, 40 Life St., Boston 35, Mass.

CIRCLE 194 ON READER-SERVICE CARD

Modular Connectors

Permit maximum power applications



Uno-Link connectors are available in variations for standard wire harness arrangements and printed circuit card receptacles. The mating in-line arrangement of plug pins and contacts utilizes nesting insulator segments, two to thirty of which can be combined. The modular construction permits maximum power applications in high density packaging requirements.

Methode Mfg. Corp., Dept. ED, 7447 W. Wilson Ave., Chicago 31, Ill.

CIRCLE 195 ON READER-SERVICE CARD

Power Supply

18 w dc output

Inputs for the 137A/PS power supply are 115 v ±10 per cent and 60 through 400 cps. Any cycle in this range produces a dc output of 18 w regulated within 0.5 per cent at +220 v and −220 v. Ripple is 0.005 per cent with 60 cps input. There is 6.3 v ac at 5 amp available.

Land-Air, Inc., Dept. ED, 7444 W. Wilson Ave., Chicago 31, Ill.

CIRCLE 197 ON READER-SERVICE CARD

Filters

50 db attenuation at null frequency

Suitable for mounting on printed circuit boards, Twin-T filters have null frequencies of 30, 60, 120, 400, and 800 cps. Attenuation at null frequency is 50 db or more. Impedance levels range from 53 to 850 K.

T T Electronics, Inc., Dept. ED, P.O. Box 180, Culver City, Calif.

CIRCLE 198 ON READER-SERVICE CARD

TWT Amplifier

For use with type A 1079 tube

Designed for use with RCA type A 1079 tube, the TWT-10 CM traveling wave tube amplifier also accommodates six other RCA types covering a 1.1 to 4.3 kmc range. The amplifier features helix protection and noise figures under 7 db over a wide band of frequencies.

LEL, Inc., Dept. ED, 380 Oak St., Copiague, N.Y.

CIRCLE 199 ON READER-SERVICE CARD

Machlett ML-6198 Vidicon

Industrial Television Camera Tube

Machlett Laboratories, Inc. makes available to the designer the ML-6198, a small television camera tube intended primarily for industrial use. Tube design includes a photoconductive layer as a light sensitive element characterized by a spectral response approaching that of the eye.

ML-6198 has a resolution capability of approximately 600 lines. Advantages include high picture quality, uniformity of signal, maximum tube cleanliness and low microphonics.

Pertinent technical data follow:

General Characteristics

Focusing Method	Magnetic
Deflection Method	Magnetic
Overall Length	6¼" ± ¼"
Greatest Diameter, excluding side tip	1.125" ± 0.010"
Maximum Radius, including side tip	0.800"
Bulb	T-8
Operating Position	Approx. Horizontal or faceplate up

Typical operation

Faceplate Illumination (Highlight)	10 to 20 ft-c
Signal-Electrode Voltage	20 to 70 volts
Grid No. 4 (Decelerator) & Grid No. 3 (Beam Focus) Voltage	250 to 300 volts
Grid No. 2 (Accelerator) Voltage	300 volts
Grid No. 1 Voltage (For picture cutoff)	−45 to −100 volts
Highlight Signal-Output Current	0.1 to 0.2μ amp
Maximum Dark Current	0.02μ amp
Uniform 2870° K. Tungsten Illumination on Tube Face to Produce Signal-Output Current of 0.1 to 0.2μ amp	3 to 10 ft-c
Average "Gamma" of Transfer Characteristic for Signal-Output Current between 0.02 and 0.2μ amp	0.65

For full technical data on this or any other Machlett tube type, write:
Machlett Laboratories, Inc., 1063 Hope Street, Springdale, Connecticut

CIRCLE 200 ON READER-SERVICE CARD

NEW PRODUCTS

Capacitance Bridge

Three-terminal

Designed to calibrate capacitive, aircraft, and fuel-gage testers, Type P-582 3-terminal bridge is also suited to general capacitance measurements at 400 cps. Capacitance range is 5 μμf to 0.11 μf with ±0.1 per cent accuracy over most of the range. Dissipation factor range is 0 to 0.11 with an accuracy of ±2 per cent of reading ±0.0002.

General Radio Co., Dept. ED, 275 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 206 ON READER-SERVICE CARD

Selenium Rectifiers

High density

Six types of selenium rectifiers cover current ratings to 650 ma and are rated at 130 v ac. An exception, the RR659, is a 650 ma, 195 v ac unit for color TV replacement. As an example of the smaller cell sizes, a 500 ma unit has 1.6 in. square cells.

Radio Receptor Co., Inc., Dept. ED, 240 Wythe Ave., Brooklyn 11, N.Y.

CIRCLE 207 ON READER-SERVICE CARD

Binary Decoder

Can eliminate memory circuits

This binary decoder can eliminate decoding matrices and memory circuits. Its design utilizes a pulse to energize and a ground pulse to de-energize the circuit. This permits rapid scanning of the input terminals and unlimited retention of

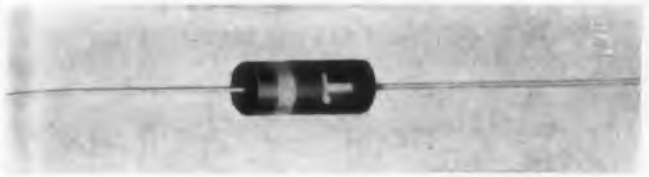
information. New data may be impressed over old without a clearing signal.

Globe Industries, Inc., Dept. ED, 525 Main St., Belleville 9, N.J.

CIRCLE 208 ON READER-SERVICE CARD

Silicon Diode References

Low temperature coefficients



Axial lead 2-w packages, these silicon diode references have temperature coefficients down to 0.001 per cent per degree C. They provide a stable reference voltage from —55 to +100 C and may be operated in any position without voltage variation.

Transitron Electronic Corp., Dept. ED, Wakefield, Mass.

CIRCLE 209 ON READER-SERVICE CARD

Vibration Tester

For electronic equipment

The Goodmans 390A vibration tester operates on the principle of an electro-dynamic shaker driven by a power oscillator. It tests electronic equipment for fatigue and structural life.

Solarton, Inc., Dept. ED, 10761 Burbank Blvd., North Hollywood, Calif.

CIRCLE 210 ON READER-SERVICE CARD

Magnetostrictive Delay

Delay time of 130 μsec

With a nominal delay of 130 μsec, model 140 magnetostrictive delay line features continuous variation of delay, medium impedance, and insensitivity to temperature changes. Applications include high access rate temporary storage for computers.

Deltime, Inc., Dept. ED, 608 Fayette Ave., Mamaroneck, N.Y.

CIRCLE 211 ON READER-SERVICE CARD

NEW PRODUCTS

Preset Counters

Modular design

Series 320 preset electronic counters are available in every size from 2 to 6 digits. They consist of a pluggable amplifier and control unit plus any combination of pluggable 2 and 3 decade modules. Maximum rate is 5000 counts per second.

Erie Resistor Corp., Dept. ED, 644 W. 12th St., Erie, Pa.

CIRCLE 214 ON READER-SERVICE CARD

RF Power Dividers

100 to 400 mc

General purpose 100 to 200 mc and 200 to 400 mc dividers for connecting 2 to 12 loads to one source. Input vswr is less than 1.25; loss about 0.1 db; power rating 500 w at 150 F.

Adams-Russell Co., Inc., Dept. ED, 292 Main St., Cambridge 42, Mass.

CIRCLE 215 ON READER-SERVICE CARD

Stitched Wiring

Modular circuit method

In this method, wire is stitched to a standard terminal board with eyelets or eyelet terminals to form complete circuits. Insulating sleeves allow wires to be crossed so that all wiring is stitched to one side of the board. Changes may be made by cutting wires and soldering in new leads.

Electronic Techniques, Inc., Dept. ED, 13761 Saticoy St., Van Nuys, Calif.

CIRCLE 216 ON READER-SERVICE CARD

Mercury Push Button Switch

No contact bounce

Trapped pools of mercury slide in and out of contact to operate this push button switch. The spdt break before type unit has no contact bounce or chatter. It mounts in any position and stands 15 g shock and vibration.

Electrosonic Engineering Co., Inc., Dept. ED, 2120 Pontius Ave., Los Angeles, Calif.

CIRCLE 217 ON READER-SERVICE CARD

Directional Couplers

For 100 to 1000 mc use

For 100 to 1000 mc use, series DC directional couplers come with type N, BNC, and TNC connectors. Directivity is 20 db minimum above coupling factor. Vswr is 1.3 maximum in the primary arm and 1.5 maximum in the secondary. Coupling factor is 30 db at 100 mc and 10 db at 1000 mc.

Maury & Associates, Dept. ED, 10373 Mills Ave., Pomona, Calif.

CIRCLE 218 ON READER-SERVICE CARD

Accelerometers

Tri-axial

Three mutually perpendicular sensing elements are mounted in these small accelerometers. The units have 25 kc frequencies and 5 to 9 mv per g sensitivities. Model 2230 operates to 200 F; model 2243 to 500 F.

Endevco Corp., Dept. ED, 161 E. California St., Pasadena, Calif.

CIRCLE 219 ON READER-SERVICE CARD

Shorting Switch

Assures one position

Switch shorts out every position but the one in use. Useful in the metering of a single position or for the gathering of pertinent information on it.

The Daven Co., Dept. ED, Livingston, N. J.

CIRCLE 220 ON READER-SERVICE CARD

Dual Servo Multiplier

Modular construction

Providing a static nulling error of 0.02 per cent, the DLI-101 servo multiplier has two channels, each of which multiply three variables by a fourth. Its automatic gain control feature maintains constant loop gain for reference voltage variation in the 2 to 100 v range. The unit is composed of Digitrol plug-in building blocks.

Electro Precision Corp., Dept. ED, P.O. Box 669, Arkadelphia, Ark.

CIRCLE 221 ON READER-SERVICE CARD

NEW PRODUCTS

Amplifiers

Recording type

These amplifiers are airborne instruments designed to amplify signals from high impedance transducers. Operating at a temperature range of −65 to +240 F, models F-510TU and F-528LU have extremely high input impedance.

Gulton Industries, Inc., Dept. ED, 212 Durham Ave., Metuchen, N.J.

CIRCLE 226 ON READER-SERVICE CARD

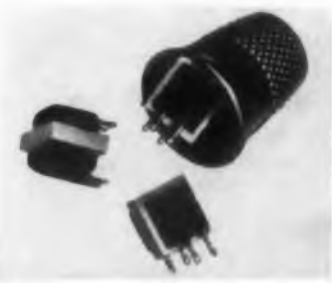
Panel Meter

Highly readable

Panel meter MM-5 occupies panel space of conventional 4-5/8 in. meters and mounting space of ASA/MIL 3-1/2 in. units, yet provides greater scale length and readability. Tracking can be held to 0.5 per cent of full scale, when plotted linearly or with a protractor reference for deflection angles up to 100 deg.

Marion Electrical Instrument Co., Dept. ED, Grenier Field, Manchester, N.H.

CIRCLE 227 ON READER-SERVICE CARD



Transformers

Miniature

Twenty of these transformers fit into a cubic inch. Suited for missile and transistor circuits, they are uncased, encapsulated, or molded plug-in type.

Palo Alto Engineering Co., Dept. ED, 620 Page Mill Rd., Palo Alto, Calif.

CIRCLE 228 ON READER-SERVICE CARD

Drift-Free

measurements of D-C voltage, current and resistance...

with L&N's Stabilized R-I-E Meter

Now you can make fast, drift-free measurements of voltage, current and resistance with L&N's 5620 R-I-E Meter. Applications include: voltage measurements of vacuum tube electrodes . . . current measurements in photo-cells, ion chambers . . . resistance measurements of high value resistors, volumetric or surface resistance of samples of small sizes, etc.

Ranges—Volts D-C (4): 0-0.5 to 0-500. Current (6): 0-5 to $0\text{-}5\times10^{-5}$ microamperes. Resistance (6): 2×10^{2} to 2×10^{8} megohms.

Limits of Error—Current and voltage range, ±3% of full scale. Resistance range, ±6% of reading for meter reading of 20 or lower.

Amplifier Output—For use as pre-amplifier for Speedomax® G or H 10 mv Recorders. Provides 10 mv across 10Ω corresponding to full scale on any selected range.

Controls—Range Switch: 11 positions. Function Switch: 5 positions. Polarity Reversing Switch. Voltage Key: Internal power supply, 10 or 100 volts.

Power Supply—120 volts, 50 or 60 cycles.

Case—Metal, 7½" (h) x 10½" (w) x 10¼" (d), with cover.

Price—$440.00, f.o.b. Phila. or North Wales, Pa. (subject to change without notice). Specify List No. 5620 when ordering from nearest L&N Sales Office or from Leeds & Northrup Co., 4908 Stenton Ave., Phila. 44, Pa.

LEEDS & NORTHRUP
Instruments — Automatic Controls • Furnaces

CIRCLE 230 ON READER-SERVICE CARD

Proportional Amplifiers

Control 90 w

Designated the PA5A and the PA5C, these magnetic amplifiers are capable of proportional control of up to 90 w output power with input power of a few milli-microwatts. The PA5A has a cylindrical case, the PA5C a rectangular case to meet different mounting requirements.

Magnetic Controls Co., Dept. ED, 6405 Cambridge St., Minneapolis 16, Minn.

CIRCLE 231 ON READER-SERVICE CARD

Relays

With AN connectors

Series SL-AN relays have AN connectors, are hermetically sealed, and are available up to 4pdt. Contacts are rated up to 10 amp for a wide range of voltages.

Hi-G, Inc., Dept. ED, Bradley Field, Windsor Locks, Conn.

CIRCLE 232 ON READER-SERVICE CARD

CABLE FERRULES.—For easy termination of Zippertubing and other sleeving, ZT ferrules permit attachment or grounding to standard AN plugs and connectors.

The Zippertubing Co., Dept. ED, 752 S. San Pedro St., Los Angeles 14, Calif.

CIRCLE 233 ON READER-SERVICE CARD

MOTOR ASSEMBLY.—Contains a gearbox, clutch, and reset mechanism capable of 7 million to 1 reduction.

Yuba Consolidated Industries, Inc., Dept. ED, 351 California St., San Francisco 4, Calif.

CIRCLE 234 ON READER-SERVICE CARD

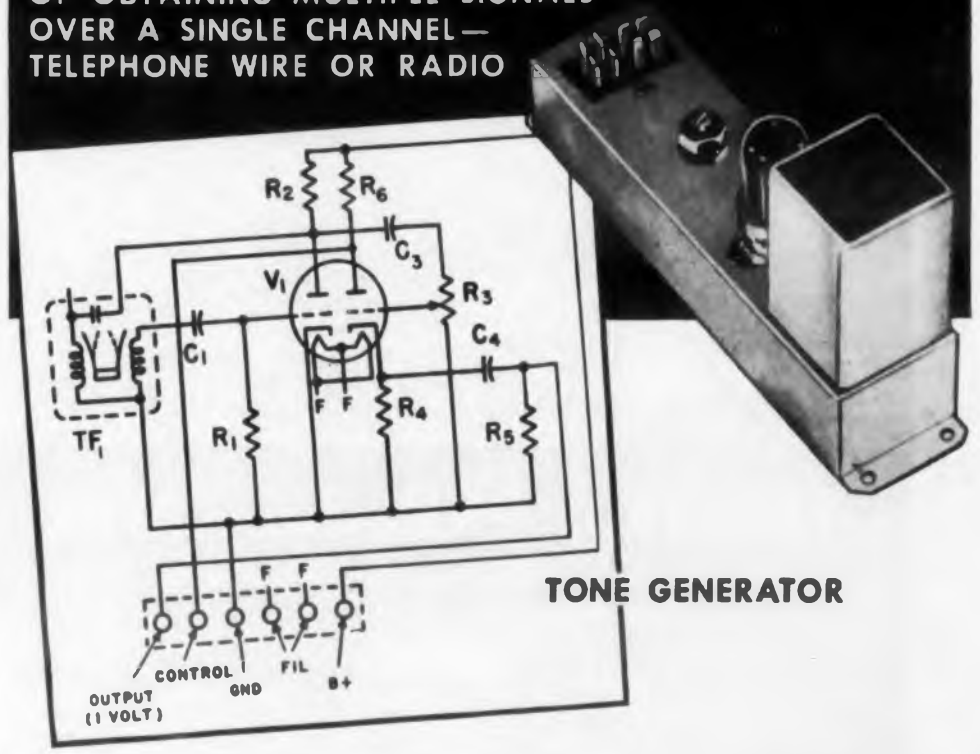
RECEIVING TUBE.—The 6/12DT5 9-pin miniature power pentode is for use as a vertical output deflection amplifier in 110 deg TV sets.

