ELECTRONIC DESIGN

NOVEMBER 1, 1956

FREED

offers for Immediate Delivery

MAGNETIC AMPLIFIERS AND SATURABLE TRANSFORMERS

FAST RESPONSE MAGNETIC AMPLIFIERS

2 ∿ response Phase reversible

Cat. No.	Supply Freq. in C.P.S.	Power Out. Watts	Volt. Out. V. AC	AC or DC signal voltage req'd for full output.	
MAF-1	60	13	110	1.0	—
MAF-6	400	5	57.5	1.2	0.4
	400	10	57.5	1.6	0.6
MAF-7	400	15	57.5	2.5	1.0

SINGLE ENDED MAGNETIC AMPLIFIERS

Cat. No.	Supply Freq. C.P.S.	Power Out. Watts	Sig. req'd for full outp. MA-DC	Total res. Contr. wdg. KΩ	Load res. ohms
MAO-1	60	4.5	3.0	1.2	3800
MAO-2	60	20	1.8	1.3	700
MAO-4	60	400	9.0	10.0	25
MAO-5	60	575	6.0	10.0	25

PUSH-PULL MAGNETIC AMPLIFIERS

Phase reversible

Cat. No.	Supply Freq. C.P.S.	Power Out. Watts	Volt. Out. V. AC	Sig. req'd for full outp. MA-DC	Total res. contr. wdg. KΩ
MAP-1	60	5	—	1.2	1.2
MAP-2	60	15	115	1.6	2.4
MAP-3	60	50	115	2.0	0.5
MAP-3-A	60	50	115	7.0	2.9
MAP-4	60	175	115	8.0	6.0
MAP-7	400	15	115	0.6	2.8
MAP-8	400	50	110	1.75	0.6

SATURABLE TRANSFORMERS

Phase reversible

Cat. No.	Supply Freq. C.P.S.	Power Out. Watts	Volt. Out. V. AC	Sig. req'd for full outp. MA-DC	Total res. contr. wdg. KΩ
MAS-1	60	15	115	6.0	27
MAS-2	400	6	115	4.0	10
MAS-5	400	2.7	26	4.0	3.2
MAS-6	400	30	115	4.0	8.0
MAS-7	400	40	115	5.5	8.0

All units designed for 115V-AC operation

VARIABLE TEST VOLTAGE MEGOHMMETER NO. 1620

The Freed Type 1620 Megohmmeter is a versatile insulation resistance measurement instrument with a continuously variable DC test potential from 50 to 1000 volts.

Components such as transformers, condensers, motors, printed circuits, cables and insulation material can be tested at their rated voltage and above, for safety factor.

Resistance — 0.1 megohms to 4,000,000 megohms.

Voltage — variable, 50-1000 volts.

Accurate — plus or minus 5% on all ranges.

Simple — for use by unskilled operators.

Safe — high voltage relay controlled.

Self contained — AC operated.

ALSO AVAILABLE:

Type 1620C MEGOHMMETER — a type 1620 with additional circuitry for testing capacitors.
Type 1020B MEGOHMMETER — a 500 volt fixed test potential.
Type 2030 PORTABLE MEGOHMMETER — battery operated, 500 volt test potential.

FOR PRECISION LABORATORY OR PRODUCTION TESTING

1110-AB INCREMENTAL INDUCTANCE BRIDGE AND ACCESSORIES

Accurate inductance measurement with or without superimposed D.C., for all types of iron core components.

Inductance: 1 Millihenry to 1000 Henry
Frequency: 20 to 10,000 Cycles
Accuracy: 1% to 1000 Cycle, 2% to 10KC
Conductance: 1 Micromho to 1 MHO
"Q": 0.5 to 100
Superimposed D.C.: Up to 1 Ampere
Direct Reading: For use by unskilled operators.

ACCESSORIES AVAILABLE:

1140-A Null Detector
1210-A Null Detector — V.T.V.M.
1170 D.C. Supply and 1180 A.C. Supply

MIL-T-27A POWER, FILAMENT, PULSE & AUDIO TRANSFORMERS

POWER TRANSFORMERS-STANDARD

All primaries 105/115/125 v, 60 c.p.s.

Cat. No.	Hi Volt Sec.	ct	DC Volts	DC Amps	Filament #1 Volt	Filament #1 Amp.	Filament #2 Volt	Filament #2 Amp.	MIL Case Size
MGP1	400/200	√	185	.070	6.3/5	2	6.3	3	HA
MGP2	650	√	260	.070	6.3/5	2	6.3	4	JB
MGP3	650	√	245	.150	6.3	5	5.0	3	KB
MGP4	800	√	318	.175	5.0	3	6.3	8	LB
MGP5	900	√	345	.250	5.0	3	6.3	8	MB
MGP6	700	√	255	.250					KB
MGP7	1100	√	419	.250					LB
MGP8	1600	√	640	.250					NB

FILAMENT TRANSFORMERS-STANDARD

All primaries 105/115/125 v., 60 c.p.s.

Cat. No.	Secondary Volt	Secondary Amp	Test VRMS	MIL Case
MGF1	2.5	3.0	2,500	EB
MGF2	2.5	10.0	2,500	GB
MGF3	5.0	3.0	2,500	FB
MGF4	5.0	10.0	2,500	HB
MGF5	6.3	2.0	2,500	FB
MGF6	6.3	5.0	2,500	GB
MGF7	6.3	10.0	2,500	JB
MGF8	6.3	20.0	2,500	KB
MGF9	2.5	10.0	10,000	JB
MGF10	5.0	10.0	10,000	KB

PULSE TRANSFORMERS

Cat. No.	Block'g. Osc.	Int. Coupl'g	Low. Pow. Out.	Pulse Voltage Kilovolts	Pulse Duration Microseconds	Duty Rate	No. of Wdgs.	Test Volt. KVRMS	Char. Imp. Ohms
MPT1	√	√		0.25/0.25/0.25	0.2-1.0	.004	3	0.7	250
MPT2	√	√		0.25/0.25	0.2-1.0	.004	2	0.7	250
MPT3	√	√		0.5/0.5/0.5	0.2-1.5	.002	3	1.0	250
MPT4	√	√		0.5/0.5	0.2-1.5	.002	2	1.0	250
MPT5	√	√		0.5/0.5/0.5	0.5-2.0	.002	3	1.0	500
MPT6	√	√		0.5/0.5	0.5-2.0	.002	2	1.0	500
MPT7	√	√	√	0.7/0.7/0.7	0.5-1.5	.002	3	1.5	200
MPT8	√	√	√	0.7/0.7	0.5-1.5	.002	2	1.5	200
MPT9	√	√	√	1.0/1.0/1.0	0.7-3.5	.002	3	2.0	200
MPT10	√	√	√	1.0/1.0	0.7-3.5	.002	2	2.0	200
MPT11	√	√	√	1.0/1.0/1.0	1.0-5.0	.002	3	2.0	500
MPT12	√	√	√	0.15/0.15/0.3/0.3	0.2-1.0	.004	4	0.7	700

AUDIO TRANSFORMERS

Freqs. resp. 300 to 10000 cps ± 2 DB. All Case Sizes AJ

Catalog No.	Application	Impedance Prim. Ohms	Impedance DL	Impedance Sec. Ohms	Impedance Ct.	DC Current Prim. P. Side MA Max.	DC Current Sec. MA Max.	Max Level DBM
MGA1	Single or P.P. Plates — to Single or P.P. Grids	10K	√	90K Split	√	10	10	+15
MGA2	Line to Voice Coil	600 Split		4, 8, 16		0	0	+33
MGA3	Line to Single or P.P. Grids	600 Split		135K	√	0	0	+15
MGA4	Line to Line	600 Split		600 Split		0	0	+15
MGA5	Single Plate to Line	7.6K 4.8T		600 Split		40	40	+33
MGA6	Single Plate to Voice Coil	7.6K 4.8T		4, 8, 16		40	40	+33
MGA7	Single or P.P. Plates to Line	15K	√	600 Split		10	10	+33
MGA8	P.P. Plates to Line	24K	√	600 Split		10	1	+30
MGA9	P.P. Plates to Line	60K	√	600 Split		10	1	+27

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ELECTRONIC DESIGN

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CIRCLE 2 ON READER-SERVICE CARD FOR MORE INFORMATION

Editorial

Engineers, Take to the Road

You could easily get frustrated if you tried to decide which of the many forthcoming conferences, meetings, or shows to take in. We just finished counting over 100 pages of literature announcing different meetings of interest to electronic designers. You couldn't possibly attend all because some are going on at the same time. On the other hand, maybe there's no conflict created because the department head says forget the whole thing, it's a waste of time and money going to such meetings. Get on with your project! The fact that more people do not go to meetings may be the bad thing.

Why go to meetings, conferences, symposiums? In many cases, a conference proceedings of all the papers can be purchased for $5 or less. Timely good papers will be sought by technical journal editors and readers can get the data fast. Far faster than listening to drawn-out monotone, broken-English or stammering speakers who stimulate nothing more than soporific ideas.