Westinghouse Electric Corp., Electronic Tube Div., Dept. ED, Elmira, N.Y.

CIRCLE 235 ON READER-SERVICE CARD

BIDDLE TONE SIGNALLING EQUIPMENT ...Packaged Circuits

A LOW COST, FLEXIBLE MEANS OF OBTAINING MULTIPLE SIGNALS OVER A SINGLE CHANNEL— TELEPHONE WIRE OR RADIO



TONE GENERATOR

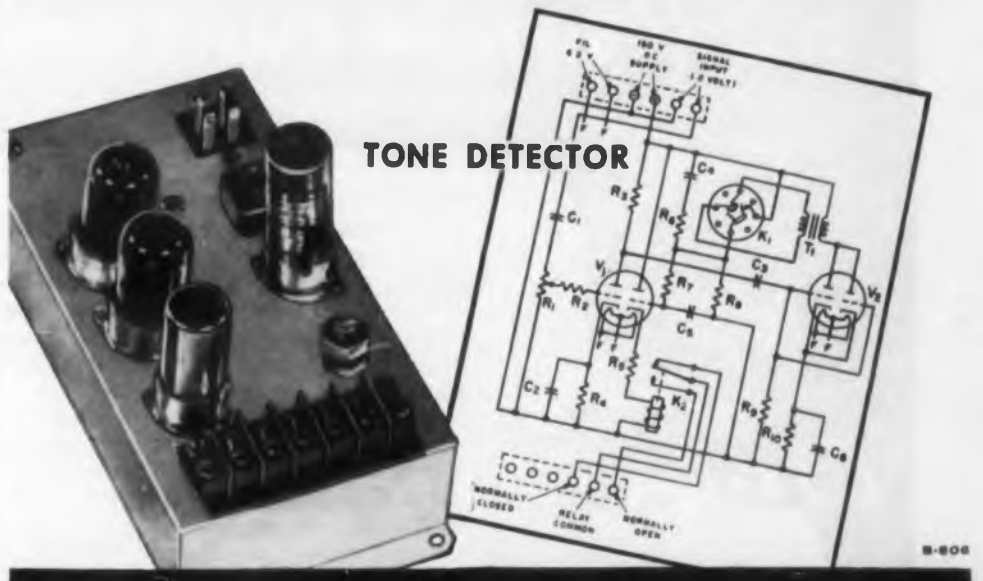
These complete tone generator and tone detector circuits, employing Frahm® Resonant Reed Oscillator Controls and Relays, are available as veritable "building blocks" for your communications system.

Applications for these packaged circuits include: selective calling, remote operation, supervisory control, data transmission, telemetering, and monitoring.

The Tone Generators are complete packaged oscillator circuits capable of supplying any one signal frequency within the ranges of 20 to 250 cps or 250 and 1100 cps, with accuracy of ±0.15%.

The Tone Detectors or receiving circuits, which employ a Frahm Resonant Reed Relay, operate the contacts of the SPDT relay in the unit when a signal of proper frequency and voltage amplitude is applied to the circuit input terminals. They operate with signals having any one frequency in the range of 20 to 1000 cps.

We particularly encourage your inquiries and correspondence on special applications and problems. Complete details on these packaged circuits as well as specifications, characteristics, etc., of our Frahm Relays and Oscillator Controls are available for the asking. *Request Bulletins 33 and 34-EE.*



TONE DETECTOR

JAMES G. BIDDLE CO.

Electrical Testing Instruments • Speed Measuring Instruments
Laboratory & Scientific Equipment
1316 ARCH STREET, PHILADELPHIA 7, PA.

CIRCLE 236 ON READER-SERVICE CARD

CIRCLE 237 ON READER-SERVICE CARD

NEW PRODUCTS

VANEAXIAL BLOWER.—Miniature 20 v dc unit with speed of 13,000 rpm. Produces about 45 cfm.
Western Gear Corp., Dept. ED, P.O. Box 182, Lynwood, Calif.

CIRCLE 238 ON READER-SERVICE CARD

DIFFUSION PUMP.—Type EP4W 4 in. fractionating oil diffusion pump for high vacuum stations.
Veeco Vacuum Corp., Dept. ED, 86 Denton Ave., New Hyde Park, N.Y.

CIRCLE 239 ON READER-SERVICE CARD

LINEAR AMPLIFIER.—Modified type 300-A for high power ssb, cw, and am operation.
Van Norman Industries, Inc., Electronics Div., Dept. ED, 186 Granite St., Manchester, N.H.

CIRCLE 240 ON READER-SERVICE CARD

TRANSISTORIZED POWER SUPPLIES.—Compact units that provide output needed to operate receiver installations. Variety of current ratings.
Universal Transistor Products Corp., Dept. ED, 17 Brooklyn Ave., Westbury, N.Y.

CIRCLE 241 ON READER-SERVICE CARD

TRANSFORMERS.—For ultrasonic use, line includes 25 and 100 w driver transformers and output transformers for 100, 300, 600, 1000 and 2000 w.
United Transformer Corp., Dept. ED, 150 Varick St., New York 13, N.Y.

CIRCLE 242 ON READER-SERVICE CARD

PRESSURE TRANSDUCER.—Model S-40 dual coil, variable reluctance units in ranges from 0.1 to 5 psi.
Ultradyne, Inc., Dept. ED, P.O. Box 3308, Albuquerque, N. Mex.

CIRCLE 243 ON READER-SERVICE CARD

VACUUM OVENS.—For high temperature, high vacuum drying, testing, or processing of small instruments and electronic parts.
Temperature Engineering Corp., Dept. ED, U. S. Highway 130, Riverton, N.J.

CIRCLE 244 ON READER-SERVICE CARD

RELAYS.—Coils are fully encapsulated for protection against corrosive, deteriorative atmospheres.
Ebert Electroncis Corp., Dept. ED, 212-26 Jamaica Ave., Queens Village 28, N.Y.

CIRCLE 245 ON READER-SERVICE CARD

DATA TRANSMISSION SYSTEM.—Model TE-206, when used with the company 768G-1 Kinecard converter and IBM 523 card reader/punch unit, reproduces and transmits punch card information at a rate of 100 cards per minute.
Collins Radio Co., Dept. ED, 2700 W. Olive, Burbank, Calif.

CIRCLE 246 ON READER-SERVICE CARD

CIRCLE 247 ON READER-SERVICE CARD

SERVO AMPLIFIER.—Packaged thyratron control for two-phase induction servomotors from ⅛ to 3 hp.

Diehl Mfg. Co., Dept. ED, Somerville, N.J.

CIRCLE 249 ON READER-SERVICE CARD

TEMPERATURE MONITORING SYSTEM.—Eliminates electronic scanning and substitutes continuous monitoring of large groups of temperatures by independent circuits. For aircraft use.

Thomas A. Edison Industries, Instrument Div., Dept. ED, West Orange, N.J.

CIRCLE 250 ON READER-SERVICE CARD

CONTINUOUS-WRITING STREAK CAMERA.—Model 194 produces a documentation which is a space versus time plot. For studying explosions, shock-tube manifestations, and flash-tube and spark-discharge phenomena.

Beckman & Whitley, Inc., Dept. ED, 973 San Carlos Ave., San Carlos, Calif.

CIRCLE 251 ON READER-SERVICE CARD

METAL STRIP.—Cadmium-silver clad phosphor bronze strip for use in electrical contact springs.

American Silver Co., Inc., Dept. ED, 36-07 Prince St., Flushing 54, N.Y.

CIRCLE 252 ON READER-SERVICE CARD

AUDIO PLUG.—XLR series replaces XL line, provides quiet operation by use of resilient inserts and shock-absorbing, resilient ribs in all socket assemblies.

Cannon Electric Co., Dept. ED, 3208 Humboldt St., Los Angeles 31, Calif.

CIRCLE 253 ON READER-SERVICE CARD

PLUGS.— Miniature type KM plugs have crimp-type snap-in contacts to eliminate soldering.

Cannon Electric Co., Dept. ED, 3208 Humboldt St., Los Angeles 31, Calif.

CIRCLE 254 ON READER-SERVICE CARD

ACTUATOR.—A4-87 actuator for alternate action push-button applications on panel mounting. For use in ground support equipment.

Electrosnap Corp., Dept. ED, 4230 W. Lake St., Chicago 24, Ill.

CIRCLE 255 ON READER-SERVICE CARD

TEMPERATURE CONTROLLER.—Sifam Pyromaxim on-off temperature controller has reading accuracy of ±1 per cent and control response within 0.25 per cent. Calibrated for any standard thermocouple.

Epic, Inc., Dept. ED, 154 Nassau St., New York 38, N.Y.

CIRCLE 256 ON READER-SERVICE CARD

SOCKET SAVERS.—The 7 pin SS-7, 8 pin SS-8, and 9 pin SS-9 are designed to prevent socket wear in tube checkers and other equipment.

Pomona Electronics Co., Inc., Dept. ED, 1126 W. Fifth Ave., Pomona, Calif.

CIRCLE 257 ON READER-SERVICE CARD

NEW PRODUCTS

LINT-FREE PACKAGE PARTITIONS.—For packaging electrical and electronic parts, these partitions come in a variety of sizes.

Paper-Wood Specialties Co., Dept. ED, 7900 Rockwell Ave., Philadelphia 11, Pa.

CIRCLE 260 ON READER-SERVICE CARD

TEST EQUIPMENT KITS.—Factory wired, tested, and calibrated, these kits are ready for use.

PACO Electronics Co., Inc., Dept. ED, 70-31 84th St., Glendale 27, N.Y.

CIRCLE 261 ON READER-SERVICE CARD

ELECTROLYTIC CAPACITORS.—Long life, vibration resistant single and multiple section units in capacitance values to 3000 μfd and 500 v dc.

The Magnavox Co., Dept. ED, Fort Wayne 4, Ind.

CIRCLE 263 ON READER-SERVICE CARD

EXPLOSION PROOF TIMING CONTROLS.—Single and multicam units with 1 to 19 switches, 10 amp rating, and time cycles from 2/3 sec to 72 hr.

Industrial Timer Corp., Dept. ED, 1407 McCarter Highway, Newark 4, N.J.

CIRCLE 264 ON READER-SERVICE CARD

MECHANICAL BOOSTER PUMPS.—Series 450 for high vacuum pumping applications. Standard sizes from 230 to 12,000 cfm.

General Vacuum Corp., Dept. ED, 400 Border St., East Boston 28, Mass.

CIRCLE 265 ON READER-SERVICE CARD

SWITCH.—Plunger actuated spdt unit for limit and control switching of noninductive loads up to 15 amp, 115 or 230 v ac.

General Controls Co., 8078D McCormick Blvd., Skokie, Ill.

CIRCLE 266 ON READER-SERVICE CARD

LOW FREQUENCY MONITOR.—Model 660 provides constant indication of frequencies between 50 and 1600 cps with 5 place resolution.

Erie Resistor Corp., Dept. ED, 644 W. 12th St., Erie, Pa.

CIRCLE 267 ON READER-SERVICE CARD

HIGH POWER SWITCH.—Mega-Switch breaks circuits as high as 10 kv. Hermetically sealed with contacts in an arc quenching gas atmosphere.

Energy Kontrols, Inc., Dept. ED, 11 S. First St., Geneva, Ill.

CIRCLE 268 ON READER-SERVICE CARD

MILLIVOLT AND MILLIAMPERE SOURCE.—Run up source has two voltage ranges and two separate current ranges: 0 to 60 and 0 to 200 mv; 0 to 5 or 0 to 25 ma.

Technique Associates, Inc., Dept. ED, P.O. Box 91, Indianapolis 6, Ind.

CIRCLE 269 ON READER-SERVICE CARD

RF-IF TRANSISTOR.—Type 2N544 pnp transistor for frequencies to 1.5 mc. Power dissipation is 80 mw; junction temperature, 85 C.

Sylvania Electric Products, Inc., Semiconductor Div., Dept. ED, Woburn, Mass.

CIRCLE 272 ON READER-SERVICE CARD

RESISTORS.—Axial-lead Koolohm resistor line now includes a 3 w unit and reduced size 5, 7, 10, and 14 w units with improved performance.

Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

CIRCLE 273 ON READER-SERVICE CARD

INSULATION TESTER.—Model 103-MP automatic leakage tester with test voltage adjustable from 0 to 2100 v ac.

Slaughter Co., Dept. ED, Piqua, Ohio.

CIRCLE 274 ON READER-SERVICE CARD

INSULATING VARNISH.—Ajax emulsion insulating varnish is water-reducible, will neither burn nor support combustion.

Sherwin-Williams Co., General Industrial Div., Dept. ED, Cleveland 1, Ohio.

CIRCLE 275 ON READER-SERVICE CARD

RECORDING HYDROGRAPHS.—Low priced hydrographs, thermographs, and hygrothermographs for industrial use.

Serdex, Inc., Dept. ED, 12 Bowdoin Sq., Boston 14, Mass.

CIRCLE 276 ON READER-SERVICE CARD

SWITCHES.—Series 4000 3-position aircraft type switches available in spst, spdt, dpst, and dpdt. In over 100 types of circuitry.

Sargent Electric Corp., Dept. ED, 630 Merrick Rd., Lynbrook, N.Y.

CIRCLE 277 ON READER-SERVICE CARD

PLUGS.—Phone plugs incorporating a set of ears that clamp over the cord jacket for secure anchoring. Screw type terminals.

Richards Electrocraft, Inc., Dept. ED, 4432 N. Kedzie Ave., Chicago, Ill.

CIRCLE 278 ON READER-SERVICE CARD

COUNTDOWN CLOCK.—The 90092-A digital system has a master clock and five slave displays. All transistorized with no moving parts.

Resdel Engineering Corp., Dept. ED, 330 S. Fair Oaks Ave., Pasadena, Calif.

CIRCLE 279 ON READER-SERVICE CARD

GEIGER COUNTERS.—Nonphotosensitive, all glass halogen quenched geiger counters with transparent nonmetallic conductive cathode surface.

Radiation Counter Labs, Inc., Dept. ED, Nucleonic Park, Skokie, Ill.

CIRCLE 280 ON READER-SERVICE CARD

NEW LITERATURE

ED Article Guide 283

Featured in the August 6 issue of this magazine, the Index of Articles lists and cross-references all articles, staff reports, Russian translations, German abstracts, abstracts, design forums, background for designers, product features, ideas for design, special features, and meeting reports published January 8 through June 25. Concise descriptions of all items (except ideas for design) follow each initial reference. Handy alphabetic key guides reader to type of article and bold face type indicates exact title of article as it appeared in ELECTRONIC DESIGN.

1200 New Produces Indexed 284

Semiannual Product Index appearing in July 23 issue of ELECTRONIC DESIGN lists over 1200 new products (except for product briefs at end of department), materials, and production products published during first half of this year. Index lists new products by category including components, microwave equipment, test equipment, and materials, production equipment, and systems. Following each category are issue and page numbers.

Wirewound Resistors 285

100 types of precision wirewound resistors are described in this 20-page 14RC catalog. Resistance values from 0.1 ohm to 20 meg are available in accuracies from 0.025 per cent to 1 per cent. Matched ratio sets and special temperature coefficient resistors are covered. Renumbering of some resistor series have been initiated for conformance with a specification system. Aerovox Corp., Cinema Engineering Div., Burbank, Calif.

Synchros and Servos 286

A 20-page catalog describes the company's line of synchros, precision computing resolvers, linear transformers, servo motors and motor generators. The catalog includes detailed tables giving the electrical and mechanical characteristics for an entire range of synchros (transmitters, receivers, resolvers, control transformers and differentials). Also included are mechanical and electrical characteristics for the company's line of linear transformers (induction potentiometers) plus ac servo motors and motor generators. Contained also in this catalog are brief descriptions of special rotary components, including frequency differentials, dc instrument motors, and a multi-pole re-

solver. Clifton Precision Products Company, Inc., 9014 West Chester Pike, Upper Darby, Pa.

Resin Base 289

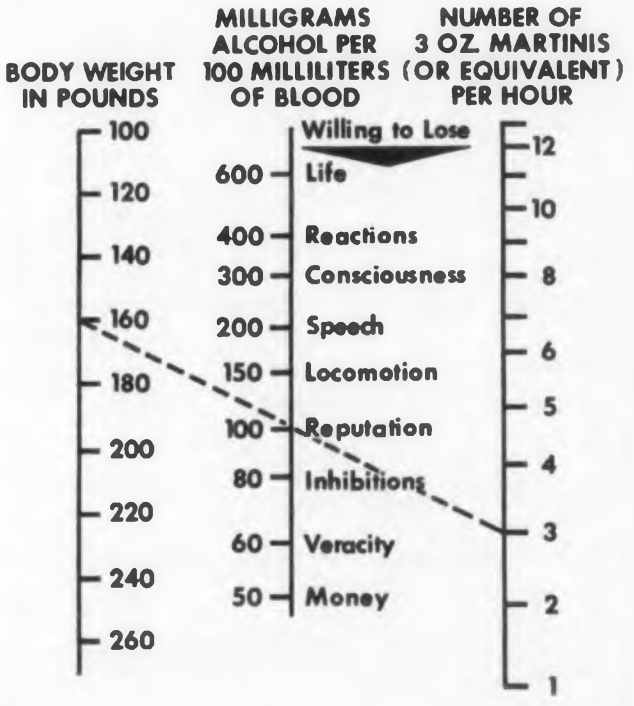
Fluorosint TFE resin is described in a 4-page illustrated bulletin. A polytetrafluoroethylene base composition, the resin is designed to improve the mechanical and thermal properties of pure polytetrafluoroethylene without materially affecting its electrical and chemical characteristics. The booklet contains charts and tables comparing the new resin to Teflon. Application data is added to that on mechanical, electrical, chemical, and thermal properties. The Polymer Corporation of Pennsylvania, 2140 Fairmont Ave., Reading, Pa.

Cooling Equipment 290

A 34-page catalog on fans and blowers describes units specially designed to fit standard electronic racks. The catalog also contains a section of engineering information for the design of forced convection cooling systems. Charts on performance limits, heat dissipation, etc., are included. A special section is devoted to blower housing variations. McLean Engineering Labs., Princeton, N.J.

Drinker's Nomograph 291

This nomograph is reprinted through the courtesy of Sarkes Tarzian, Inc., "in the interest of preserving engineers (particularly those who attend conventions), during this period of scientific shortages." Sarkes Tarzian, Inc., 415 N. College Ave., Bloomington, Ind.



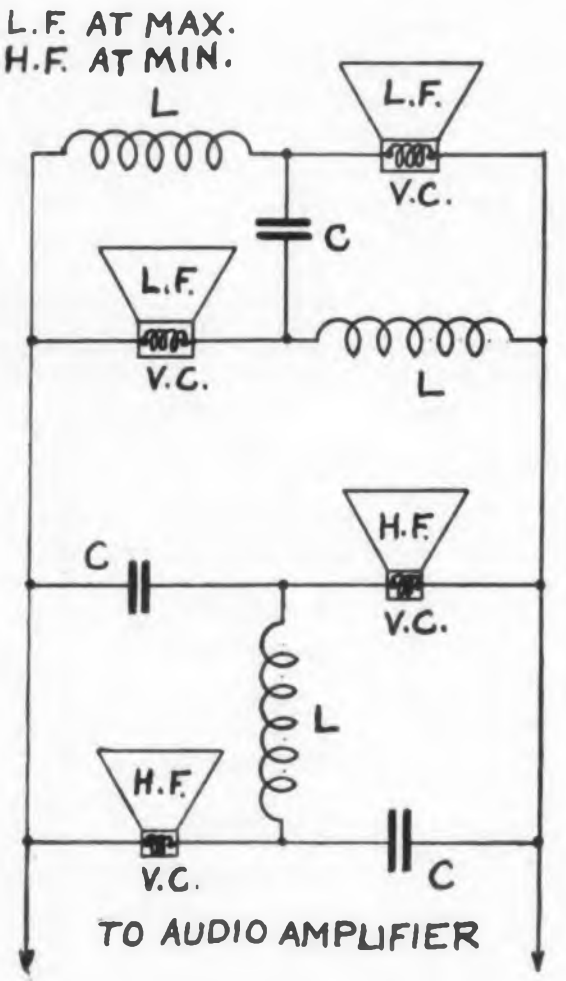
PATENTS

Loudspeaker Circuitry

Patent No. 2,832,828. Sidney E. Levy.

An array of l-f and h-f speakers is designed to permit maximum power transfer from the audio amplifier to the speakers. A simple modification of the circuit permits the selection of the transition frequency of the network. Since audio amplifiers having large negative feedback are essentially constant voltage sources, an increase of power delivered to a load at any frequency requires that the impedance of the load be made low at that frequency. Simple analysis of the invention illustrates how the impedance is reduced for the selected range of frequencies. For low frequencies the two woofers are in parallel since the reactance of the condenser is high and the reactance of the inductance is low. At higher frequencies, the woofers are in series and therefore the combination constitutes a high impedance which permits little power to be delivered by the amplifier. By contrast, for low frequencies, the tweeters are in series and for high frequencies the tweeters are in shunt. Maximum power transfer to the tweeters is transferred properly at the higher frequencies.

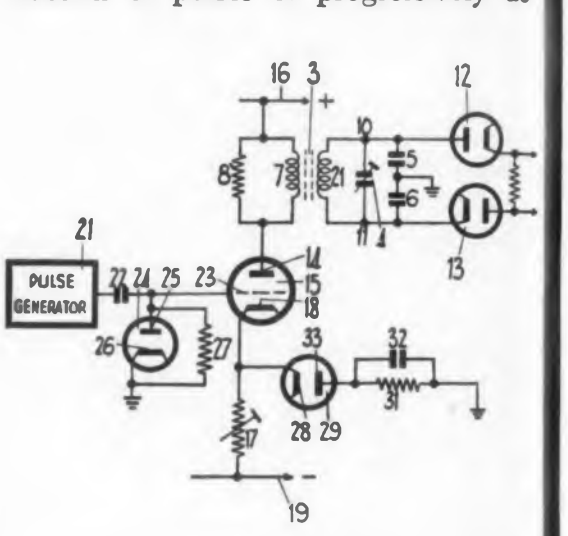
The transition frequency may be selected by modifying the capacitance branch to a resistor and condenser either in series or in shunt.



Circuits for Controlling the Peak Amplitude of Electric Current Pulses

Patent No. 2,822,470. Ronald Charles Imm. (Assigned to the General Electric Co., Ltd.)

The circuit provides a convenient means to control the peak amplitude of electric current pulses in order to shock excite a pulse modulation system for production of pulses of progressively decreasing amplitude. In general, the constant amplitude pulses are produced by pulse generator 21 and tubes 24, 15 and 29 suitably biased and clamped. Transformer 3 and diodes 12 and 13 develop the desired trains of positive and negative decremental pulses.



The constant amplitude pulses which excite the antiresonant circuit of transformer 3 are generated as follows.

Grid 23 is clamped to ground by diode 24. Diode 29 has its plate voltage at about 5 v below ground since cathode 28 returns to —150 v through the preset resistor 17. A positive voltage applied to grid 23 causes diode 29 to cut off and the current flowing in the primary winding is set by resistor 17. When the input pulse terminates, there is an appreciable voltage drop in cathode 18 which causes diode 29 to conduct. As a result all of

the current through resistor 17 is bypassed by diode 29 and triode 15 is cut off so that no current flows through primary winding 7.

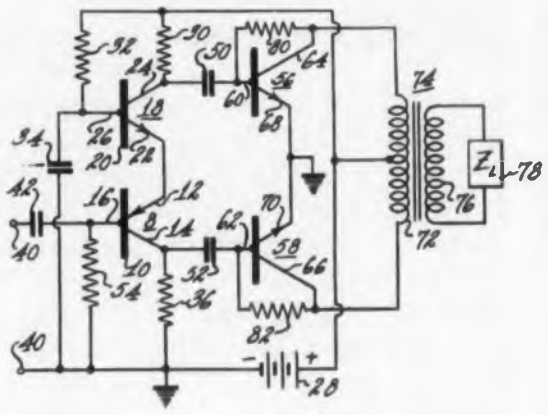
Pulse current in winding 7 results in a pair of balanced signals at points 10 and 11. Each of these signals has a damped sinusoidal waveform. Diodes 12 and 13 are biased to pass only those portions of the waveforms which are respectively positive and negative with ground. The ratio of the amplitudes of adjacent pulses is determined by the time constant of the transformer secondary circuit.

Phase-Inverter Complementary Transistor Amplifier

Patent No. 2,832,846. Frederick D. Waldhauer. (Assigned to Radio Corporation of America)

A phase inverter comprises two complementary symmetry (opposite conductivity) transistors connected in series to produce substantially balanced output current even though the circuit components are not in precise balance. When the phase inverter is combined with a push-pull output stage, a signal from a single-ended source can be used to control the power delivered to the output load such as a speaker. Complementary transistors have two essential properties: 1. Under normal bias conditions the current which flows in each electrode of a pnp transistor is the negative of the corresponding electrode current in the npn transistor; 2. The polarity of an input signal necessary to increase conduction in a pnp transistor is the opposite of that necessary to increase conduction in an npn transistor.

It follows that when complementary symmetry transistors are connected in series, two signals of opposite phase may be developed from a single-ended source. Likewise, the invention demonstrates that when the transistors are connected in series with a single battery, the output currents of the transistors are identical. This follows since the sum of the base and collector currents of one transistor equals the sum of the base and collector current of the second transistor. The series circuit has inherent stability because the collector-emitter impedance of each of the transistors provides dc emitter degeneration for the other transistor.



The circuit illustrates the phase inverter consisting of npn transistor 18 connected in series with pnp transistor 8, with emitter 18 joined to emitter 12. A single-ended signal is injected on base 10 of transistor 8 while base 20 of transistor 18 is held at ac ground. The equal and opposite signals are ac coupled to npn transistors 56 and 58 which comprise the push-pull output stage driving the load Z_1.

An essential feature of the circuit is that a single power source, battery 28, is required for the phase inverter and push-pull output.

Transistor Switching Circuit

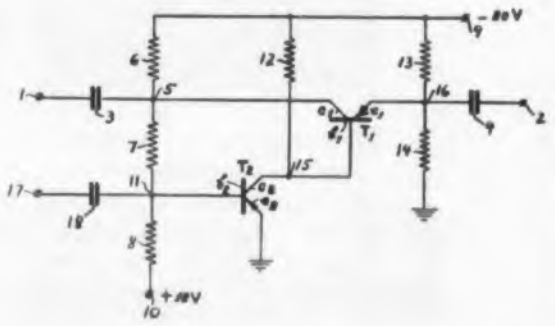
Patent No. 2,829,281. Adrianus Johannes Wilhelmus, Marie Van Overbeek. (Assigned to North American Philips Co., Inc.)

The circuit facilitates the opening of line 1-2 when a negative gate is applied to terminal 17.

In the absence of a gate at terminal 17, transistor T_1 is conducting and line 1-2 is closed through the low emitter to collector resistance of transistor T_1.

However, transistor T_2 is nonconducting since the base b_2 is at a positive voltage with respect to both collector C_2 and emitter e_2.

A negative gate applied to terminal 17 causes transistor T_2 to conduct and



PATENTS

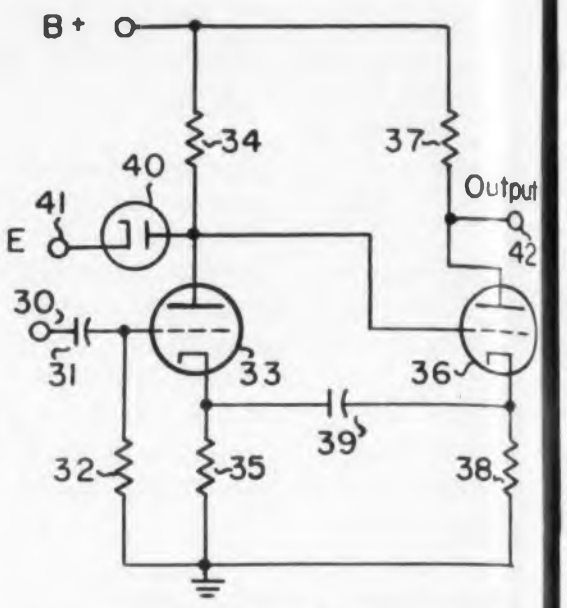
the voltage at the base b, becomes positive with respect to that of either collector C, or emitter e, of transistor T_1. Hence transistor T_1 becomes non conducting and line 1-2 is opened. In addition, transmission signals which may be coupled through the capacitance of emitter e, and base b, are shorted to ground through the low resistance existing between emitter e_2 and collector C_2.

Pulse Amplitude Discriminator

Patent No. 2,821,626. Melvin B. Freedman. (Assigned to Tracerlab, Inc.)

The pulse height discriminator has a short recovery time. It is adapted to generate an output pulse of uniform amplitude and duration for each of a random series of positive input pulses in excess of a predetermined threshold. The circuit has application in scintillation detectors used with counting rate meters.

In the quiescent state both triode (or pentode) 33 and triode 36 are conducting in accordance with the voltage E on



the cathode of diode 40. A positive impulse at terminal 30 is differentiated by the input rc circuit causing triode 33 to conduct. The negative-going voltage on the plate of triode 33 makes diode 40 nonconducting and also reduces the current of triode 36. As a result, a negative voltage is coupled by condenser 39 to the cathode of triode 33 causing the latter to conduct even more. This action carries the circuit rapidly to a state wherein tube 33 conducts heavily and

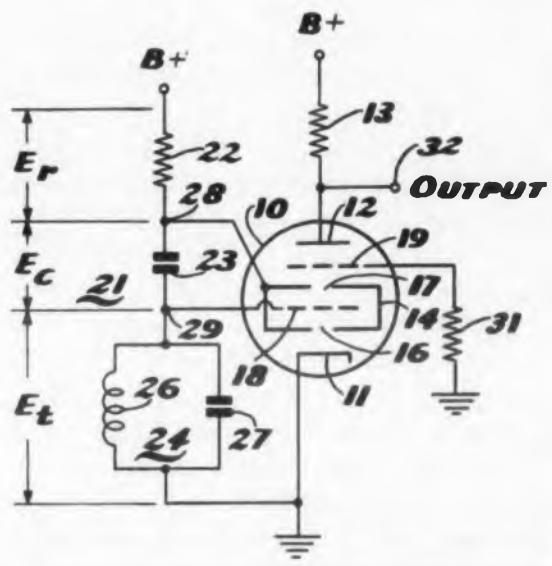
tube 36 is nearly cut off. The system remains in this state until condenser 39 has almost assumed the charge required by the new state. Thereafter, the tapering off of the charging current of condenser 39 reduces the voltage feedback and tube 33 becomes less conducting. The plate voltage of tube 33 rises, tube 36 becomes more conducting and the signal cross-coupled by condenser 39 to the cathode makes tube 33 less conducting. A cumulative pile up of voltages in the opposite sense reduces the current of tube 33 until the plate voltage assumes the voltage set the reference voltage E. Now, the determining time constant of the circuit is the product of the capacitance of condenser 39 and the cathode resistances of tubes 33 and 36 in series. Since both tubes are conducting at all times, with consequent low impedance, the time constant can be made very short without recourse to an extremely small capacitor. Likewise, it is apparent that the voltage E sets the threshold below which an applied pulse will not produce an output pulse and this, in effect, permits a convenient means to adjust the pulse discriminator level.