The simple answer to why go is that there is no better time or place to exchange ideas or swap notes than at a technical conference. Even if you refuse to enter into the spirit of exchanging information, you may very likely make the whole trip worthwhile simply by eavesdropping on others' conversation. More than once something will be said that is the missing link in your own study and investigation. Ask the alert engineer who goes to a meeting. Very likely it's information coming entirely aside from the papers being read that is valuable to him. Of course the papers presented focus attention on the problem, and it may be that the real nugget of information will come up in the question and answer period following the delivery of the paper. The main point is that free interchange of ideas accelerate progress and technical meetings provide the time, place and direction.

Professional engineering and educational groups and trade groups that sponsor such affairs deserve respect and support. Support should be given by the industry by sending engineers to meetings and encouraging participation in committees that organize such meeting. For those whose interest is only self-interest, participate simply by sending your engineers. Even if you take part in only a unilateral way everyone will benefit.Why not assign at least one engineer, if not more to cover every meeting coming up? Stipulate only one thing, that they write a trip report. Possibly better yet, schedule your own interdepartmental meeting where everyone reports on what he learned from being on the road.—JAL.

Engineering Review

For more information on developments described in "Engineering Review," write directly to the address given in the individual item.

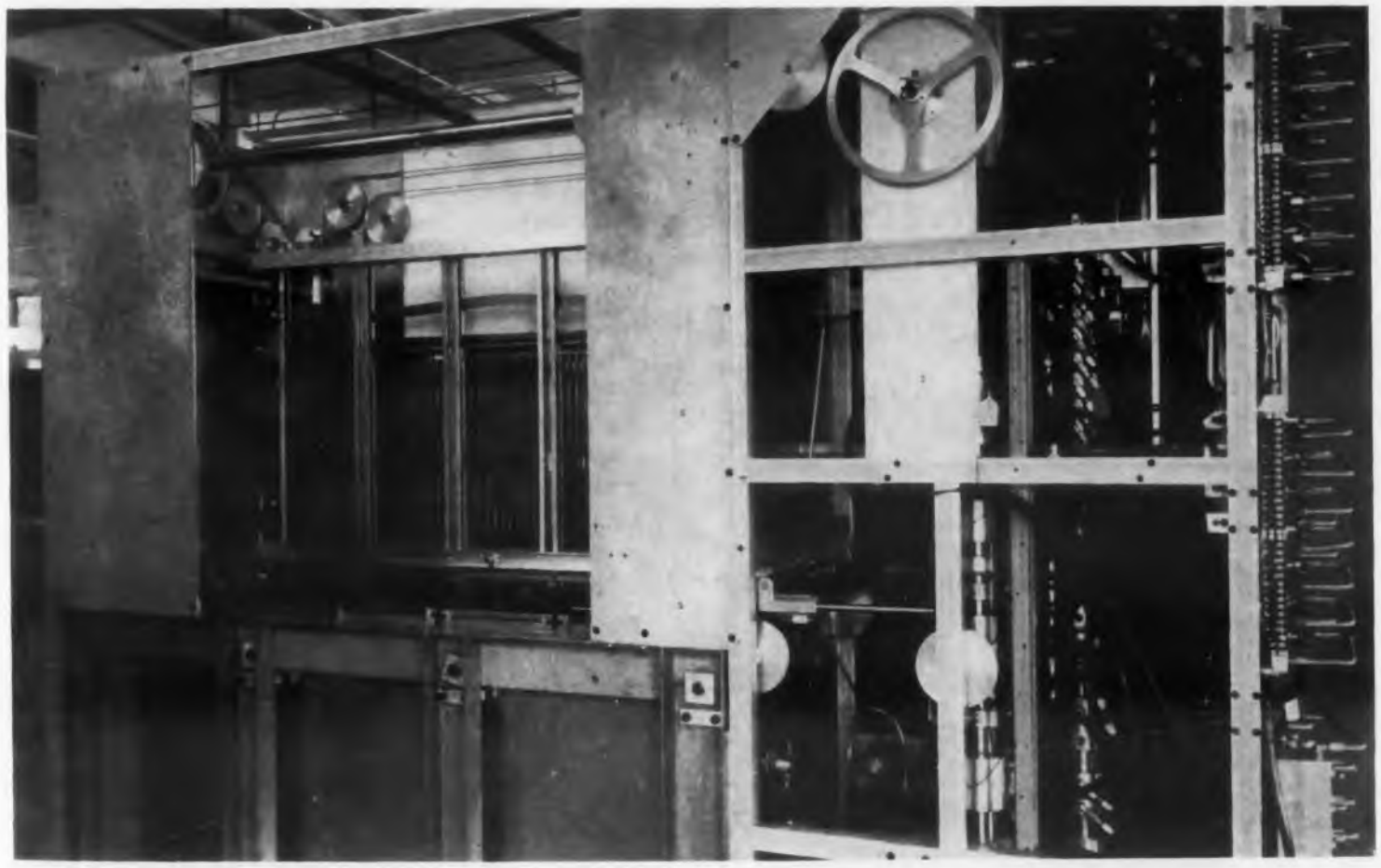
Biggest, Most Flexible Memory Yet

With access time of less than a second to any one bit of information out of a total of 500 million bits, the Potter RAM is ready to automatize large-size clerical filing systems. Inventory control recording for mass production manufacturers, lifetime subscription fulfillments, cataloging, or insurance record keeping are areas the RAM will serve. Four hundred thousand different addresses can store 64 million 8-bit characters. The Potter Instrument Co., Inc., Great Neck, N.Y., RAM is equal in capacity to 20 standard tape handlers or 13 of the heretofore largest random access memory mechanisms. The information can run high speed printers.

Memory tapes are supported in a bin which has a 3-dimensional physical configuration much like a filing cabinet drawer. Data are stored on conventional 8-track magnetic tape strung in vertical columns on "pages" which can be lifted vertically to bring a selected data location into contact with the record-playback head. The removable storage bin holds 200 pages.

In normal usage, one of the eight tracks is used to identify the beginning and end of blocks and one is used as a clock track, leaving six tracks for binary-coded alphanumeric information. Positive and negative saturation recording is used with return-to-zero or non-return-to-zero techniques.

Positioning of the mechanical access mechanism is achieved by serially-connected pneumatically-programmed cylinders which contribute modified binary-coded motion increments simultaneously.



One "page" of memorized data of RAM is shown raised at the left for reading. At the extreme right are solenoid valves operated by digital code which send air signals through hoses to serially connected pistons, middle right. As pistons move a page is lifted from the bin, the recording head is positioned to pick up the right tape and the proper section selected and scanned.

IBM Electric Typewriter employing electronic tabulation. Note small size of electronic control unit which mounts beneath keyboard.

Electronic Control for Typewriters

In an effort to further simplify the typists job, the Electric Typewriter Division of International Business Machines Corporation has introduced electronic sensing and control equipment in their standard electric typewriter. Incorporating an electronic-tube switching circuit which operates a relay hooked up to the tabulator, the electronic unit makes tabulation entirely automatic.

Conductive ink is used on the billing or accounting forms which, according to IBM spokesmen, costs only a little more than ordinary ink. Contact for "tab sensing" is made by a conducting brush as it passes over the ink line, thus operating the relay and stopping the carriage in a prescribed number of spaces beyond the line.

Admitted by IBM officials to be only the first of a number of coming electronic applications to typewriters, an expanding market for electronic components and equipment seems assured.

The electronic unit currently being used by IBM, although employing a tube, measures only approximately 3 by 6 inches in size. It is mounted beneath the keyboard. One of the problems in "electronfying" the typewriter is the small space available for the electronic unit. Transistors can be expected to play an important part in this development.

Electric Contour Controls Miller

Boeing Airplane Company is using two new 85-ton contour profile milling machines, equipped with GE tracer control systems. The machines are being used in the production of B-52 global bombers for the USAF. Boeing's application of the GE control system has made possible stepped-up production and greater precision. Actual production figures are classified but Boeing officials report that the new machines quickly cleared away a six-week backlog of work immediately after their installation and have not been behind schedule since the third week of operation.

Onsrud Machine Works manufactures the milling machines which are used in processing spar and wing chords and wing skins requiring a wide variety of machine cuts. Many of the necessary cuts require rise and fall, transverse, and twist motions simultaneously. The GE tracer control system, which operates from cams or templates, includes six selsyn-type tracers capable of controlling three motions on each of two heads simultaneously.

Room Color Control by Electronics

The first full-scale presentation of man's newest light source, electronic light, was made recently in Pittsburgh when Westinghouse unveiled a complete room lighted by electroluminescence.

Panels no thicker than window glass lined the ceiling and three walls, giving off light (approximately 50-foot-candles at an efficiency of 3 lumens per watt) equivalent to that in a modern, well-lighted office or class room.

The unveiling was the climax of a demonstration on electroluminescence by Edward G. F. Arnott, lamp division director of research, and was a preliminary event in the dedication of Westinghouse's new multimillion dollar research laboratories.

Electroluminescence is light emission by suitable phosphor powders embedded in an insulator and subjected only to the action of an alternating current electric field. The phenomenon was first discovered in 1936 by French scientist Georges Destriau, who published a paper on his findings in 1947. Small-scale applications, such as flashlights, were perfected as early as 1954.