Controlled Oscillator Means Utilizing Gated-Beam Tubes

Patent No. 2,833,990. Jack D. Van Tilburg. (Assigned to Collins Radio Co.)

A series circuit consisting of a resistor, a capacitor and a parallel resonant network in conjunction with a gated-beam tube such as a 6BN6 conveniently produces free oscillation, frequency division, frequency modulation or gated oscillation.

Gated beam tube 10 shown in the dia-



PATENTS

gram contains cathode 11, accelerator 14, limiter grid 18, gating grid 19 and plate 12. Its operating characteristics are special since the cathode current is constant, the current through aperture 17 is determined by the limiter grid bias, and the plate current is prescribed by the gating grid bias. Thus the entire cathode current goes to either the accelerator alone or to the accelerator and the plate according to the voltages on the respective grids.

In the operation of the circuit as a free running oscillator, the gating grid is biased above cut off.

Voltage on the limiter grid increases with the positive going cycle and electrons pass to the plate. Accelerator current decreases, and hence the tank voltage increases causing regenerative build-up of the positive half cycle until the maximum portion of the electron stream reaches the plate. The tank circuit then swings negative, the limiter grid is cut off and the entire electron stream goes to the accelerator until the accelerator voltage reaches a maximum. Feedback is thus maintained constant. The cycle repeats when the tank swings positive.

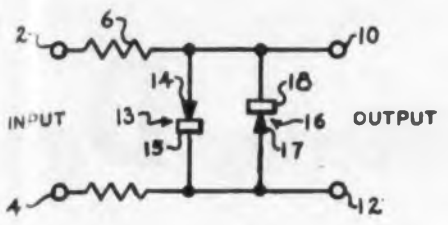
Frequency division is achieved by tuning the tank to f/N where N is a multiple of 2 and f is the frequency of the synchronizing voltage. The synchronizing signal drives the gating grid about cut off f-times per second. The tank and the limiter grid, however, swing negative each even multiple of f so that the tank locks to an even division of f.

Signal Attenuator

Patent No. 2,835,867. Daniel Golden. (Assigned to Underwood Corp.)

Crystal diodes such as 1N34s are used in series or in parallel or in series-parallel combination to attenuate pulse signals which exceed the constant resistance range of the crystals. For the attenuator shown, voltages in excess of ±10 mv are attenuated in an inexpensive and effective manner.

The resistance characteristics of crystal diodes prescribe decreasing resistance with increasing positive applied voltage and rapidly increasing resistance as negative voltage increases.



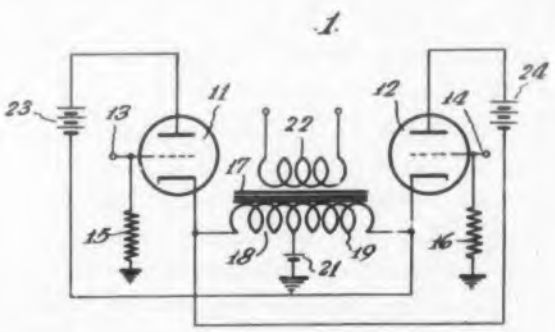
An increase in voltage beyond the predetermined level causes the resistance of one of the series diodes to increase faster than the resistance of the other diode decreases. In effect, the series circuit shows higher resistance and therefore attenuation of the input. As the input voltage increases further, the resistance of one of the shunt diodes decreases and the resultant parallel resistance decreases to cause additional attenuation of the applied voltage.

High Fidelity Audio Amplifier

(Patent No. 2,828,369. Alpha M. Wiggins. Assigned to Electro-Voice, Inc.)

An amplifier output stage is designed to operate as a high fidelity push-pull output having unity coupling between the tubes, a low impedance output transformer and full drive of the entire load by each tube. As a result, the amplifier may be operated Class AB or B with negligible distortion due to transients.

Plate supply of each tube is returned to the cathode of the other tube. Two power supplies obviously are required but the advantages of the circuit are likewise evident. Thus each tube looks into the total load impedance between the cathodes of the tubes as contrasted to one fourth of the total load impedance in a conventional push-pull circuit. Unity of coupling results thus obviating transient switch distortion. The lower impedance required enables the use of a transformer having fewer windings. This produces lower distributed capacitance and, therefore, better frequency response.



ELECTRONIC DESIGN **Engineering Data**

Determining Multi-Pin Connector Voltage Ratings

William B. Schwartz
Continental Connector Corp.
Woodside, N. Y.

WHEN DESIGNING electrical connectors for altitude applications it is necessary to establish breakdown voltage at decreased atmospheric pressures. The values shown in the accompanying conversion chart are in accordance with standard multi-pin connector practice (MIL-C-8384A) in which test voltage is equal to three times the working voltage and 75 per cent of the breakdown voltage.

Where one parameter is known, such as a required working voltage, the resultant breakdown and test voltage may be determined. The ratings normally supplied by the connector component manufacturer represent the actual air gap breakdown voltage between unprotected contact solder terminals. This rating is useful in fixing a test voltage for component inspection purposes. However, in actual practice increased working voltage results when insulation or potting compound is used between terminals.

Conversion chart values represent reduction in dielectric strength for dry, dust-free air with respect to altitude in thousands of feet above sea level. It should be remembered that the figures shown correspond to cool gaps with only normal ionization. Values can be changed considerably by heating of the air gap during operation of contacts. According to "Paschen's law," the dielectric breakdown voltage for air is a product of pressure and electrode spacing. Regardless of reduced atmospheric pressure or contact spacing, it is impossible to cause breakdown to occur between contacts in air at voltages under 350 v. This minimum breakdown voltage is due primarily to the potential required for ionization of air to occur.

This chart is useful in determining component voltage rating based on a known or estimated breakdown voltage at sea level and at reduced pressure, altitude conditions. When the working voltage is known, the resultant breakdown voltage and required test voltage may be determined. All values are based on sea level ambient conditions. (50-60 per cent relative humidity.)

Example 1. Determine the ratings at 50,000 ft. where the breakdown voltage is found to be 4000 v rms at sea level conditions.

Solution. (a) Locate 4000 v breakdown voltage on sea level reference line (Fig. 1). Read up to test voltage 3000 v and down to working voltage 1000 v. (b) Locate 4000 v breakdown voltage on 50,000 ft. altitude line. Follow down to sea level reference line and convert as in (a) to breakdown voltage 900 v, test voltage 675 v and working voltage 225 v.

Example 2. Determine breakdown voltage and the required test voltage at sea level which will yield a 250 v working voltage for 60,000 ft. operation.

Solution. (a) Locate 250 working voltage (Fig. 2). Read chart up to 60,000 ft. intersection and across to voltage breakdown 5500 v. (b) Convert breakdown voltage 5500 v to test voltage 4125 v at sea level conditions.

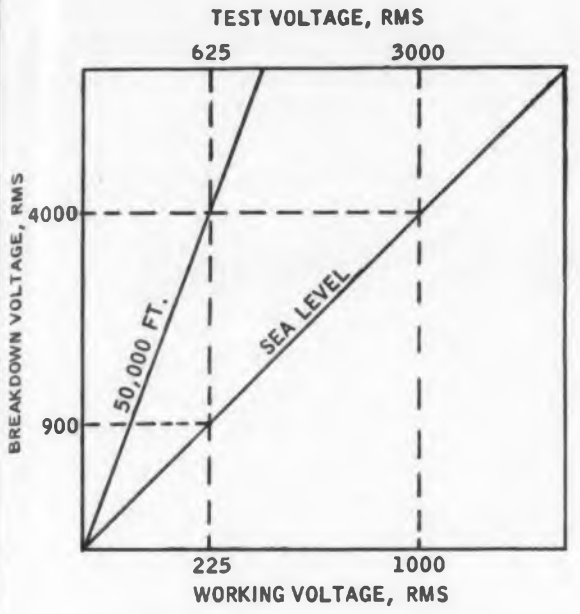


Fig. 1. Solution to Example 1.

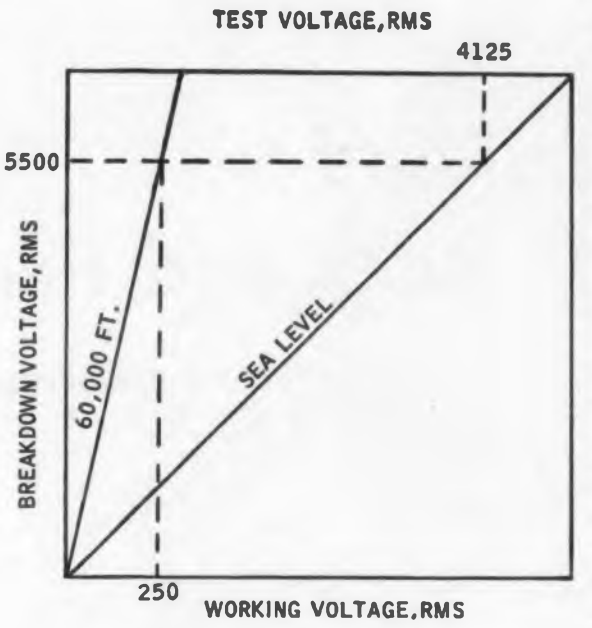
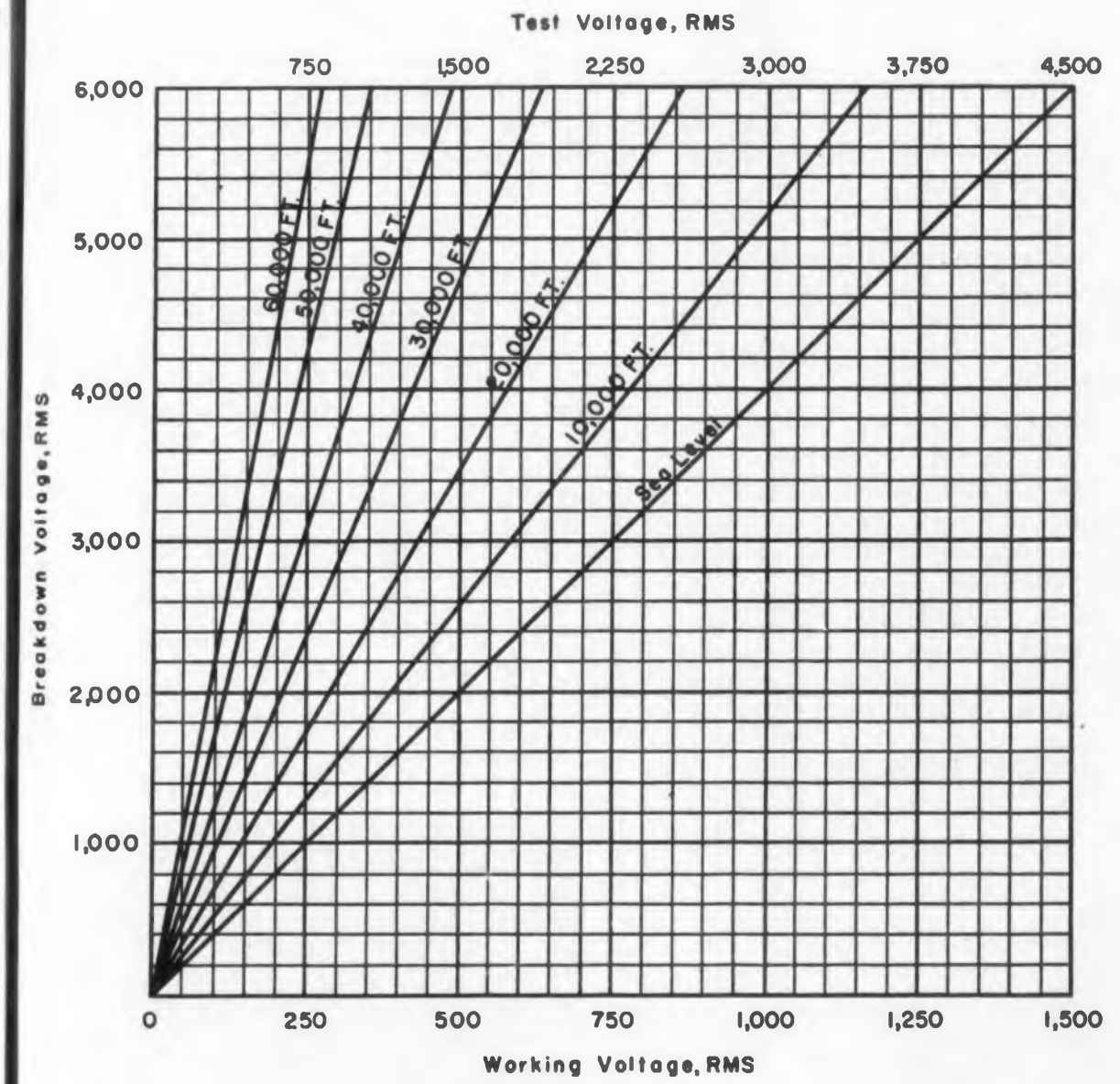


Fig. 2. Solution to Example 2.



Graph to determine multi-pin connector voltage ratings at various altitudes.

IDEAS FOR DESIGN

Get $10.00 plus a by-line for the time it takes you to jot down your clever design idea. Payment is made when the idea is accepted for publication.

Simplified Rack and Panel Mounting

can be handsome, too

THE STANDARD method of attaching a panel in an instrument case involves screws through the panel to lugs within the periphery of the case. This usually results in poor front panel appearance, inaccurate fit, and awkward panel and chassis removal. Fig. 1 shows a scheme which avoids these problems and eliminates the unsightly gaps which allow dust and water to get into the chassis.

The panel and chassis are bolted together with screws which are invisible when the knobs and dials are in place. A casting, which forms the front of the unit, and requires no costly machining, covers the panel to case gap.

The unit, consisting of the panel, chassis, and casting is secured to the back of the case with two fast-lead screws. A strip of aluminum, spot-welded to the inside of the case, and protruding from its outside edge, locates the edge of the casting exactly with reference to the case by engaging in a slot in the casting. As the locating screws are tightened, the casting, front panel and chassis are firmly pulled into place. The package is completely dust-proof and can be water-proofed easily.

The unit is easily adapted for rack mounting. In this case a rack mounting adapter panel is clamped between the front casting and the instrument case, and held by the fast-lead screws at the back of the case.

Kenneth Ricketts, Southwestern Industrial Electronics Co., Houston, Texas.

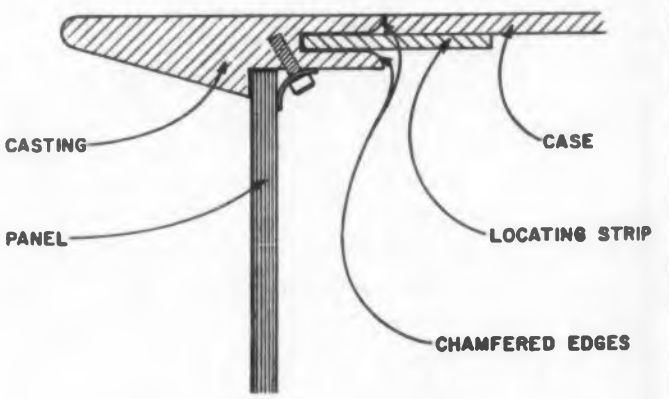


Fig. 1. This panel-to-case mounting scheme eliminates unsightly gaps, keeps out dust and water, and makes it easy to mate the panel and instrument case.

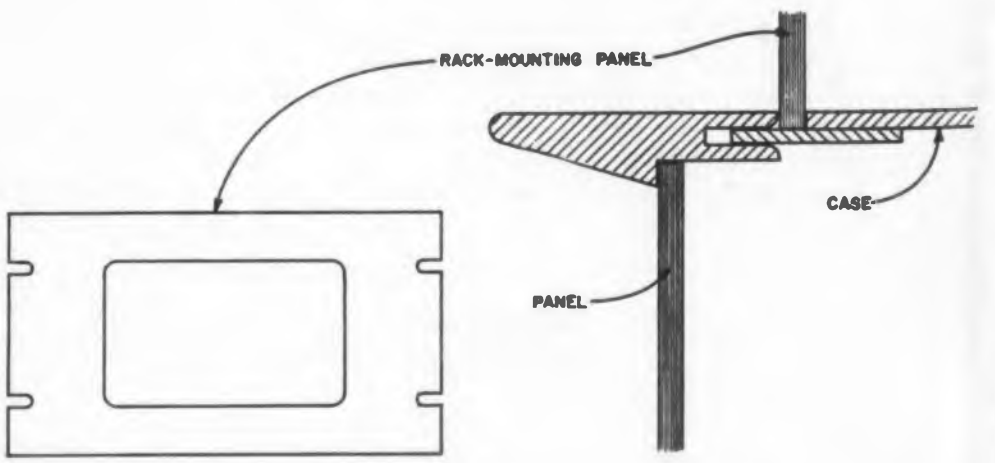


Fig. 2. A rack mounting adapter can be secured between the front panel and case by tightening two thumb screws at the back of the case.

Testing DPDT Choppers

Many circuit applications require a single DPDT chopper rather than two SPDT choppers to obtain exact synchronism between the two chopper poles. Here's a circuit that can be used to check both poles simultaneously for phase lag, balance, dwell time, and tracking. The circuit is also useful for matching characteristics in SPDT choppers.

With tracking defined as the difference in phase lag between two switch sections, one can measure it to within one degree.

The circuit shown is simple and easy to assemble. The chopper coil voltage is fed to an *RC* phase shift network. The coil voltage is sent to the scope *X* plates and the 90 deg shifted

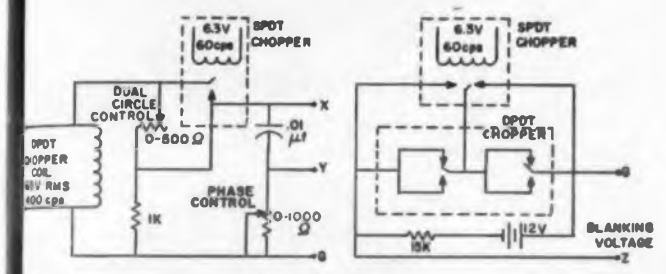


Fig. 1. This simple circuit can check the tracking of DPDT choppers or it can compare the operation of two SPDT units.

voltage to the *Y* plates. A second circle is created by periodically reducing the voltage to these plates using an auxiliary SPDT chopper operating at a frequency other than that applied to the DPDT chopper under test.

The "phase control" adjusts the circle for roundness. An additional SPDT chopper, operating at the same frequency as the first SPDT chopper, alternately inserts each section of the DPDT chopper into the blanking circuit. Whenever the contacts of the DPDT chopper open, the trace is blanked. The inner circle represents one set of contacts, while the outer circle represents the other.

Warren E. Hodges, Project Engineer, The Bristol Company, Waterbury, Conn.

Fig. 2. Oscillogram of a typical DPDT chopper's performance.

REPORT BRIEFS

Adiabatic Magnetization

A study has been made of the adiabatic suppression of super conductivity by the application of a magnetic field. The effects of specimen geometry, rate of magnetization, and departures from the isentropic magnetization path were studied. The excessive heating accompanying adiabatic magnetization was found to arise from thermal effects along the magnetization path associated with hysteresis in the magnetization path. When these hysteresis effects are included in calculations of expected values of cooling good agreement with experimentally observed values is achieved. The exact nature of the hysteresis effect is unknown. Unless control of this irreversibility is possible, the cooling of a superconductor by adiabatic magnetization cannot be utilized effectively for refrigeration nor for producing temperatures much below one degree Kelvin. *Traversal of the Intermediate State of a Superconductor by Adiabatic Magnetization, by R. L. Dolecek, U. S. Naval Research Laboratory. Jan. 1958, 19 pages, graphs, table, $0.50. Order PB 131485 from OTS, U. S. Department of Commerce, Washington 25, D. C.*

PFM Response of Single Tuned Parallel Circuit

The steady state expression of the voltage across a single tuned parallel circuit fed by a current source possessing periodic pulse frequency modulation is computed in the case of relative frequency deviation less than or equal to one. The corresponding envelope and instantaneous frequency are derived and plotted for certain numerical examples. Presented to a conference at the Symposium "La Theorie et la Technique des Impulsions," Paris, France, Oct. 1953. *Steady State Response of a Single Tuned Parallel Circuit to a Sinusoidal Current Source with Periodic Pulse Frequency Modulation, by E. Weber, Polytechnic Institute of Brooklyn, Microwave Research Institute, Brooklyn, N.Y. Apr. 1955, 35 pages, diagrams, graphs, microfilm $3.00, photocopy $6.30. Order PB 126150 from Library of Congress, Washington 25, D. C.*

Study of Semiconductor Materials and Devices

The effects of heat treatment at 1300 C on the infrared absorption of silicon have been investigated. Conductance measurements were made on p-type silicon samples before and after oxida-

tion. Silicon npn diffused base transistors were made by diffusion and alloying. When germanium grown junction diodes are placed in 100 per cent humidity ambients, reverse currents 10 times or more higher than the saturation current are obtained. *Study of Semiconductor Materials and Devices, Second Quarterly Interim Technical Report. Jan. 1, 1956 to Mar. 31, 1956, Raytheon Manufacturing Co., Research Div., Waltham, Mass. Apr. 1956, 47 pages, photo, diagrams, graphs, tables, microfilm $3.30, photocopy $7.80. Order PB 129686 from Library of Congress, Washington 25, D. C.*

Radio Echoes from Auroral Ionization

Contents: I. Theories of aurorae and summary of radio results to date; II. Long-range auroral-zone echoes; III. Low-latitude auroral effect; IV. Recommendation for further study; V. Summary and conclusions. Appendices: (A) Previous radio studies of aurorae; (B) Equipment; (C) Plane-earth plane-ionosphere ray path derivations; (D) Curved-earth curved-ionosphere ray path derivations. Bibliographical references. *Radio Echoes from Auroral Ionization Detected at Relatively Low Geomagnetic Latitudes, by R. L. Leadabrand, Stanford University, Radio Propagation Lab., Stanford, Calif. Dec. 1955, 203 pages, photos, diagrams, graphs, table, microfilm $9.30, photocopy $31.80. Order PB 126332 from Library of Congress, Washington 25, D. C.*

Emissive Materials for Electron Tubes

Standard diodes, exhausted at a partial pressure of 2.5 mm during the exhaust cycle, show slumping or lower emission levels during the life burning cycle of the tube. The completed standard triode tests show that the emission levels of the tube are affected by variations in vacuum pressure at exhaust. Physical analysis of standard diodes exhausted at 5 mm pressure Hg show definite signs of non-adherence of cathode coating. Diodes exhausted at 15 mm pressure of mercury show signs of a chemical reaction between the cathode coating and the nickel sleeve. A test structure for evaluation of cathode sleeve sublimate by use of spectrographic means is presented at this time. The evolution and description of the sublimation structure are described in detail. The first analytical results are also presented. *Investigation of Emissive Materials for Electron Tubes, Frederick T. Hill, Raytheon Manufacturing Company, Receiving and Cathode Ray Tube Operations, Newton, Mass. 1957, 32 pp, microfilm $3.00. Order PB 126364 from Library of Congress, Washington 25, D.C.*

Nonlinear and Parametric Phenomena In Radio Engineering

A. A. Kharkevich
Translated by J. George Adashko

Part 1

We, at ELECTRONIC DESIGN, are pleased to present, for the first time, a complete book translation in serial form. Unlike most of our "Russian Translations" this book is not intended to reveal the "state of the art" in the USSR.

It is an excellent and lucid introduction to an important aspect of electronic design—too long neglected by many American design engineers. It is brief, unified, and unexcelled in its clarity.

The Russians are past masters in nonlinear theory. Of American books on the subject, there are but four—three of which have appeared in the last few months. None have been written for the practicing electronic design engineer.

We believe that our translation of "Nonlinear and Parametric Phenomena in Radio Engineering" will provide a genuine service—not for the theorist, nor the mathematician, but for the practicing electronics design engineer.

—The Editors

Prof. A. A. Kharkevich was born in 1904 in Leningrad. He graduated from the Leningrad Electrotechnical Institute in 1930. A doctor of technical sciences since 1938, Prof. Kharkevich became a corresponding member of the Ukrainian Academy of Sciences in 1948. At present he holds a chair as professor of theoretical radio engineering at the Moscow Electrotechnical Institute of Communication. He is Director of the Communication Laboratory of the Academy of Sciences of the USSR.

Prof. Kharkevich's book **Nonlinear and Parametric Phenomena in Radio Engineering,** is the third part of a textbook, the first two parts of which were published under the title *Theoretical Principles of Radio-Communications* (State Publishing House of Technical and Theoretical Literature, Moscow, 1957).

Translator's Foreword

For every electronic engineer exposed to a course on nonlinear mathematics or nonlinear circuit theory, there must be at least a dozen, whose knowledge of the subject does not go beyond the B-H curve, drawing a load line, or calculating harmonic distortion. Yet almost all electronic functions—rectification, oscillation, detection, and so on—are inherently nonlinear. A possible exception is amplification, and even there the linearity is more formal than actual.

There is good reason for this—the principle of superposition. As long as the electronic art was more interested in the circuit aspects, the powerful tools based on this principle (e.g., Thevenin's or the reciprocity theorem, Laplace or Fourier transforms) could not be given up readily, and the various linearization techniques were preferable to "pure" nonlinear analysis.

It seems inevitable, however, that electronics is doomed to leave the straight though not narrow path of linearity (to pitch a wild curve at the metaphor). In the case of transistors, for instance, the old work horse, the equivalent circuit, is frequently quite hard pressed to provide a satisfactory theory, even in the first approximation. It is most likely that twenty five years from now the electronic engineers will wonder how their parents managed to do without a knowledge of Poincaré's theory, just as we marvel how it was possible to get through the EE course in 1933 without a knowledge of Maxwell's equations.

Russian work on nonlinear theory dates back to Liapunov's "Problème Général de la Stabilité du Mouvement" of 1892, but serious work began in the early thirties. The results are not our primary concern here; suffice it to point out that Andronov and Chaikin's "Theory of Oscillations" (Princeton, 1949) and Krylov and Bogoliubov's "Introduction to Nonlinear Mechanics" (Princeton, 1943) are among the most frequently referred-to books when it comes to nonlinear theory.

It is little wonder, therefore, to those who have been following our abstracts in "What the Russians are Writing," that articles on nonlinear circuits or methods appear frequently in Russian electronic literature. There are several books exclusively devoted to "Nonlinear Radio Engineering," one of which is Prof. A. A. Kharkevich's monograph "Nonlinear and Parametric Phenomena in Radio Engineering." It is a brief and clear theoretical introduction to the subject, written for practicing engineers. Your translator liked it, your editors liked it—we hope you like it, too.—

J.G.A.

Author's Introduction

1. Scope of the subject

This book is devoted to nonlinear and parametric phenomena in radio engineering.

The term "nonlinear" pertains to the physical features of the studied phenomena, features reflected in the mathematical equations for the behavior of various radio engineering elements.

In radio engineering we deal with phenomena that can be described by mathematical equations of the following three types:

1. Linear equations with constant coefficients.
2. Linear equations with variable coefficients.
3. Nonlinear equations.

These three types are quite dissimilar in their properties and must be solved by entirely different methods; hence the traditional division into "linear" and "nonlinear" approaches to radio engineering.

Linear equations with constant coefficients are the simplest type. Their theory has been developed in detail and powerful general methods exist for their solution (for example the Fourier and Duhamel integral methods). These general methods are based on the superposition principle whose applicability serves as a *definition* of a linear system, i.e., of a system described by linear equations with either constant or variable coefficients.

The general form of a homogeneous linear equation with constant coefficients is

$$a_n \frac{d^n y}{dt^n} + a_{n-1} \frac{d^{n-1} y}{dt^{n-1}} + \ldots + a_1 \frac{dy}{dt} + a_0 y = 0,$$

where $a_n, a_{n-1}, \ldots, a_1, a_0$ are constants.

A characteristic of linear equations with variable coefficients is that the coefficients depend on the *argument t,* i.e., they are specified functions of time. The theory of such equations is more complicated and less fully developed. This is why phenomena described by equations with variable coefficients are frequently classified as "nonlinear."

From the physical point of view, equations with variable coefficients describe the behavior of systems with parameters that vary with time in some manner. Such systems, and the phenomena that take place in them will be called *parametric.* Examples of equations with variable coefficients are

$$\frac{d^2 y}{dt^2} + ty = 0,$$

$$\frac{d^2 y}{dt^2} + (a + 2q \cos 2t)\, y = 0.$$

(Continued on next page)

The latter equation is called the Mathieu equation and plays a very important role in radio engineering.

Finally, nonlinear equations are distinguished in that their coefficients depend on the *function* or on its derivatives. This type of equation is the most difficult to solve. Several general methods will be considered as applied to various radio engineering problems.

Examples of nonlinear equations are

$$\frac{d^2y}{dt^2} + ay^2 = 0, \qquad \frac{d^2y}{dt^2} + \frac{dy}{dt}\,y = 0,$$

$$\frac{d^2y}{dt^2} + f\left(\frac{dy}{dt}\right) + y = 0.$$

The last equation is quite general; it is encountered in the theory of vacuum tube oscillators.

Mathematical Analysis

We are interested in the mathematical aspects of this subject because mathematical analysis permits a quantitative investigation of various types of electronic apparatus and, in the final analysis, provides us with a design procedure.

As to the physical and engineering aspects of the subject, it must be mentioned that some of most important phenomena and processes used in radio engineering—oscillation, frequency multiplication and division, rectification and detection, modulation, and frequency conversion—are nonlinear or parametric.

They are describable by nonlinear equations or equations with variable coefficients. These equations indeed constitute the mathematical formalism of "nonlinear" radio engineering.

2. Methods of Nonlinear Theory

The principle of the superposition, which is the basis of linear theory, cannot be used for the investigation of phenomena in nonlinear systems.

Let us explain this statement briefly by starting with a linear system, describable by the linear algebraic equation $y = ax$.
Here x and y are functions of time, x being the input to the system and y the output. The principle of superposition says that if the input to the system is $x = x_1 + x_2$,
the output will be

$$y = ax = a\,(x_1 + x_2) = y_1 + y_2,$$

i.e., the two components x_1 and x_2 act independently. Thus, the current resulting from several voltages in a linear system is the sum of the cur-

rents produced by each voltage separately, in the absence of the others.

The principle of superposition is the basis of all general methods for solving many linear-theory problems. We are so used to constant application of this principle, that we must be especially reminded that this principle cannot be employed for nonlinear problems without causing serious errors.

Let us illustrate this with a simple example. Suppose we have a nonlinear, say quadratic, equation. $y = ax^2$.

Let furthermore

$$x = x_1 + x_2.$$

Then

$$y_1 = ax_1^2, \quad y_2 = ax_2^2.$$

But

$$y = a(x_1 + x_2)^2 = ax_1^2 + ax_2^2 + 2ax_1x_2 \neq y_1 \times y_2,$$

i.e., the square of the sum does not equal the sum of the square.