In the demonstration, one hundred and twelve glass panels, each one foot square and about 1/8 inch thick, were used to illuminate the room with soft green light.

Since the emitted color of electroluminescence varies with the frequency of the exciting energy, the 350 v ac, 3 kc green power source may be varied by means of an oscillator control knob. In this way, the housewife of the future may have complete mastery over the lighting in her house with two control knobs in every room, one for brightness and one for color.

Home television tape player developed by RCA reproduces pre-recorded black-and-white television selections on a standard TV set.

Television Tape Player for the Home

Recent developments in an air conditioner, the electronic light amplifier, and a home "hear-see" tape player were disclosed last week by RCA while celebrating Brig. General David Sarnoff's 50th year in the fields of radio television and electronics. All of the items have been announced previously but significant new developments have come about.

The principles employed in the television tape recording system have been applied in the development of a home television sight and sound tape player. An electronic room air conditioning system and a new larger electronic refrigerator have been developed from the earlier small refrigerator. From the original light amplifier, the scientists have developed a new amplifier capable of increasing by 1000 times the brightness of projected light. Such a system for industrial X-ray use has been perfected.

Dollar Savings Through Standards

Seventy-nine cases of savings resulting from standardization are covered in a newly-published survey by ASA entitled, "Dollar Savings Through Standards." The studies were prepared for ASA by 70 American companies and 6 associations. They cover about 27 industrial fields. Copies of the survey will be furnished by ASA free on request. Also recently published by ASA is a four-page booklet entitled "What Is an American Standard?". Copies of this booklet may also be obtained without charge from ASA.

Cool Weather on Demand

Airplanes based in warm-weather areas can have their high-altitude equipment properly serviced with the MA-3 weather simulator.

A cool 100 lbs of air per minute at 45 F can be supplied regardless of ambient temperatures. In operation the unit is towed to the aircraft site and then moved into final position under its own power. It is completely self-contained with compressor, evaporator, condenser, and all gauges and controls.

The weather simulator is now in production at American Electronics, Inc., El Monte, Calif.

Silicon Coating Aids Printed Circuits Soldering

Silicon solution can be coated on printed circuit boards to produce better soldering connections. The silicon coating is applied by a silk screen process similar to the one used in transferring the printed circuit pattern itself to the board. The silicon solution, employed by Admiral Corp., 1191 Merchandise Mart, Chicago 54, Ill., forms a hard heat-repellent film and covers the circuit side of the board, except for the points where component connections are to be soldered. By repelling the 550 F heat of the solder pot into which the board is dipped, the heat resistant silicon is said to force the solder toward the component connections.

High Speed Data Reduction

Electronic equipment at the Lockheed Missile Systems division in Van Nuys, Calif., changes a tape recording of scrambled tones into graphs from which scientists and engineers can interpret a missile's flight performance. The equipment cuts the analysis period of flight test data from months to days. Upper left is tape recording, line of equipment in rear transforms information on taped record to decks of punched cards, and foreground is a plotter which produces graphs from information on the cards.

Reflectoscope Protects Against Railway Accidents

Sound waves are being successfully used to indicate defects in railway car axles and journal areas. The Sperry Rail Service Co.'s reflectoscope, employed by the Chesapeake and Ohio Railway Co., sends a beam of sound energy into the journal area. If there is a crack in the axle or journal box a portion of the energy is reflected back to the reflectoscope's search unit.

The Chesapeake and Ohio Railway has in operation a mobile carrier on which the reflectoscope is mounted. It combines all the necessary equipment to test car journals while they are on a car. This method supersedes the time consuming and costly method of removing the journal before they can be checked.

CIRCLE 6 ON READER-SERVICE CARD ➤

Mobile Interference Labs

A fleet of mobile radio-interference shielded laboratories will soon be dispatched for on-site testing of electronic equipment. The mobile laboratory was designed because modern installations of major subassemblies are frequently so elaborate that they must be tested at the point of installation. This is especially true of today's missile systems.

A unit has been built by Filtron Co., Flushing, N.Y., completely equipped with 60 and 400 cycle rotary power supplies, air conditioning, and measuring and calibrating equipment to measure from 14 kc to 1000 mc, in accordance with military requirements. Screen room construction filters out interference from the portable power installation. The laboratories will be used to measure radio-frequency interference of electronic equipment which cannot be transported to stationary screen rooms or test facilities.

Magnetizer Produces 500,000 Gauss

A magnetizer, with a maximum line demand of only 6.6 kva, uses the stored energy principle to produce peak impulses of 1500 kva, of up to 50 milliseconds duration. An 1800 mfd. condenser storage bank is discharged through an ignitron tube to the primary of a step-down transformer. The single turn secondary acts as the magnetizing loop. Because of the single magnetizing loop and the high intensity, almost completely closed circuit magnets can be made easily.

Electronic control circuits assure precise field output, uniform from pulse to pulse.

Full Range Electrostatic Loudspeaker

Balanced response over the entire audible spectrum of 25 to 25,000 cps is possible with the electrostatic speaker system designed by Pickering & Co., Oceanside, L.I., N.Y. Low frequency woofers, which also operate electrostatically, can be used to complement the isophase high frequency electrostatic speakers being manufactured presently. Present state of the art indicates that electrostatic speakers have a place in the hi-fi market.

Electronic Printer Does Forty Different Documents a Minute

Using a "Compositron" tube which simulates typesetting, a new RCA printer decodes 4000 signals a second direct from "Bizmac" magnetic tape, composes translated information in specified form, and reproduces data on business stationery. All of these steps are done simultaneously.

The printer is thus capable of processing speeds of up to 50,000 words a minute. It will produce in one minute 40 complete and different documents as large as 8-1/2 by 11 in. According to Arthur L. Malcarney, V-P and General Manager, of RCA Commercial Electronic Products, the unit is in a developmental stage and no commercial plans as yet have been established.

The electron-image tube translates code by selecting the proper alphabet letters and numerals, one by one, from a "font" and projects them in any desired pattern on the tube's ten-in. face. The pattern is photographed direct from the tube face by a 35 mm camera.

A film-processing system develops the exposed film at the rate of 10 feet a minute. The RCA Electrofax dry-process enlarging printer accepts the 35 mm film, enlarges it about 11 times and reproduces the information.

Test Equipment Study

US Dept. of Defense has established a national center at NYU for monitoring research and development on electronic equipment. A team of NYU research engineers are to serve as staff for the Electronic Test Equipment Coordination Group. Test equipment research and development throughout the electronics industry and the armed services is to be studied. Other tasks include: providing technical assistance for analysis and evaluation of proposed and present electronic test equipment projects; calling attention to new lab advances and trends here and abroad; anticipating future needs for certain equipment and initiating research to meet those needs; ending unnecessary duplication of effort by reporting on industrial and service-wide developments.

1.2 Million Letters and Numbers Per Minute

Letters and numbers can be reproduced at the rate of 1.2 million per minute for recording photographically with the use of a new model of the Charactron Shaped-Beam Tube. The tube, designated Type C7C11, is produced at the San Diego plant of Stromberg-Carlson. It has a seven-inch diameter and is capable of nine times the information density possible with other models of the Charactron Shaped-Beam Tube. Each character has been reduced to a height of .035 inches. Ten thousand can be reproduced for photographing in one frame. They can be arranged in the form of 100 lines of 100 characters each.

The Charactron Shaped-Beam Tube has been called an "electronic typewriter" because it utilizes a stream of electrons to create numbers and letters on a phosphor-coated screen. similar to the screen of a television set.

The tube actually reproduces numbers and letters by squirting or extruding electrons through a tiny metal stencil within the tube itself.

Maximum Hardness in Beryllium-copper Strip

By changing from the customary 600 F treatments for processing and fabrication of beryllium-copper strip Penn Precision Products, Inc., Reading, Pa., have developed a stronger and harder product. The new process involves a slightly higher temperature and varying treatment times depending on the hardness desired.

100,000 Mc Generator Tube

Designed to operate at extremely high frequencies with large power outputs, a new electron tube, called a "retarding field oscillator," permits more accurate radio beam control and adds more channels to the available frequency spectrum. Ohio State University, under contract to USAF Air Research and Development Command, Baltimore, Md., developed the tube whose characteristics are such that it operates at 70,000 mc, and with reduced power output at 100,000 mc.

CIRCLE 9 ON READER-SERVICE CARD ➤

Thin Cathode-Ray Picture Tube

Radical departure from conventional cathode-ray display tubes is the thin cathode picture tube developed by Kaiser Aircraft and Electronics Corp., 1924 Broadway, Oakland 12, Calif. The tube consists essentially of a phosphor screen and transparent deflection plates sandwiched between glass face plates. The tube functions by electronically exciting selected areas or spots on the phosphor screen.

An electronic beam is injected along an edge of the tube. This beam flows in a field-free region along this edge of the phosphor screen and adjacent to a row of transverse deflection plates. Through control of the voltages on these deflection plates, the beam is bent vertically at any desired place along the edge of the tube. The beam then flows vertically in a second field-free region between a series of transparent deflection plates and the electrically charged phosphor screen. Deflection of the beam into the screen at any desired vertical level is made possible by controlling the voltages on the transparent deflection plates. The position of the spot created by the deflection beam may be exactly controlled.