Therefore, for example, when several voltages act on a nonlinear circuit, one can no longer reduce the solution of the problem to the summation of currents due to each individual voltage. It is necessary to take into account all the voltage components simultaneously.

The situation becomes more complicated when we go from nonlinear algebraic to nonlinear differential equations.

Specialized Methods

The fact that we are forced to forego the principle of superposition causes us to lose many possible solution techniques. Unfortunately, such powerful and universal methods as are available to linear theory are still missing from nonlinear theory. A worker in the nonlinear field has at his disposal a variety of specialized methods and artifices, each of varying effectiveness and of differing range of applicability. We shall describe these methods briefly, for the moment; later we shall become better acquainted with their applications to various problems in radio engineering.

1. The algebraic problem of finding $y(t)$ for a specified $x(t)$ and for a given nonlinear characteristic

$$y = f(x)$$

can always be solved graphically with any degree of accuracy desired.

2. The same problem can also be solved analytically, i.e., it is possible to find a function

$$y(t) = f[x(t)],$$

(Continued on following page)

provided an analytic expression is available for the characteristic of the system

$$y = f(x).$$

Under these conditions it is usually possible to solve differential equations.

3. In must be noted that the characteristic of the system is quite frequently known from experiment, i.e., it is given in the form of a graph or tabulated data. The determination of an analytic expression, representing the actual relation with sufficient accuracy, is thus a very important operation in nonlinear theory. This operation is called the *approximation* of the nonlinear characteristic.

The approximation should, as far as possible, satisfy the following requirements: (a) The analytical expression should represent the approximated relation with sufficient accuracy, (b) it should be amenable to the performance of various required mathematical operations, and (c) it should be as short and simple as possible.

Unfortunately, the existing approximation methods do not satisfy these requirements to an equal extent. The following principal methods are used: (a) approximation by a polynomial, (b) approximation by a broken line, (c) approximation by transcendental functions.

The first methods consist of representing the function $y = f(x)$ in the form

$$y = a_0 + a_1x + a_2x^2 + \ldots + a_nx^n = \sum_{k=0}^{n} a_kx^k,$$

The number of terms of the polynomial depends on the required accuracy. In any case, the approximation must reflect at least the fundamental qualitative features of the phenomenon. This applies naturally to all approximations.

Approximation by a broken line, also called piecewise linear approximation, consists of replacing the plot of the actual relation with linear segments, the approximation improving with the number of segments employed.

Piecewise linear approximation is particularly suitable for representing characteristics of rectifiers, tube operation at cutoff, etc. This form of approximation is interesting because it permits a special method for solving nonlinear differential equations, the so-called "joining method."

This method consists essentially of representing the behavior of the nonlinear system by different linear equations for different intervals of the values of the variable, and replacing the nonlinear characteristic by a segment of a straight line within each interval. The solutions of the various linear equations must then be "joined" on the boundaries of the intervals, i.e., the value on the end of one interval must be equated to the value on the beginning of the next interval.

As regards approximation by transcendental functions, for example, by exponential or hyperbolic functions, this method leads to very compact expressions, which give at the same time a very good approximation. Unfortunately the subsequent treatment of these expressions becomes quite difficult.

4. An important role is played in nonlinear radio engineering by so-called "quasi-linear" methods. In these methods the equation of the nonlinear system is replaced by an equation of linear form, but the coefficients of this latter equation are certain *average* parameters, determined with allowance for existing nonlinearities.

The average values of the parameters thus depend on quantities that characterize the performance of this system. Quasi-linear methods are particularly suitable for the investigation of *steady-state* response of nonlinear systems to nearly sinusoidal signals.

5. If we are interested in a system approaching steady-state, the quasi-linear method of *slowing varying amplitudes* can be used to advantage. The general idea of this method is to assume that the steady-state oscillations in the investigated apparatus have amplitudes and frequencies that vary slowly. This permits a substantial simplification in the problem. Subject to certain assumptions (which will be discussed in detail), we obtain as a rule, an equation of one order lower than the initial equation. The method of slowly-varying amplitudes is used principally in cases when it is known beforehand that the oscillation is nearly sinusoidal.

6. Perhaps the most general method is that of plotting integral curves for the given nonlinear differential equation. This is known as the *isocline method.* We note for the time being that the method permits a solution of nonlinear problems of most general character.

It is suitable for both steady-state and transient modes, both sinusoidal and pronouncedly non-sinusoidal, the so called relaxation oscillations. A convenient variant of this method, which reduces the determination of the slope of the integral curve to a purely geometrical construction, is known as the *Lienard construction.*

7. Finally, a general method, which leads (sometimes with great simplicity) to important conclusions of general physical character, is the energy method. It consists essentially of considering the energy balance of the nonlinear system, i.e., of direct application of the law of conservation of energy. This method does not always throw light on the details, but gives reliable generalizations concerning the nature of the phenomenon.

These, in brief, are the research tools which will be used henceforth.

(To be continued in next issue)

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What The Russians Are Writing

J. George Adashko

NEW PERIODICALS

An ambitious undertaking of the Ministry of Higher Education in the USSR is the publication of 23 series of periodicals called "News of the Higher Institutions of Learning of the Ministry of Education, USSR." Those journals of interest to electronic design engineers cover radio engineering, radio physics, and instrument building. Others are devoted to mathematics, physics, electromechanics, and electric power.

We have just received the first issue of the radio engineering journal, *Izvestiya MVO-Radiotekhnika*, dated Jan.-Feb. 1958. Published by the Kiev Order of Lenin Polytechnic Institute, and intended for teaching staffs of higher scientific institutions, graduate students, and technical personnel of commercial and scientific-research institutes, it has a heavy theoretical emphasis.

ELECTRONIC DESIGN will expand its coverage to include abstracts of papers in these journals which are significant to our readers.

MODULATION

Use of Controlled Surface Effect for Modulation by V. S. Etkin. RE 3/58, pp 66-69, 2 figs, 1 table.

In an earlier article by the same author (*Radiotekhnika i elektronika*, April 1957) it was shown that in systems containing ferromagnetic conductors it is possible to obtain modulation by using the dependence of the high frequency resistance of the conductor on its magnetic permeability (skin effect). This article is a brief summary of experimental results on this effect.

Adoption of Auto-Anode Modulation by A. I. Miroshin. RE 3/58, pp 15-20, 6 figs.

Auto-anode modulation was first developed by M. G. Kruglov in 1949. Extensive tests have been made on this method using short-wave, medium-wave, and long-wave broadcast transmitters, and the results of the tests are reported. It is recommended that this system of modulation be more extensively used.

ACOUSTICS

Investigation of an Electron-Acoustic Converter by Yu. B. Semennikov. AJ 1-3/58, pp 73-84, January-March 1958, pp 73-84.

Description of a mechanism of an electron-acoustic conversion. The fundamental relations are derived for the output signal of an electron-acoustic converter as a function of the applied sound pressure at a specified contrast of the electric image. A procedure is given for the experimental determination of the equivalent electric parameters of an electron-acoustic converter.

Possibility of Employing Maximum Amplitude Limitation of Speech Signals in Communication Systems by Yu. G. Rostovtsev. EC 6/58, pp 49-52, 5 figs.

The author gives the articulation characteristics of speech signals in the case of strong amplitude limitations. These characteristics were obtained by connecting various linear filters before

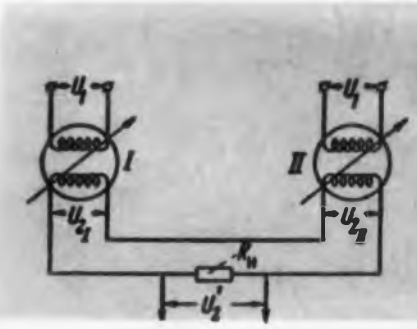

Fig. 1. Principle of the inductive linear potentiometer. The voltage across the load resistance is proportional to the angular displacement between rotary transformers I and II.

and after the limiter. It is shown that the use of a limiter of more than 40 db increases the interference immunity of the reception to such an extent, that there is a 7-10 fold gain in power.

COMPONENTS

Induction Linear Potentiometer for General Commercial Use by O. I. Aven, S. M. Domanitskiy, and Yu. M. Pul'yer. AT 3/58, pp 268-279, 11 figs.

The linearity of this potentiometer holds over a rotor angle close to ± 90 deg. A procedure for the design of such a potentiometer and a procedure for experimental investigation is given. The results of the experimental tests are reported. See Figs. 1 and 2.

Miniaturized Transformers for Multi-Channel Communication Apparatus by K. P. Yegorov and L. D. Paramonkova. EC 2/58, pp 51-58, 7 figs, 2 tables.

The authors consider the miniaturization of transformers intended for multi-channel communication apparatus, and primarily for individual channel equipment. It is shown that the limit to which power transformers can be reduced is dictated by the nonlinear distortion, and that voltage transformers are limited by structural difficulties.

Certain Properties of Non-Solid Shields for a Symmetrical Line by N. S. Kochanov. EC 3/58, pp 58-62, 7 figs.

Discussion of the shielding action of a shield having periodically-repeating transverse annular slits for a symmetrical two-conductor line. A formula is derived and is confirmed experimentally. It is shown that for certain frequency range a shield with slits can be more effective than a solid shield.

Concerning Some Properties of Ferromagnetic Clutches by P. N. Kopay-Gora. AT 4/58, pp 366-375, 7 figs.

Ferromagnetic clutches are magnetic clutches whose working gaps are filled with powdered carbonyl iron to which a solid or liquid filler is added. The

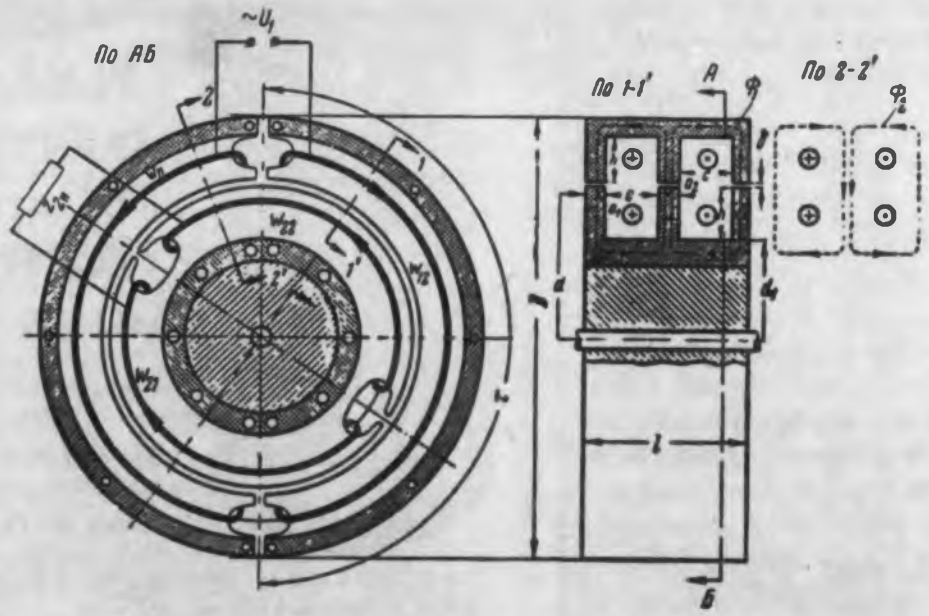

Fig. 2. Construction of the potentiometer. W_{21} and W_{22} are rotor coils, while W_{11} and W_{12} are an analogous pair of stator coils.

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author compares such clutches with electric motor, friction, and hydraulic devices with regard to starting time, electromagnetic time constant, control power, and ratio of output to inertia torques. The ferromagnetic clutches appear to be superior to torque motors and friction clutches. Reference is made to "Characteristic of Some Magnetic Fluid Clutch Servo Mechanisms" by Pairiale and Tilton (*Transactions AIEE*, Volume 69, Part 1, 1950).

Calculation of an Adjustable Rectifier with Allowance for the Effect of Phase Overlap by V. N. Aksenov. EC 12/57, pp 30-36, 5 figs, 1 table.

This appears to be the first attempt to analyze inductance loaded, grid-control rectifiers with allowance for the sector of phase overlap. The author gives a procedure for calculations in generalized coordinates of the characteristics, the short-circuit current, and the output ripple. Tables and graphs accompany the discussion.

Grapho-Analytic Method of Calculation of Transients in DC Electromagnetic Mechanisms by R. A. Agaronyants. EC 1/58, pp 34-42, 8 figs.

A rigorous grapho-analytical method is given for solving the dynamic equations involved in transients of moving-armature dc electromagnetic mechanisms. A solution is obtained by numerical integration. The calculations for a telephone relay are presented as an illustrative example.

Mechanism of Action of Cathode-Ray Barrier-Grid Memory Tube for Digital Computers by N. L. Yasnopol'skiy and A. P. Alekseyeva. REE 1/58, pp 142-154, 12 figs.

The fundamental factor that limits the capacity of the memory and the permissible number of addresses in memory tubes for digital computers is the parasitic seeding of neighboring elements of the dielectric target. This is primarily due to secondary electrons, in the recording, reading and recovery of signals in any element. The article gives the results of a direct experimental investigation of the seeding using a grid-barrier tube as a model. On the basis of these results, the authors analyze the processes of recording, reading, and retrieval of binary symbols in this tube. The conditions under which maximum number of addresses are obtained for a specified size of signals are indicated. The increase in the pulse for the recording of a unit obtained by changing over to mode of unbalanced recording,

makes it possible to obtain a gain in number of addresses of 5-10 times. References is made to work by Williams and Kilburn (*Proceedings IEE*, 1949, 96, 2, 50, 183-202) and Hines, Chryney and McCarthy (*Bell System Technical Journal*, 1955, Vol. 34, No. 6, page 1241).

Isochronous Traveling Wave Tube by G. F. Filimonov. REE 1/58, pp 85-93, 9 figs.

By artificial synchronization of the motion of the electron beam and of the wave it is possible to increase the power of the high frequency field in the traveling wave tube by three db. The effect of many parameters of the tube on the magnitude of this effect is investigated. Refers to work by Nordsieck (*Proceedings IRE*, 1953, Vol. 41, uages 630), Tien, Walker and Volontis (*Proceedings IRE*, 1955, Vol. 43, page 260), Rowe (*Transactions IRE*, 1956, ED-3, page 39) and Pierce's book on traveling wave tubes.

PROPAGATION

Forward Scatter Radio Communication at UHF, Employing Meteoric Ionization of the Atmosphere by M. N. Arone. EC 6/58, pp 40-48, 8 figs.

A survey is given of the essential factors that determine the effectiveness of a meteor-burst system for radio communication. Formulas are given for estimates of the power of the received signal. The block diagram, operating principle, certain results of an experimental system of meteor-burst communication are considered. Reference is made to several American and Canadian articles on the subject.

Correlation of Fading in Neighboring Sections of Radio-Relay Communication Lines by Yu. B. Sindler and A. S. Nemirovskiy. RE 11/57, pp 21-28, 4 figs, 2 tables.

The factors that affect the probability of failure of radio relay lines due to fading are analyzed. Certain problems in the statistical analysis of fading in radio-relay lines with a large number of sections are given, along with data on the operation of the Moscow-Gor'kiy radio-relay line during 1954-1956.

Effect of Correlation of Scatterer Velocity on Statistical Properties of Scattered Radiation by G. S. Gorelik. REE 10/57, pp 1227-1233, 3 figs.

The scattering of radio waves by irregularities, the velocities of which change in a stationary random manner and which are dependent on each other, is investigated. A formula is derived for the correlation functions (spectra) of the scattered field, of the components of its slowly-vary-

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ing amplitude, and of its intensity. The general relations are illustrated with the aid of a two-scale model of partially correlated motion of the scatterers. This work extends the investigation, reported by the same author in the June 1956 issue of *Radiotekhnika i Elektronika* (Page 695), dealing with the connection between the theory of scattering of radio waves by wandering irregularties and the theory of turbulent diffusion.