Proton Beam Viewed by TV

The versatile closed-circuit television camera is now being put to work observing the Cosmotron's high-energy proton beam. Use of a small 5-pound television camera developed by General Precision Laboratory of Pleasantville, New York, enables the physicists at Brookhaven to watch the pattern made by the 3 Bev external proton beam on a sodium iodide mosaic with greater clarity and without exposure to radiation.

Federal Support for Science Students

Through various programs for the support of higher education, during 1954 the Federal Government aided better than 1 out of every 5 graduate students and 1 out of every 6 undergraduates, in all fields of study. At an average cost of more than $1000 per student, over 101,000 science students

were helped. While only one-fourth (82,000) of the undergraduate group were studying in the sciences, approximately one half (18,000) of the graduate students, and virtually all (1300) of those receiving such assistance for postdoctoral training and research were pursuing scientific studies. The National Science Foundation report "Federal Support For Science Students in Higher Education" indicated that eligibility for Federal support at the undergraduate level was determined almost exclusively by military service, either through the completion of past service or commitment to future service.

Mobile Calibration Test Van

To assist field installations in maintaining equipment accuracy, the US Signal Corps has developed a mobile Equipment Calibration Test van which operates from signal depots to service field installations. Periodically visiting field maintenance shops, Signal Corps and Ordnance detachments supporting anti-aircraft defended areas, Strategic Air Command bases, National Guard shops and division signal companies, it is intended that by next year there will be one van for each Army area in the US.

In addition to adjustment and recalibration of field equipment, the van stocks some repair parts and basic meters to repair defective equipment on the spot.

Optical Driverless Tractor

Sniffing its way along a white line, the optical guidance system of this tractor can steer it without wires or operator.

The nose of the sniffer is a low-powered bulb which reflects from the white tape or paint on the floor and actuates photo-electric cells.

The Guide-O-Matic electronic industrial tractor, manufactured by the Barrett Cravens Co., 628 Dundee Rd., Northbrook, Ill., can be converted from optical type to wire type, should the need arise.

CIRCLE 11 ON READER-SERVICE CARD ➤

The silhouette of the Ebicon, supersensitive television camera tube, is seen against a test pattern background.

Supersensitive Camera Tube

Seeing in the dark, or at levels of illumination below the human visual threshold, may soon be achieved by the "Ebicon" television camera tube developed by the Westinghouse Corp., Pittsburgh, Pa. The heart of the device is a selenium layer which acts as an electron multiplier with a factor of about 100. In this way a gain is achieved which overrides the noise inherent in the subsequent vacuum tube amplifiers.

The tube may replace photographic plates in astronomy, or improve medical fluoroscopic techniques which are now limited by the amount of radiation a patient can safely absorb. Indoor or outdoor events could be recorded regardless of time of day or weather conditions. In the field of nuclear physics, the tube might see and record high-energy atomic reactions as they take place inside luminescent crystals. Another version of the same type tube, which is the process of development, is expected to be eight times smaller by volume and weight than existing sensitive tubes.

New Core Material

Flakenol I, a new high permeability material developed by the Naval Ordnance Lab., White Oak, Silver Spring, Md., is intended to replace powdered molybdenum-permalloy as a magnetic core material for use at most communications frequencies. Flakenol I has the advantage of lower eddy-current losses and lower density than high nickel-content alloys presently used for magnetic cores. Its adoption offers the possibility of extending the frequency range of magnetic powder cores to the hypersonic and low radio frequencies, where they were prohibited earlier because of high eddy-current losses. Low in cost, Flakenol I is expected to surpass high-nickel alloys in performance.

Washington Report

Herbert H. Rosen

Project Vanguard Events are moving faster each day as the start of the International Geophysical Year approaches. A new radio tracking station for the earth satellite has been established at Blossom Point, Maryland. *Minitrack*, the NRL-developed tracking system is to be first tested here. It is supposed to have a 4000-mile range. J. Paul Walsh has been named deputy to Dr. John Hagen for the project.

Federal Trade Commission Industry-inspired rules of practice help guide the FTC in its job of protecting the consumer. The latest action has been taken by the environmental equipment industry. A conference (has been) was called on October 19 for the purpose of outlining trade practice rules for the industry. RETMA has also been active in this area and has recently agreed to supply the FTC with a definition of a "transistor radio." The RETMA resolution prescribes that sets using both transistors and vacuum tubes may properly attach the name "transistor" to its name only as follows: "transistor-power" or "transistor pick-up."

Civil Aeronautics Administration Ever since the start of the Government's mutual assistance programs, the CAA has been responsible for helping foreign countries get their civil aviation programs going. They have sent teams of expert engineers and aviation planners all over the world. Right now they have 26 such teams overseas. They operate through the International Cooperation Administration, which through itself and its predecessors has allotted $10 or $11 million to CAA for the procurement of navigation and airport control equipment. The latest contract for $197,108 has been awarded to Gates Radio for high frequency transmitters to be used in Pakistan.

Nuclear Reactors Washington may soon become the reactor center of the world. The Naval Research Laboratory recently put a research reactor under test—the first operative one in the area. Fort Belvoir is on schedule for the construction of the first "transportable" power reactor. The University of Maryland has received a grant to build a "no-power" reactor to be used in teaching nuclear physicists and engineers. ACF Industries' Nuclear Energy Division, with headquarters in Washington, talks about building its own reactor in Maryland. And the National Bureau of Standards, too, is thinking of erecting one on its new grounds in Gathersburg, Maryland.

Meetings

Nov. 7-9: Conference on Electronic Technology in Medicine and Biology.
McAlpine Hotel, New York, N. Y. Sponsored by the AIEE, IRE, Instrument Society of America. Two days of technical sessions and evening symposium to discuss latest electrical and electronic techniques in biology and medicine. For information, write to AIEE, 33 W. 39th St., New York, N. Y.

Nov. 13-16: Fourth Annual Meeting of the Investment Casting Institute.
Sheraton Cadillac Hotel, Detroit, Mich. "Vacuum Metals Symposium" is the theme of the meetings. An extensive program of talks has been scheduled. Registration fee is $25.00. Details available from the Investment Casting Institute, 27 East Monroe, Chicago 3, Ill.

Nov. 14-16: Symposium on Optics and Microwaves.
George Washington University, Washington, D. C. Sponsored by the IRE Professional Group on Antennas and Propagation, the George Washington University and the Optical Society of America. For further information, contact the IRE, 1 E. 79th St., New York 21, N. Y.

Nov. 15-16: ORSA Tenth National Meeting.
Hotel Mark Hopkins, San Francisco, Calif. Operations Research is the theme of the meeting. Further information may be obtained from the Program Chairman at the U. S. Naval Postgraduate School, Monterey, Calif.

Nov. 17: Professional Group on Engineering Management of IRE.
Engineering Auditorium, New York City. General Doriot, pres. American Research Development. Subject of meeting, "Science and Management." For further information contact Harold Hechtman, Airborne Instruments Labs., 160 Old Country Road, Mineola, N. Y.

Nov. 26-30: *Third International Automation Exposition.*
Trade Show Building, New York, N. Y. Clinic sessions will be offered in electronic computers, process automation, machine tool automation, office automation, automatic materials handling, servomechanisms, electromechanical components, and electronic components. More than a hundred exhibitors will participate in the clinics. A two-day "Senior Officer Conference on Office Automation" directed by Gordon L. Mattson and sponsored by Fordham University School of Business will be held. For information, write to Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 22, Pa.

Dec. 3-4: *Second Midwest Symposium on Circuit Theory.*
Michigan State University. Symposium will consist of four sessions: Topology and Circuit Theory, System Analysis and Synthesis, Circuit Theory and Applications, and the Place of Circuit Theory in Education. A talk on "Engineering Education for the Future" will be given by Dr. J. D. Ryder on Monday evening. Papers will also be presented by engineers in the education field. Contact for further information, IRE, 1 West 79th St., N. Y., N. Y.

Dec. 5-7: *Second IRE Instrumentation Conference.*
Biltmore Hotel, Atlanta, Ga. Sponsored by the Professional Group on Instrumentation and the Atlanta Section of the IRE. Sessions will be devoted to industrial applications, missile range instrumentation, and the application of solid state devices. For further information, contact the IRE, 1 E. 79th St., New York, N. Y.

Dec. 10-12: *Eastern Joint Computer Conference.*
Hotel New Yorker, New York, N. Y. Sponsored by the IRE, AIEE, Association for Computing Machinery. "New Developments in Computers" is the theme of the meeting. In addition to an extensive program of technical papers, the meeting will feature exhibits by many manufacturers in the computing field. For information, contact Al Forman, Room 639, 480 Lexington Ave., New York 17, N. Y.

Dec. 19-20: *RETMA Symposium on Applied Reliability.*
Bovard Hall, University of Southern California, Los Angeles, Calif. Sessions on Mechanical Reliability, Information Feedback, Component Evaluation Usage will be presented. "Failure Feedback —Is It Effective" is highlight of the meeting. Registration in advance is $3.00. Further information received from RETMA Engineering Office, Room 670, 11 West 42nd St., New York 36, N. Y.

Jan. 9-11, 1957: Symposium on Communication Theory and Antenna Design.
Boston University, Boston, Mass. Sponsored by the Air Force Cambridge Research Center and Boston University. For information, contact Miss Alice Cahill, Air Force Cambridge Research Center, Air Research and Development Command, Laurence G. Hanscom Field, Bedford, Mass.

Jan. 14-15, 1957: Third National Symposium on Reliability and Quality Control in Electronics.
Hotel Statler, Washington, D. C. Sponsored jointly by the IRE Professional Group on Reliability and Quality Control, the American Society for Quality Control, and RETMA. For information, write to IRE, 1 E. 79th St., New York 21, N. Y.

Jan. 16-18: Society of Plastics Engineers, Inc., Thirteenth Annual Technical Conference.
Sheraton-Jefferson Hotel, St. Louis, Mo. Sixty-eight advanced technical papers will be presented. For further information contact Jas. R. Davidson, Executive Secretary, Society of Plastics Engineers, Inc., Suite 116-18, 34 East Putnam Ave., Greenwich Conn.

Jan. 23-25, 1957: Very Low Frequency Symposium.
NBS Boulder Laboratories, Boulder, Colo. Co-sponsored by the Denver-Boulder chapter of the IRE PGAP and the Boulder Laboratories, National Bureau of Standards. The program is titled "Theoretical and Experimental Results in the Propagation and Radiation of Very-Low-Frequency Electromagnetic Waves (less than about 100 kc)." Authors are being requested to submit summaries for appraisal as soon as possible to Dr. J. R. Wait, Chairman, Denver-Boulder PGAP Chapter, National Bureau of Standards, Boulder, Colo. For further information, contact U. S. Dept. of Commerce, NBS, Boulder Laboratories, Boulder, Colo.

Feb. 7: Annual Symposium of the New York Section of the ISA.
Garden City Hotel, Garden City, N. Y. Short papers on "Practical Accuracy of Measurement" will be presented followed by a discussion. Afternoon session will be on "Data Handling." For further information contact G. Newberg, Publicity Chairman, Fairchild Engine Division, Fairchild Engine & Airplane Corp., Deer Park, L. I., N. Y.

Feb. 26-28: Western Joint Computer Conference.
Statler Hotel, Los Angeles, Calif. The Conference is under the joint sponsorship of the IRE, AIEE, and ACM. Theme of the meetings will be "Techniques For Reliability." For further information contact S. Dean Wanlass, Aeronutronic Systems, Inc., 13729 Victory Blvd., Van Nuys, Calif.

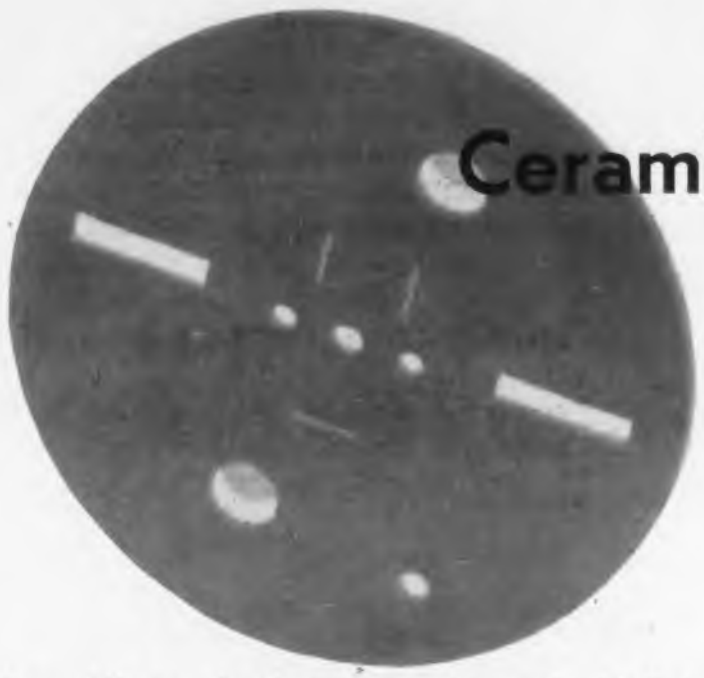
March 11-15: The 1957 Nuclear Congress
Convention Hall, Philadelphia, Pa. Exhibits and conference sessions covering latest developments relating to the utilization of atomic energy in its various non-military forms for civilian use. For further information contact Atomic Exposition Office, 304 Architects Bldg., Phila. 3, Pa.

March 18-21: The 1957 SPI Annual National Conference and Pacific Coast Plastics Exposition.
Hotel Biltmore, Los Angeles, Calif., sponsored by the Society of the Plastics Industry, Inc. Sessions will cover plastics in the fields of electronics, aircraft and defense, building, and processing. Exposition will be held at the Shrine Exposition Hall. Further information may be obtained from the Society of the Plastics Industry, Inc., 250 Park Ave., New York, N. Y.

April 8-11, 1957: Fourth National Electrical Industries Show.
71st Regiment Armory, New York, N.Y. Sponsored by the Eastern Electrical Wholesalers Association. For more information, contact William S. Orkin, Co-Producer, The American Electrical Industries Expositions, Inc., 19 W. 44th St., New York, N.Y.

April 11-13, 1957: Southwestern IRE Conference and Electronics Show.
Houston, Texas. Sponsored by the Houston Section of the IRE. This conference will be augmented by the National Simulation Conference which will be sponsored by the IRE Professional Group on Electronic Computers. For information, write to Ninth Southwestern IRE Conference and Electronics Show, P. O. Box 1234, Houston 1, Texas.

May 16-18: Eighth Annual Conference and Convention, American Institute of Industrial Engineers.
New York City, Hotel Statler. For information write to AIIE, P.O. Box 8, Substation 135, The Bronx 53, New York.



Ceramics In Electronic Design

Peter J. Lazarkis
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With the rapidly growing importance of ceramics in electronic design, basic questions concerning these materials are continually being asked by design engineers. The questions that occur most frequently are answered below. For those whose knowledge of ceramics ends with conventional pottery and chinaware, these answers will serve as an introduction to a subject that sooner or later is bound to concern them. For those who are already acquainted with technical ceramics, reference tables are included as convenient guides towards more effective and economical ceramic applications. Thus, this brief article is intended to bridge the gap between the electronic engineer and the ceramic supplier and to provide a working knowledge of ceramic characteristics as related to electronic design.

What are ceramics?

Basically, they are metallic oxides of varying compositions that have been fired or matured at high temperatures, resulting in permanent form and hardness. Common examples are steatite, forsterite, and alumina.

Why are ceramics becoming so important?

Progress in electronics, aviation, and allied fields, spurred on by military necessity, demands utmost ruggedness and reliability under increasingly rigorous environmental conditions. These include extremes of temperature, vibration, and shock, as well as space limitations and seal requirements—hermetic, oil, gas, and vacuum—in the packaging of electronic equipment. These requirements can best be met by the unique properties of ceramics; often they can be met in no other way.

What are the properties of ceramic materials?

The properties of primary interest to electronic design engineers are shown in Table I. This table represents typical values from available literature as well as manufacturers' specifications for the materials shown. These values show the relative relationship of the various materials for each characteristic and should not be considered as absolute. Since a wide range of characteristics is available by varying the composition and processing, the ceramics manufacturer should be consulted for the precise values of specific compositions. (Ferroelectric and ferromagnetic ceramics, which have valuable properties peculiar to themselves, are not covered in this article.)

How are these properties so unique?

The outstanding characteristics of ceramics are: resistance to high temperature, shock, and vibration; high dielectric strength, high electrical resistance at all temperatures; extreme hardness; high mechanical strength; and sealing capability. These qualities are not found either in combination or to the same degree in any other material.

One of the most valuable characteristics is that certain ceramics can be joined to metals at high temperatures by hard solder techniques. This allows a vacuum seal that is a combination of conductor and insulator and will withstand high temperatures.

What standard shapes of ceramics are available and what shapes are practicable?

Bushings, cylinders, discs, rings, tubing, and rod, although not always offered as shelf items by all manufacturers due to the varied detail requirements, are readily available in a wide variety of sizes (see Fig. 1). Special shapes of differing contours and with differing numbers and sizes of holes are entirely practicable but should be worked out in the early design stage with the ceramic supplier (see Fig. 2).

Why are ceramics superior to glass in electron tubes?

Higher shock and vibration specifications, increased reliability, and more rugged construction are demands best met by ceramics. Ceramic tube construction with the elimination of glass allows higher "bake-out" temperatures limited only by the associated metals and solders. Bake-out temperatures of 700 C for ceramic tubes are common as against a maximum of about 450 C for glass tubes. This permits a more thorough degassing of tube elements with a resulting increase in tube performance, life, and reliability. Microwave tubes with peak powers of several megawatts or more are made possible through the use of ceramic windows which are free from the customary softening of glass with consequent imploding of the vacuum tube. Ceramic construction also permits a reduction in overall tube size.

What dictates the choice of one ceramic over another or even over other materials such as glass or plastics?