Medium-Wave Radio Broadcast Antenna on Low Masts by B. S. Nadenenko. RE 7/57, pp 46-55, 12 figs.

A popular article on the same subject appeared in Vestnik Svyazi for May 1957. The present article has an engineering description and various tuning schemes of a slot-type medium-wave antenna, and details a method for the analysis of all the parameters of the antenna.

Limiting Accuracy of Long Range Radar System by G. A. Zuykina. RE 12/57, pp 19-20, 2 figs, 1 table.

The author discusses the effect of propagation conditions on the phase and phase velocity of radio waves in the 100-150 kc band. Results of calculation of correction for phase and phase velocity for the various types of grounds are given. Plots are given for the phase velocity as a function of the ground properties. An estimate is made of the limiting accuracy of long range radar with a phase measurement, as affected by a ground surface.

Calculation of Gain of Periscopic Antenna Systems by A. M. Pokras. RE 11/57, pp 13-20, 5 figs.

Modern periscopic systems can be subdivided into two classes: systems with parabolic radiators, and those with ellipsoidal radiators. Each class can be subdivided into two subclasses, with either plane or parabolic reflectors. Formulas and universal graphs for the gain of a periscopic system with an ellipsoidal mirror radiator, having either a round or square aperture, are derived. Systems with plane and parabolic reflectors are also considered. Refers to an article by E. Bedrosian, Transactions IRE, page 168, 173, October 1955.

Investigation of Upper Layers of the Atmosphere by L. Karyakin. R 12/57, pp 19-20.

Brief popular discussion of the effect of various ionized layers on the propagation of radio waves.

MEASUREMENTS

Determination of the Error in the Constancy of the Phase Difference Over a Frequency Band by D. N. Vinogradov. EC 5/58, pp 35-43, 13 figs.

It is required to obtain, in a certain frequency band, constant phase difference between the output voltages of networks I and II in Fig. 3. Errors in the constancy of the phase will rise because of the inexact matching of the wave impedances of the networks to the load impedances. Measures of eliminating these errors are indicated in the article.

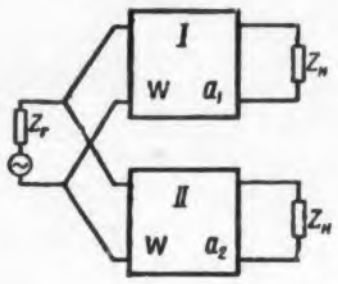

Fig. 3. Two networks, whose output phase difference is to be kept constant.

Contactless Method of Determining Specific Electric Resistivity by G. G. Yarmol'chuk. AT 3/58, pp 257-267, 10 figs.

Description of a method for measuring specific resistivity. The method is based on the use of high frequency currents induced in a conducting body placed in an alternating magnetic field. The equivalent circuit of the tested body is first developed, and a bridge method is designed for the measurements. In addition, the use of this method for quality control of carbon brushes is described. Reference is made "Now a Useful Nondestructive Testing Tool" by H. Staats (*Materials and Methods*, Volume 38, No. 4, 1953) and "Eddy Current Testing" by R. Hochschild (*Control Engineering*, October 1954).

TELEMETRY

Telemetering System With Pulse-Code Modulation by G. V. Burdenkov. AT 1/58, pp 55-63, 11 figs.

Examination of a high speed pulse-code telemetering system. It is shown that it is possible to synthesize telemetering systems using magnetic elements with rectangular hysteresis loops in conjunction with transistors and crystal diodes. The fundamental parameters of the equipment are given and an estimate of the telemetering accuracy is made. Refers to "Oxford Pulse-Code Modulation System" (*Proceedings IEE*, Volume 41, No. 7, 1953), "Coding by Feedback Methods" (*Proceedings IEE*, Volume 41, No. 8, 1951).

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Optimum Frequency Deviation in a Single-Channel Telemetering System by Yu. I. Chugin. AT 4/58, pp 346-364, 6 figs.

The author shows that it is possible to obtain, for telemetering systems with idealized receiver characteristics, an analytic expression for the optimum deviation. The computation method is based on an analysis of the noise in the energy spectrum. Standard methods of the theory of random functions are used. Reference is made to "Statistical Properties of Sign-Wave Plus Random Noise" by S. O. Rice (*Bell System Technical Journal*, Volume 27, No. 1, 1948) and "The spectrum of Frequency Modulated Waves After Reception in Random Noise" by D. Middleton (*Quarterly of Applied Mathematics*, Volume 7, No. 2, 1949).

Telemetering Balanced Device For the Measurement of Linear Displacements by A. A. Kol'tsov and L. F. Kulikovskiy. AT 3/58, pp 280-284, 7 figs.

Description of an inductive follow-up system for linear displacements, suitable for automation and remote control. A theoretical analysis and construction data of the system are given. The transducers are essentially closed magnetic circuits having one coil, in which the induced voltage is proportional to the linear displacement.

AUTOMATIC CONTROL

Optimum Transients in an Automatic Control System with a Limited Regulator Position by Ye. K. Krug and O. M. Minina. AT 1/58, pp 10-25, 13 figs, 3 tables.

Optimum transients are determined for control systems that contain objects with different dynamic characteristics, including delay elements, in which the regulator has limited positions. It is shown that it is quite difficult to realize optimum transients in a control system by using continuous-action regulators, since the characteristics of the nonlinear converters of these regulators depend on the magnitude and position of the disturbances and on the initial values of the limited coordinates. It is proposed to employ a discrete regulator for the production of the optimum transients. Reference is made to "Predictor Servomechanisms" by L. Silva (*Transactions IRE*, March 1954).

Concerning the Synthesis of Linear Dynamic Systems with Variable Parameters by A. M. Batkov. AT 1/58, pp 49-54.

A method is developed for determining the differential equations of a linear dynamic system with variable parameters from a specified pulse

transfer function. Reference is made to "Frequency Analysis of Variable Networks" by L. A. Zadeh (*IRE*, Volume 38, No. 3, March 1950) and "Properties of Impulse Responses and Green's Functions" by K. S. Miller (*IRE Transactions on Circuit Theory*, Volume CT-2, 1955).

Frequency Methods of Remote Control of Distributed Objects by V. A. Il'yin and K. P. Kurdyukov. AT 2/58, pp 174-186, 12 figs, 1 table.

The problems involved in the remote control of many small objects (rather than large concentrated objects) are quite different. For example, it is not so much a problem of signal to noise ratio or load capacity of the system (both are high in distributed systems), but a question of reliability of apparatus at unattended points of the system and the simplicity of the system as a whole. The author shows that the frequency method of selecting and controlling distributed objects, using a wire transmission channel, is preferable for such service. The construction of remote control devices, including frequency relays with series tuned circuits, is considered.

Increase of Speed of Certain Automatic Control Systems with the Aid of Nonlinear and Computing Devices by G. M. Ostrovskiy. AT 3/58, pp 208-216, 3 figs.

The problem of introducing nonlinear devices into certain automatic control systems for improving the quality of regulation are discussed. The analysis of a third order control system (one with derivative and acceleration feedback) is analyzed as an example.

ELECTRON PHYSICS

Concerning the Drift Velocity Method by Yu. N. Obraztsov. Journal of Technical Physics. 2/58, pp 245-249.

The author considers the causes of the apparent discrepancy between the results of calculating the current density by strict solution of the Boltzmann equation and by using the drift-velocity method in the case when the mean free path time depends on the velocity. A correctly performed calculation by the drift-velocity method leads in this case to the correct results. This topic was also treated recently by R. B. Dingle (*Physica*, Vol. 22, page 671, 1956).

Volume Peltier Effect in Germanium by P. I. Baranskiy. Journal of Technical Physics (*Zhurnal Tekhnicheskoy Fiziki*), 2/58, pp 225-230, 6 figs.

The Peltier effect, developed on the boundary between two conductors or between a semiconductor and a metal, has been investigated in considerable detail. This article seems to be the

RUSSIAN TRANSLATIONS

first attempt in an investigation of the volume Peltier effect, which develops at irregularities in the specific resistivity of germanium single crystals. The experimental results show that the Peltier effect is proportional to the current.

Equilibrium Distribution of the Potential, Field, and Carrier Concentration on Fused-In Junctions by E. I. Adirovich, Yu. S. Ryabinkin, and K. V. Temko. Journal of Technical Physics *(Zhurnal Teknicheskoy Fiziki)*, 1/58, pp 55-66, 9 figs.

The authors show that, except in special cases, the thermodynamic equilibrium distribution of the potential, field, and carrier concentration cannot be solved in general by the Shockley method (*Bell System Technical Journal*, Vol. 28, pages 435, 1949). One cannot neglect the concentrations of the electrons and holes in the junction region compared with the concentration of the dominating impurities, and proceed to give a mathematical formulation and a general solution to the problem.

Propagation of Electromagnetic Waves in Decelerating Systems Employing a Helix and a Dielectric by B. M. Bulgakov and V. P. Shestopalov. Journal of Technical Physics *(Zhurnal Tekhnicheskoy Fiziki)*, 1/58, pp 188-201, 7 figs, 3 tables.

The article considers the propagation of electromagnetic waves in a helix, placed in a dielectric medium, in the presence of an electron beam. It also considers the properties of decelerating system, in which it is possible to vary structurally both the helix as well as the dielectric. This article covers much of the ground that is covered also in a similar article by one of the authors (Shestopalov) in the January 1958 issue of *Radiotekhnika i Elektronika.*

Preliminary Results of Nonlinear Theory of Self-Oscillations of Backward Wave Tube with Longitudinal Field by G. N. Rapoport. RE 2/58, pp 249-254, 4 figs.

The nonlinear equations of a type O backward wave tube are formulated for the case of small space charges and small damping. The analysis of the solution is used to consider the bunching of the electrons in the backward wave tube and the causes that reduce the effectiveness of a backward-wave oscillator compared with that of an ordinary traveling wave oscillator. The dependence of the power on the oscillator parameters and the maximum efficiency are calculated. Refers to work by Johnson (*Proceedings*

IRE, 1955, 43, 684), Grow & Watkins (*Proceedings IRE*, 1955, 43, 848) Palluel and Goldberger (*Proceedings IRE*, 1956, 44, 333) Nordsieck (*Proceedings IRE*, 1953, 41, 630) and Rowe (*Proceedings IRE*, 1956, 44, 200).

Calculation of the Dependence of the Current Gain Coefficient on the Emitter Current in Alloy Type Germanium Transistors for Injection and Extraction at High Temperatures by L. L. Makovskiy. Journal of Technical Physics (*Zhurnal Tekhnicheskoy Fiziki*), 1/58, pp 52-54, 1 fig.

A theoretical explanation is given for the experimental results reported previously in this journal. The explanation is based on work by W. M. Webster, *Proceedings IRE*, Vol. 42, No. 5, 1954. Reference is also made to work by R. N. Hall, *Proceedings IRE*, Vol. 40, No. 11, 1952.

Nonlinear Semiconductor Impedance, Sensitive to Magnetic Fields by G. Ye. Pikus and O. V. Sorakin. AT 2/58, pp 187-188, 1 fig.

A useful property of nonlinear resistances is that the sign of the change in resistance depends on the directions of the electric and magnetic fields. Since the dimensions of the individual resistances are small, a block of such resistances, assembled and oriented in a suitable manner, can be placed as a whole in the gap of a single permanent magnet.

RADAR

Influence of Fluctuations On the Operation of an Automatic Range Finder by I. N. Amiantov and V. I. Tikhanov. AT 4/58, pp 325-333, 6 figs.

The article considers the operation of the simplest type of range finder used in automatic tracking systems, in the presence of fairly small fluctuations and a stationary target. Straightforward statistical theory is employed.

RELIABILITY

Increase of the Reliability of Systems with Spares by B. R. Levin. EC 11/57, pp 65-72, 6 figs.

The reliability of a system with many elements has been studied by many investigators. This article is devoted to methods of increasing reliability by introducing spare elements. One of the fundamental assumptions that any two elements of the system are independent, i.e., that when one element goes out of order it does not affect the reliability of the second element. Reference is made to work by Moskowitz and McLean "Some Reliability Aspects of System Design" IRE Transactions, PGRQC-8, September 1956.

E. Brenner

Analog Solution of Mathieu Equations

THE PRINCIPLE of frequency division by use of mixers with feedback can be used to construct electronic circuits which solve Mathieu's, Hill's and similar linear differential equations with variable coefficients. Such equations describe physical systems with parametric excitations and serve as "auxiliary" equations to determine the stability of solutions of many nonlinear systems.

Frequency division by use of feedback-controlled mixers is illustrated schematically in Fig. 1. Assume a signal of frequency f_o at the output is fed to a nonlinear circuit in the feedback loop so that harmonics are generated. A filter selects the kth harmonic, kf_o. In the mixer the frequency f_i is mixed with kf_o and a beat frequency is filtered out. Hence, the frequency at the output, f_o, is an exact submultiple of the input frequency and may be represented by

$$f_o/f_i = 1/(1 \pm k)$$

For the case $k = 1$, $f_o/f_i = 1/2$ and the feedback channel is simplified as shown in Fig. 2 since

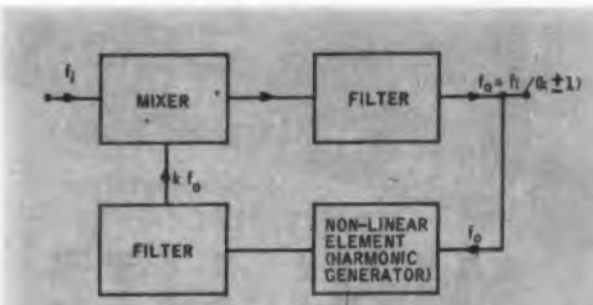

Fig. 1. Frequency divider using a feedback-controlled mixer.

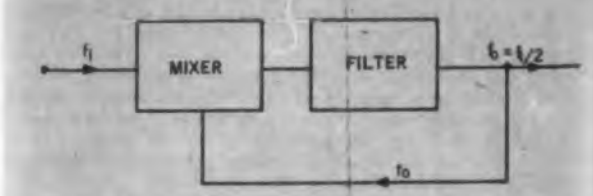

Fig. 2. Schematic diagram for frequency division by two.

the harmonic generator and the associated filter may be omitted.

To show how this circuit is related to Mathieu equations, consider first the ideal mixer (which does not load the filter circuit and which has zero output impedance) as shown in the frequency divider circuit ($k = 1$) of Fig. 3. If the mixer is a multiplier so that $v_m = -v_i v_o / K_m$ then the differential equation for the circuit can be shown to be

$$\frac{d^2 v_o}{dt^2} + \frac{1}{LC}\left(1 + \frac{v_i}{K_m}\right) v_o = 0$$

If the input signal is sinusoidal, $v_i = V \cos \omega_i t$, then this equation is of the form

$$\frac{d^2 v_o}{dt^2} + \frac{1}{LC}\left(1 + \frac{V}{K_m} \cos \omega_i t\right) v_o = 0$$

which is a special case of the Mathieu equation

$$y'' + (\alpha + \beta \cos x)\, y = 0$$

If the losses in the mixer and in the filter circuit are included in the calculations as indicated in Fig. 4, then the differential equation for the output voltage has the form

$$\frac{d^2 v_o}{dt^2} + 2\delta \frac{dv_o}{dt} + \nu^2 v_o = 0$$

where

$$2\delta = (R/L + G/c)$$
$$\nu^2 = (1 + GR \pm v_i/K_m)/LC$$

Referring to Fig. 4,

$$R = R_L + R_i \text{ and } G = G_c + G_i$$

Abstracted from an article by H. Jungfer, Frequenz, *Vol. 12, No. 6, June 1958, pp. 169-178.*

Abstracter's Note: The abstract above is taken from the first part of a paper which is to be continued in a forthcoming issue of *Frequenz*.—E. B.