The requirements of the application determine the selection. Usually, the high-temperature requirements rule out plastics, whereas fragility, higher loss factor, and lower softening point temperature discount glass. In general, most requirements, including the most stringent, can be met by alumina ceramics, while for lesser requirements, forsterite and steatite can be used.

Are ceramics really all they claim to be, with no drawbacks?

Within their rated characteristics, ceramic materials do live up to their claims, but along with advantages there are naturally certain limitations. Ceramics, like metals, should be used where there is an actual need for one or more of their properties; and a particular ceramic should be selected because it provides a predominance of the particular properties required. As a general rule, ceramics do not have as wide a flexibility of size and shape as do metals.

What are the size limitations on ceramic parts?

Size limitations depend on the facilities of the ceramic manufacturer as well as on the ceramic material, fabrication process, and end product under consideration. Extruded rods and tubing can be made in lengths up to several feet with various diameters; however, there is the problem of the camber and concentricity

allowable over the required length for the final ceramic piece. Discs and cylinders of alumina ceramics produced by the dry-press method are usually limited to about four inches in diameter. Special shapes and larger pieces can be made by processes such as slip casting or isostatic pressing combined with individual batch firing.

Do ceramic parts cost much more than parts made of other materials?

Ceramic parts cost little if any more in the final analysis, since the use of ceramics, particularly in ceramic-to-metal assemblies, often results in an overall saving in manufacturing cost. Ceramics permit better accuracy and dimensional control to be maintained in design and allow more precise assembly to be performed with actually less skill than that required in glass work. Ceramic-to-metal assemblies also allow one-shot brazing operations, for further savings.

How high a temperature can ceramics stand?

This depends on the material selected; with alumina ceramics operating temperatures up to 1700 C are permissible.

Can ceramics be joined to metals?

Using metallized alumina ceramics, the author's company has manufactured on a production basis many different types of vacuum seals that pass helium leak detector tests and meet military specifications. These joints are formed by brazing the ceramic to the metal with either soft or hard solder. Most of the metals are suitable, particularly Kovar.

What are the temperature limitations of ceramic-to-metal seals?

The metals and solders selected determine the temperature limitation of the entire assembly. For example, a copper brazed joint will form a vacuum seal at approximately 1100 C, thus allowing a variety of other seals to be made in subsequent brazing operations at successively lower temperatures. Copper-silver, eutectic, pure silver, and gold alloys are some of the other high-temperature solders that may be used, not to mention the soft solders.

In what state are ceramics supplied and used?

Contrary to some belief, ceramics are supplied not as powders but in a finished, fired state ready for use. The ceramic manufacturer forms the finished, fired ceramic compositions by methods akin to those used in powder metallurgy. For example, a ceramic might be obtained in the form of a bare ceramic insulator, a metalized shape, or a complete ceramic-to-metal vacuum-tested assembly.

What is meant by metallized ceramics?

Through special processes of the ceramic manufacturer, metal coatings are fired into the ceramic at high temperatures, thus producing a conductive layer. Since this layer is firmly bonded to the ceramic by chemical

Fig. 1. Some standard sizes and shapes of ceramic parts. Shown are parts of alumina ceramic.

Fig. 2. Alumina ceramic parts of specialized form to meet exacting applications.

reaction, it permits the ceramic to be brazed to metals by a wide variety of hard solders. The resulting bond permits a true vacuum seal and is as strong as the ceramic itself.

Are ceramics available already metallized for subsequent use in a ceramic-to-metal assembly?

Yes, ceramics can be supplied already metalized for production brazing in the customer's plant. Or, if preferred, ceramic-to-metal assemblies can be supplied complete, 100% helium-leak-tested, thus eliminating the need for ceramic-to-metal brazing by the customer. Final assembly operations may then be carried on by conventional methods that are essentially the same as those used for forming metal-to-metal brazes or welds.

What tolerances are possible on ceramic parts?

Generally speaking, a tolerance of $\pm 5\%$ or 0.005", whichever is greater, is desirable from a manufacturing point of view. Tolerances of tenths of thousands can be achieved by special control and processes such as diamond grinding if necessary. Fig. 4 shows typical as diamond grinding if necessary. Ceramic parts for electron tubes are being made. Silhouette on preceding page shows a tube part.

Can ceramics be machined and worked by the design engineer?

After firing, ceramics are extremely hard and do not lend themselves to machining. Alumina ceramic, for instance, has a Moh factor of 9 and is difficult to grind except by ultrasonic machining or diamond tools. This means that the entire fabrication is done by the ceramic manufacturer in his processing and by machining the piece in the "green" state. Thus, after firing, the ceramic is ready for use or metalizing.

In specifying a ceramic design, what are the general considerations?

A check list, next page, covers key points to be considered for good ceramic design. Careful use of this check list will result in a practical design that is economical to produce, with the added benefits of minimum lead time and ensured quality and repeatability. It is important that the preliminary drawings supplied to the ceramics manufacturer be consistent with good ceramic practice, which is not necessarily the same as good metal practice. Expensive and time-consuming redesign work is thereby avoided, and the final details can be speedily handled by consultation with the ceramic sales engineer.

Why are ceramic terminals finding increasing applications?

Ceramic terminals, particularly those of the alumina type, are readily assembled into electronic units over a wide range of processing temperatures. They produce reliable seals that can meet the higher temperature, shock, and vibration requirements of advanced military equipment.

Why are ceramic spacers replacing mica spacers in electron tubes?

Vibration of tube elements eventually enlarges the support holes of mica spacers, thus altering the original tube parameters. Ceramic spacers are not affected by vibration, and in addition are non-flaking and permit more thorough outgassing during tube manufacture. Since these advantages all contribute to tube reliability, ceramic spacers are of increasing interest to the military.

What are some of the most common electronic applications?

Among the basic electronic circuit components that utilize ceramics in one way or another are resistor bodies, coil forms, condensers, condenser shafts, terminals, transducers, and printed circuit bases. Ceramics are employed in electron tubes for spacers, envelopes, and output windows.

What is the future trend in electronic applications?

Due to their high strength, high voltage, wide temperature range, and metalizing characteristics, ce-

ramics will find increasing use in electron tubes. Stacked ceramic tubes as well as other ceramic tube designs are readily adaptable to mass production by automatic machinery. Ceramic terminals and connectors, which are already being used in military equipment such as airborne radars, will be used increasingly in high-quality commercial equipment. Due to temperature limitations, plastics will soon be overtaken by ceramics in the design of airborne radomes as velocity specifications further increase.

Of all the ceramic compositions available, the major trend is towards the alumina ceramics, since they can best satisfy the majority of electronic requirements.

Ceramic Design Checklist

Material

Select proper ceramic material on basis of characteristics required for your particular application. Consider mechanical strength, mechanical and thermal shock properties, temperature, dimension stability, porosity, hardness, water absorption, gas permeability, chemical inertness, and electrical properties such as losses, dielectric strength, and volume resistivity.

Shape

Simplicity is the rule. Good ceramic design practice invariably stems from simplicity. Avoid heavy, variable cross sections with abrupt changes in level and thickness. Attempt to simplify more complicated pieces by use of inserts. Does the item have to be entirely of ceramic? Consider use of ceramic-to-metal assemblies.

Dimensions

Indicate non-critical dimensions on ceramic piece in fractional form, key dimensions in decimal form with appropriate tolerances. Consult the ceramic manufacturer for dimensioning of metalized and brazed dimensions for best results.

Tolerances

Keep tolerances as broad as possible. Express wide tolerances in fractions of an inch, close tolerances in decimal form. A tolerance spread of ±5 per cent or .005 in., whichever is greater, is required to avoid grinding. Tenths of thousands can be held by grinding, but such tolerances should be specified only when the application actually requires them. Remember that standard machine shop tolerances and practices for metals do not necessarily apply to ceramics.

Specifications

Specify completely. Make sure all important specifications are clearly stated and not merely implied. Even if a specification is not important, include it on drawing with broadest permissible tolerance to show that you have taken it into consideration. Check:

concentricity	parallelism
perpendicularity	ellipticity
flushness	radii of fillets
camber	chamfer
threads	holes
inside angles	warpage
flatness	

Specify radii of fillets to reduce risk of cracking ceramic and to strengthen inside corners. On inside angles where ground surfaces are to meet, specify an undercut.

Reduce the camber and ellipticity by using proper and sufficient wall thickness. Likewise, in ceramic designs with holes or counterbores, avoid cracking by allowing sufficient material wall thickness. Avoid placing holes too near each other or to edge of piece; allow a wall thickness at least equal to diameter of hole.

Consider chamfers on exposed edges that may be subject to chipping.

On threads, specify a flat or radius to avoid a sharp "V"; check possibility of transferring thread to metal insert. Generally, threads increase cost of ceramic parts, particularly on the harder ceramics, and should be avoided if possible.

Blisters, chips and cracks are acceptable commercially and by government specifications to a certain extent as defined and where there is no impairment of performance.