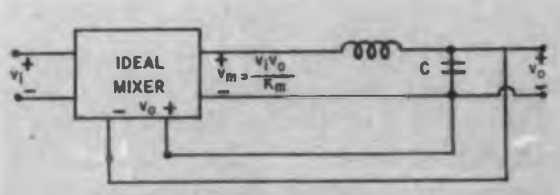

Fig. 3. Idealized circuit of a frequency halver using an L-C low pass filter.

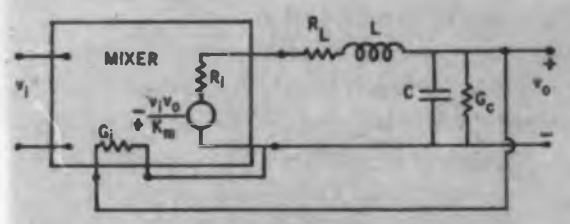

Fig. 4. Similar to Fig. 3 but losses are represented by equivalent resistance.

NEW Automatic Electronic Cable-making Machine Announced

(Los Angeles, California) After years of development, The Zippertubing Company announces production of a machine which automatically makes cables at speeds up to 900 feet per hour. This machine, occupying only 24 square feet of floor space, produces cables with up to 108 conductors and is so simple to operate that inexperienced personnel can make cables to any specification.

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Complete unit with wire reels in place.

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By using Zippertubing laminated materials, cables which require jackets of several different materials can be made in one step without costly re-handling. Available jackets include copper, aluminum or Co-netic steel in combination with such materials as vinyl, Mylar,* or fiber glass. Other laminates for high temperature exposure, abrasion protection, etc., also may be used in the machine.

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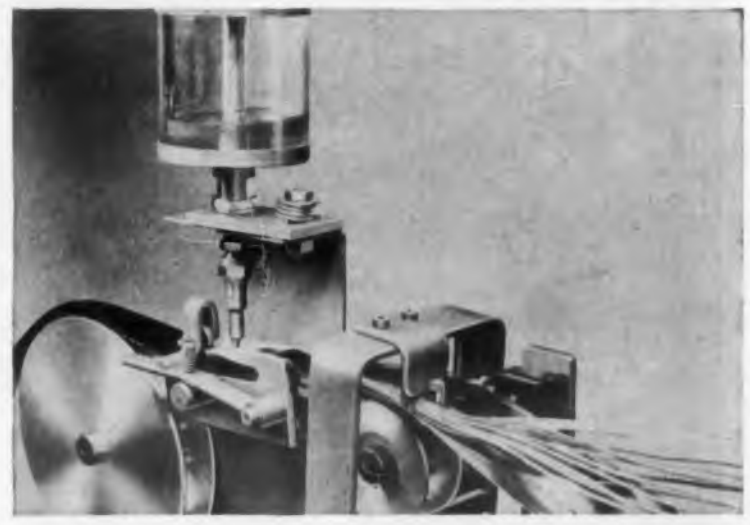
Up to 90% of the labor costs formerly involved in fabricating cables are eliminated through the use of the Zippertubing Cable Machine. Only limited floor space is necessary for long-run continuous lengths, and material waste, skilled labor investment and expensive extruding equipment no longer are required. Expensive "minimum" orders for custom extruded cabling as well as delay in deliveries also are eliminated. Because of the flexibility of Zippertubing, small cable runs for R & D work are economically feasible. Zippertubing cables can be re-opened for additional work on conductors, virtually eliminating the great costs formerly incurred in correcting mistakes in prototype development.



Close-up of head showing Zippertubing jacketing and conductors being formed into cable and automatically sealed.

MEET MIL SPECS

Cables produced on this new equipment meet all necessary MIL specs, depending on the jacketing material and the purpose for which it is to be used.

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One of the purposes of this new machine is to help manufacturers reduce their capital investment and inventory in electronic cables. A special plan has been developed whereby manufacturers who use 10,000 feet or more of Zippertubing jacketing per month will be provided with one of these machines at no cost. For those with more modest requirements, the machine may be leased very inexpensively with option to buy, or it may be purchased outright. A 100% lifetime guarantee is available under all plans. When ordering, allow three weeks for delivery.

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GERMAN ABSTRACTS

E. Brenner

Frequency Cut-Off

IN AN inductive attenuator the H_{11} mode is excited and received in a cylindrical waveguide whose length is made variable by use of a "line-stretcher" and which is excited by means of coupling loops. The basic arrangement is shown in Fig. 1. In Figs. 2 and 3 the two types of attenuators used are presented.

It can be shown that in a Type 1 attenuator the voltage ratio is proportional to the wavelength. Moreover for small values of distance l, the voltage division is proportional to sinh (4.81 1/d).

For Type 2 attenuation is independent of wavelength. Both attenuators have similar characteristics as a function of l.

Abstracted from an article by A. Sander, Nachrichtentechnische Zeitschrift, *Vol. II, No. I, Jan. 1958, pp. 1-5.*

Modulated Light

THE MODULATION of light by means of standing waves in a fluid is possible because the refractive index of fluids is a function of the degree to which it is compressed. To accomplish modulation an ultrasonic quartz crystal is placed at one end of a column of fluid as shown in the illustration. A reflector is placed at the other end. If the crystal is excited, then standing waves, i.e. compressions and refractions, are set up in the fluid. In order to have the entire surface of the crystal oscillate with the same phase, an excitation frequency somewhat lower than the natural frequency of the crystal is used.

Because of the standing sound waves in the liquid, the refractive index, n, will vary in accordance with the law

$$\frac{C}{n \pm \Delta n} = \Delta v \pm v$$

where

C is the velocity of light in vacuum, and v is the velocity of light in the fluid under normal pres-

Response of Attenuators

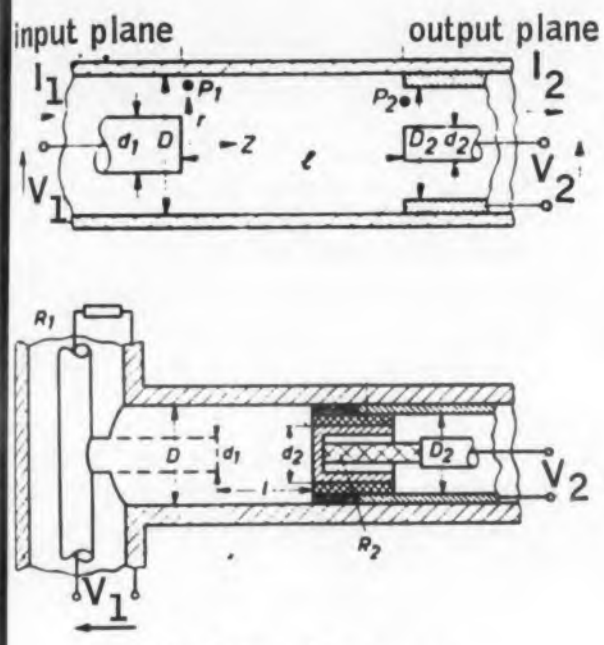


Fig. 1. Cylindrical waveguide with coaxial terminations.

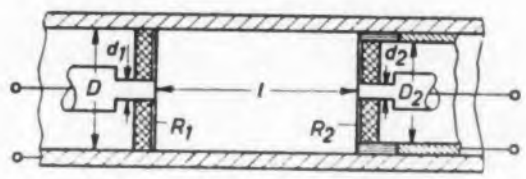


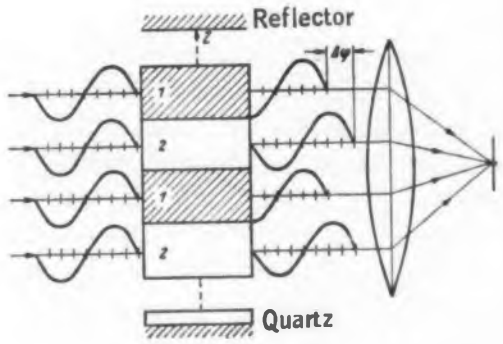
Fig. 2. Type 1 attenuator.

Fig. 3. Type 2 attenuator.

re distributed so that a simpler representation achieved. The effect which is observed when e collimated light beam is projected on a reen is analogous to the optical phenomena served with the aid of a diffraction grating. uctuations of light intensity occur at twice the equency of the crystal oscillations.

In the original paper detailed measurement ocedures and the results of these procedures e cited.

Abstracted from an article by H. F. Reimann, achrichtentechnik, *Vol. 7, No. 11, Nov. 1957,* p. *515-518.*



Simplified diagram to illustrate the modulation of light by means of standing waves in a fluid. The shaded regions are regions of compression, the unshaded regions represent rarefactions. In place of the sinusoidal distribution of compressions abrupt steps (i.e. alternate regions of compressions) are shown to illustrate the principle.

STANDARDS AND SPECS

Sherman H. Hubelbank

Relays

MIL-R-25018(USAF), Relays, Miniaturized, Hermetically Sealed, Airborne Equipment, General Specification for, Amendment 1, 12 February 1958

The requirements for Sealing Test 1 have been changed to read: the leakage rate shall not exceed an equivalent rate of 3cc of helium (at standard conditions) in ten years. An alternate method for making this test may use a radioactive tracer method with an inert, nontoxic, radioactive gas such as Krypton.

Switches

MIL-S-3950A, Toggle Switches, Amendment 1, 1 April 1958

Terminals not functionally required as indicated in the applicable standard need not be supplied. Group A inspection has been revised to indicate that quality acceptance levels shall be as specified in Table II. Major and minor defects shall be as defined in MIL-STD-105.

Crystal Holders

MIL-H-10056C, General Specification for Crystal Holders, 20 March 1958

The scope of the spec has been changed so that the spec now covers only metal and glass crystal holders. The plastic crystal holder HC-5/U has been deleted. A metal holder HC-21/U, which is electrically and physically equivalent to HC-5/U, has been added.

Solenoids

MIL-S-4040C, General Specification for Electrical Solenoids, 23 January 1958

The general requirements for aircraft solenoids are covered in this spec. The solenoids may be either continuous duty or intermittent duty types. Solenoids meeting the requirements of this spec are of compact design and of sufficiently rugged construction to withstand the mechanical shocks and stresses incident to their use in aircraft. The solenoid coils are terminated with an electrical connector conforming to MIL-C-5015 on terminals of the screw-stud type. This spec supersedes MIL-S-004040B(USAF) and MIL-S-4040A.

Capacitors

MIL-C-3965B, Capacitors, Fixed, Electrolytic (Tantalum) General Specification for, 3 April 1958

The overvoltage requirement has been replaced by a surge voltage requirement. The life test has been increased from 1000 hours to 2000 hours. Various electrical requirements have been changed. This issue supersedes coordinated spec MIL-C-3965 and single-service spec MIL-C-003965(USAF).

MIL-C-26244(USAF), Capacitors, Fixed, Paper (or Paper-Plastic) Dielectric, D-C, High Reliability (Hermetically Sealed in Metallic Cases), 31 January 1958

This spec is intended for capacitors used primarily for filter, by-pass, and blocking purposes, where the a-c component of the impressed voltage is small with respect to the d-c voltage rating. It is the intent of this spec that the manufacturer shall control the quality of his production to an AQL of 0.4% or below. Capacitors having this quality will have a minimum failure rate ranging from 0.01%/1,000 hours to 0.97%/1,000 hours depending upon the manner in which used. Capacitors meeting this spec may be used a full rated voltage at 125°C with an expected failure rate of less than 1% per 1,000 hours. A typical type designation of capacitors meeting this spec is CPV08A1E1041.

Microfilm Storage

ASA PH5.4-1957, American Standard Practice for Storage of Microfilm

Humidity, temperature, dust, or gas will not ruin microfilm records if the microfilm is stored as outlined in this standard. All the problems involved in storge, ways to protect and methods of inspection to insure safety of microfilm, are outlined in this new standard. The standard gives storage provisions for commercial permanence, that is, for microfilm to be used within approximately 25 years; for archival permanence, for microfilm that must be kept safely for maximum period obtainable; and for protection against fire. The standard covers general principles of humidity during storage, temperature, impurities in the air, fire protection, reels on which microfilm is wound, containers for storing microfilm, storage housing, storage rooms, conditions of air and inspection. A comprehensive bibliography is also included. Copies of this standard are available from the American Standard Association, 70 East 45 Street, New York 17, N.Y. at 50 cents a copy.

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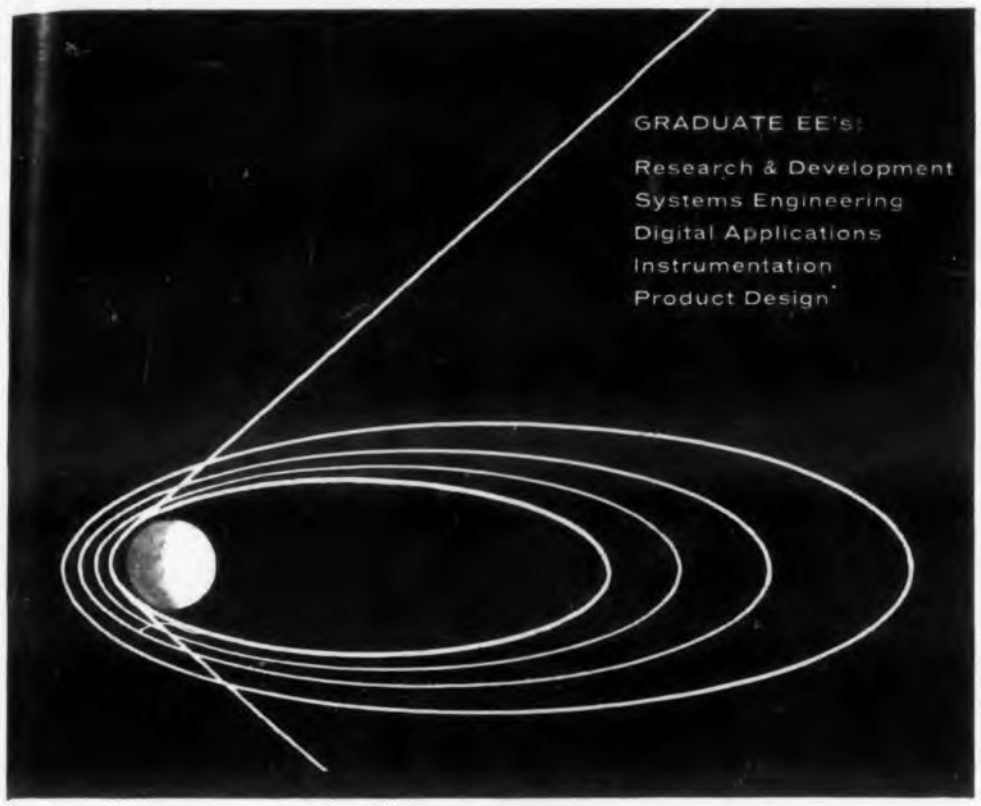

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A Viking Fable

When the terrible green monster suddenly appeared alongside the good ship Viking Queen, all hands save one promptly disappeared over the side into the chill waters of the North Atlantic. Only Lief Smorgasbord, radar operator, remained aboard to face the beast.

If we may take a trembling Lief from history, we will follow the conversation that ensued:

Lief (trembling): Why . . . why didn't you show up on my scope?

Monster (in a high, feminine voice): I'm enchanted, that's why! Oh, Mr. Viking, I'm just a poor princess who has been bewitched and transformed into a teen-age she-sea serpent! If you could answer the mysterious riddle, you could break the spell and marry me!

Lief (still trembling): The Mysterious Riddle?

Monster (hopefully): It goes like this.

Heart of that which has no ears, but hears;
No eyes, but sees; no nose, but knows . . .
Tube B or not Tube B, that is the question!

*Lief managed to answer the riddle, breaking the spell and instantly transforming the monster into a lovely princess. And so they were married and lived happily ever after.**

** The single word was "Bomac," of course. Lief knew "Tube B or not Tube B" must refer to Bomac tubes, heart of any radar system ("that which has no ears, but hears, etc.") Smart one, that Smorgasbord.*

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A Viking Fable

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