Drawings

Submit drawings on ceramic parts and assemblies in line with above comments to ceramic manufacturer. Save time; supply all environmental and operating data along with the drawings. On assemblies, your end requirement represents the most important drawing. The intermediate and ceramic drawings as far as seal dimensions and tolerances are concerned can be left to the ceramic manufacturer, provided he adheres to the final assembly drawing. This drawing should contain all dimensions requiring inspection.

Finish

Is surface to be unglazed, glazed, metalized, or specially treated?

The mechanical surface strength of ceramic is generally somewhat lessened by glazing, which aids only in the cleaning of ceramic.

Table I
Approximate Characteristics Of "Electronic" Ceramic Materials

Characteristic	Material								
	Electrical Porcelain	Steatite	Fused Quartz	Magnesia	Cordierite	Glass Bonded Mica	High Alumina	Forsterite	Zircon
Dielectric Constant (1 mc)	6-7	5.5-6.5	3.7	5.8	4-5	7-8	8-9	6.5	9
Power Factor (1 mc)	.009	.0008	.00035	.0008	.008	.002	.0006	.0002	.0014
Loss Factor (1 mc)	.055	.004	.0013	.004	.03	.016	.005	.0014	.013
Water Absorption (%)	0.1.0	0-.01	0	16	3-8	0.5	0.00	0-.01	0-.01
Tensive Strength (p.s.i. x 10^3)	2.6	13	8	2.8	3	8	26	10	10
Flexural Strength (p.s.i. x 10^3)	11	20	—	6	7-10	18	48	12	18.5
Compressive Strength (p.s.i. x 10^3)	30-65	65-65	200	48	50-95	25	275	80	80
Dielectric Strength (volts/mil)	100-200	250	200	65	200	245	500	250	200
Hardness, Moh's scale	7.5	7.5	5	6	7	—	9	7.5	8
Modulus of Elasticity (p.s.i. x 10^6)	10	14	4	—	5	—	40	—	21
Specific Gravity	2.4	2.6	2.2	3.0	2.5	—	3.6	2.8	3.7
Linear Thermal Expansion 20-100 C (in./in./°C x 10^{-6})	3.6	6	.20	9.4	2.5-4	—	6.2	8.5	2.5-5
T_E Value (°C)*	—	450°-800°	—	—	750°	—	1000°	990°	700°

*T_E is that temperature at which the volume resistivity reaches 1 Meg.

The region of metalized areas should be clearly defined. Is metalizing required for brazing or electrical conduction? State temperatures and solders involved, as well as any special plating requirements.

Application

State the application as clearly as possible. Include environmental as well as operating conditions.

Check:

- vacuum or non-vacuum
- mechanical shock and vibration
- temperature range, max and min
- continuous operating temperature
- temperature cycling
- mechanical stresses
- thermal shock
- humidity
- pressure
- altitude
- atmosphere, oil, or gas
- electrical ratings

If an assembly, what type of seal is involved? Hermetic, pressure, oil, gas, or vacuum? Remember that a hermetic seal does not mean a vacuum seal. Is pressure or helium leak detection required? On a sampling basis or 100 per cent? Indicate desired temperature range over which seal must be satisfactory.

Quantity

Specify quantity involved on sample or production order as well as future potential. The quantity may determine the manufacturing process selected as well as the design of temporary or permanent tooling. Thus, it may determine the ultimate unit cost.

Delivery

Allow as much time as possible so as not to needlessly rush the design and prevent proper consideration being given to it. Generally, at least several weeks are required for ceramic parts; where extensive tooling is needed, three to four additional weeks may be needed.

Use

Ceramics are technically dependable and reliable for doing the job they are intended for but are in general relatively brittle. Avoid mishandling or dropping of heavy parts and pouring or dumping of small pieces.

In brazing ceramic assemblies, check the brazing temperatures, temperature cycling, solders used, and the thermal shock to be encountered in all brazing operations. Consult freely with the ceramic manufacturer on all subsequent brazing operations or whenever questions arise.

The author is grateful to all those who gave him assistance and constructive criticism in the preparation of this article, with special thanks to L. J. Cronin, head of the Techniques Laboratory of The Raytheon Manufacturing Company.

A subsequent article will discuss ceramic-to-metal seals.

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But the need for good men with good ideas grows... because Firestone plans to keep growing in this field. For instance, here are just a few specific needs—a few from a list too long to show in full:

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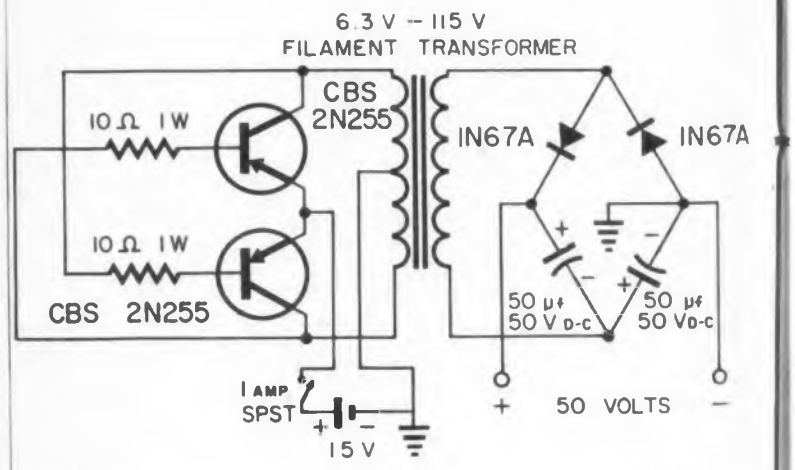
Low-Cost Power Transistors

COMPETITIVELY priced with vacuum tubes, two new power transistors have been announced which are designed expressly for experimental purposes. The pnp germanium alloy junction semiconductors are hermetically sealed and each incorporates a metal mounting flange electrically connected to the collector for good heat dissipation.

With a heat-sink, both the 2N255 and the 2N256, manufactured by CBS-Hytron, Danvers, Mass., are rated at 6.25 watts. The two transistors are electrically similar. The primary difference is that the 2N255 is intended for use with 6 volt power supplies and is rated at 15 v maximum, while the 2N256 is designed for 30 v maximum, utilizing a 12 v supply. Each unit has a collector



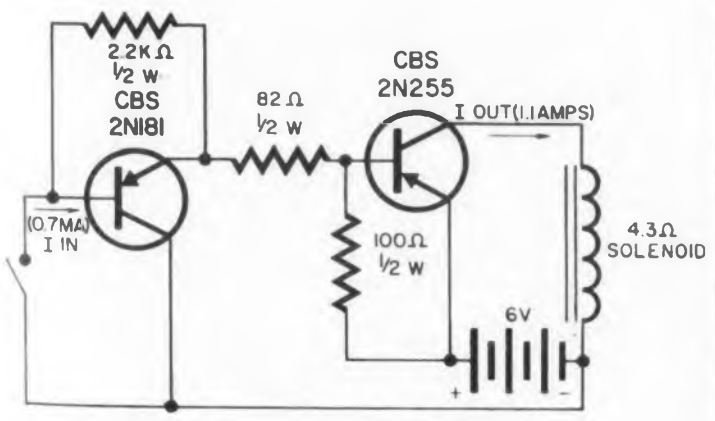
DC Voltage Multiplier—This dc voltage multiplier will provide high voltage from a low-voltage source, eliminating a vibrator or B+ battery. When the transistors oscillate, an ac voltage is provided across the transformer. The output voltage and current are determined by the battery voltage and transformer turns ratio; therefore, they may be varied to suit the application as long as the transistor and diode ratings are not exceeded.

to base current dc amplification of 30 to 50.

Maximum ratings include 3 amps steady state dc collector current and operation from —40 to +85 C. Alpha cutoff frequency is 200 kc at 25 C.

Several methods of mounting are practical for amplifier circuitry. For grounded collector circuits, the transistor flange may be fastened directly to the chassis. A heat-radiator plate that is insulated from the chassis can be used for other circuits; or if high heat dissipation is not required, the base pins can support the transistor with the collector circuit lead fastened directly to the flange. The two heavy plug-in leads fit standard 9-pin miniature sockets.

For more information on these transistors, turn to the Reader's Service Card and circle 19.



Relay Circuit—A sensitive relay circuit with good temperature stability in which an input current of less than 1 ma will control a 1 amp solenoid.

Guides to Tube Selection

Keats A. Pullen, Jr.
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SELECTION of the proper tube to perform a given operation can be broken down into five steps: 1, selection of the triode group or pentode group as required; 2, selection of a tube capable of providing a required current change at the chosen minimum plate voltage, E_{bp}; 3, selection of a tube having an adequate transconductance; 4, selection of a tube having adequate heat dissipation rating; and 5, selection of a tube capable of operating well within its dissipation rating. Other factors affecting the selection of the best tube for a specific application are listed later in this article.

Selection between triodes and pentodes frequently is difficult to make. The pentode has, because of improper techniques of use, been neglected for many of its most effective applications. The applications most suited to triodes include circuits best built with dual section tubes, circuits requiring minimum internal tube noise, and circuits providing the smallest possible voltage across the tube at high currents.

Plate conductance, g_p, in the triode, and screen-to-plate transconductance, G_{M2}, in the multigrid tube, control the ability of the tube to provide plate current change at any level of supply voltage. A high value of g_p or G_{M2} makes available a large plate current change at low supply voltages, and vice versa. As a result, they determine the ability of the tube to develop usable power within a specified dissipation rating for the tube. These g_p and G_{M2} parameters vary rapidly as a function of bias and plate voltage, or bias and screen voltage respectively. The maximum conductance values available in any tube type depend on the geometry of the elements in the individual tube.

The non-linearity, which is inherent in any tube, complicates the determination of power handling ability of a tube in a circuit. The presentation of data on the non-linearity of the tube characteristics may be accomplished in many ways. One most effective way is to plot contours of constant g_m and g_p or contours of constant G_{M1}. Tubular data on g_p and G_{M2} are particularly useful in tube selection, whereas the contour curves are of particular value in actual circuit design. See typical *12BH7* curves.

Tube Selection Tables

Table 1 lists a group of triodes in order of ascending g_p values. Table 2 lists a group of pentodes in order of ascending G_{M2} values. These tables offer a convenient method of guiding tube selections rapidly to the proper tube group. They include, in addition to the primary parameter data, values of g_m or G_{M1} and maximum power dissipation, limits for the plate or the plate and screen. The values of g_p and G_{M2} given in the tables are typical ones selected on the zero bias contour for the control grid, with the tube operating in the area near full dissipation, the values of g_p and G_{M2} from the tables are used with estimates of the g_p or G_{M2} obtained from equations (1a) or (1b), respectively.

Equations:

$$g_p = I_{bp}/E_{bp} \qquad (1a)$$

$$G_{M2} = I_{bp}/E_{c2} \qquad (1b)$$

are needed to develop the required maximum plate current at minimum plate voltage; because a large signal estimate of g_p or G_{M2} is used to obtain the corresponding small signal value, the estimate is multiplied by a gamma factor to adjust for the non-linearity in the tube. For normal operation, the value of gamma used in the selection of a trial tube should be between 1.5 and 2. If the value of gamma chosen is less than 1.5, the tube cannot accomplish its function for extended periods without serious overload; if the value of gamma chosen is more than 2, the tube will accomplish its function, but does not provide best power economy.

Abnormal environmental conditions in some cases may make necessary selection of a gamma factor either above or below the 1.5 to 2 range recommended above. High altitude or high environmental temperature operation may make necessary the selection of a gamma greater than two. On the other hand, an operation requiring the tube to function for only a few seconds or minutes at a time, with a minimum of total input power, may be best obtained by use of a gamma less than 1.5 in the tube selection.

Table 2. Pentodes listed in order of ascending screen-to-plate transconductance.

Tube	G_{M1}	G_{M2}	Dissipation
6AU6, 6BH6	5000	160	3 w
6BA6, 6BJ6	5000	170	3 w
6CB6	7000	188	2 w
6AK5	7000	240	1.7 w
6AH6	12000	260	3.3 w
5840	6000	300	1.1 w
6134	12000	312	3 w
6AC7	12000	312	3.0 w
5686	4000	420	7.5 w
6CM6	5000	480	12 w
12BY7	13000	500	6.0 w
6CL6, 6AG7	12000	520	7.5/9.0 w
6V6/6AQ5	5000	580	12 w
6L6	6000	960	19 w
6Y6, 6BQ6	10000	2200	12.5/10 w

Table 1. Triodes listed in order of ascending plate conductance.

Tube	g_m	g_p	Dissipation
6SL7	2000	27	1 w
12BZ7	7000	54	1.5 w
12AY7	2500	55	1.5 w
6AM4	9000	100	2.4 w
12AT7	8000	105	2.5 w
6J6	6000	150	1.5 w
6J5	4000	175	2.5 w
12AU7	3500	180	2.75 w
12AV7	9000	180	2.75 w
2C51	6600	200	1.5 w
6BQ7A	8000	225	2.0 w
12BH7	8000	400	2.5 w
6AS7	10000	5000	13 w

In no case should a gamma be selected which is large enough to permit placing either plate or screen voltages (or both) in the low area of erratic characteristics. Normally this area lies below 25 to 30 v. Tests on some tubes have shown that such things as bias line crossovers and other abnormalities may develop in the low voltage area.

Calculation of Peak Plate Dissipation

The verification that a tube is being used within its dissipation ratings requires the calculation of the peak plate dissipation. The plate voltage at which maximum dissipation occurs may be found by dividing by two the plate voltage value at which the dynamic load line intersects the zero plate current line, E_{bz}. Or, the maximum power input is

$$P_{pm} = 1/2\ E_{bz}\ [i_b]_{e_b} \qquad (2)$$

where i_b is the current at which $e_b = 1/2\ E_{bz}$

Triode Peak Dissipation—For triodes, the initial steps in the evaluation are the plotting the static load line, the location of the static operating point, and the plotting of the dynamic load line. Then Eq. (2) is used to determine the maximum plate dissipation.

Example A—A triode R-C amplifier having a supply of 300 v and identical static and dynamic load impedances of 10,000 ohms, uses a *12BH7* tube. What is the maximum plate dissipation? From Eq. 1, $P_{pm} = 2.25$ w.

Pentode Plate and Screen Dissipations—Calculation of the plate dissipation of pentodes is accomplished in similar manner. First, the screen voltage (trial) to be used is selected. The static operating point is chosen, and the load impedance to be used is selected. The plate voltage at which the dynamic load line intersects the zero plate current line is determined. The balance of the calculation is the same as for the triode.

The maximum power dissipation on the screen of the tetrode or the pentode with constant screen voltage normally occurs at maximum plate current and minimum plate voltage. The screen dissipation is calculated as:

$$P_{c2} = E_{c2}\ I_{bp}\ X_{c2p} \qquad (3$$

where the value of X_{c2p} used is that of maximum plate current (or minimum plate voltage where the load reactance may be neglected).

Example B—A transformer coupled pentode amplifier uses a screen voltage of 100 v and a plate supply voltage of 250 v. The static plate current in the tube at the static operating point is 20 ma, and the load impedance is 10,000 ohms. $X_{c2p} = 0.08$. What are the maximum dissipations?

Equations	Solution
$E_{bz} = E_{bo} + I_{bo}\ R_L$	$E_{bz} = 450$ v
$[i_b]\ (E_{bz}/2) = (E_{bz}/2R_L)$	$[i_b]\ (E_{bz}/2) = 22.5$ ma
$P_{pm} = (E_{bz}/2)\ [i_b]\ (E_{bz}/2)$	$P_{pm} = 5.06$ w
$i_b = (E_{bz} - e_b)/R_L$	At $e_b = 70$ v, $i_b = 38$ ma
$P_{c2m} = X_{c2m}\ I_{bp}\ E_{c2}$	$P_{c2m} = 0.3$ w

Selection of Current Change in the Tube

The selection of the tube to accomplish a given function is based on the required power of voltage output, the available supply voltage, and the limitations applying to circuit impedance level. Several typical conditions are discussed in the following paragraphs to show how different combinations may affect the design procedure.

Power Output and Voltage Change Known—Frequently one needs to develop a certain average output power when a specified supply voltage is available. Since output power is a function of the product of the voltage change by the current change, the output power for sinusoidal wave-forms is:

$$P_o = 1/8\ (E_{bn} - E_{bp})\ (I_{bp} - I_{bn}) \qquad (4a)$$
$$= 1/8\ \Delta e_b\ \Delta i_b$$

From the above equation, the required current change to produce a specified average output power is for a single tube:

$$\Delta i_b = 8\ P_o/(\Delta e_b) \qquad (4b)$$

For push-pull output tubes, the current change per tube required is

$$\Delta i_b = 4\ P_o/\Delta e_b \qquad (4c)$$

where P_o is always the total required output power.

The required load impedance per tube is

$$Z_L = \Delta e_b/\Delta i_b \qquad (4d)$$

For push-pull applications, the Z_L is half the plate-to-plate impedance.

Example C—A single tube amplifier, capable of developing 2-w output power, is required. For a peak plate voltage of 300 v and a minimum of 50 v, the current change is, from (4b):

$$\Delta i_b = 64 \text{ ma}$$

The load impedance is, from (4d)

$$Z_L = 3900 \text{ ohms.}$$

Power Output and Output Impedance Known—If the tube load impedance is the limiting factor in design, as is true in video amplifiers or transformer coupled audio output amplifiers, then a different design procedure is required. The current change required to develop a specified output power, for a single tube, is:

$$\Delta i_b = (I_{bp} - I_{bn}) = 2\sqrt{2P_o/Z_L} \qquad (5a)$$

or for push-pull amplifiers,

$$\Delta i_b = 2\sqrt{P_o/Z_L} \qquad (5b)$$

Z_L is half the total plate-to-plate impedance.
The peak voltage change developed, for the single tube, is:

$$\Delta e_o = \Delta i_b\ Z_L = 2\sqrt{2P_o\ Z_L} \qquad (5c)$$

and for push-pull, amplifiers

$$\Delta e_o = 2\sqrt{P_o\ Z_L} \qquad (5d)$$

Example D—A peak voltage change of 200 v peak-to-peak is required from a push-pull amplifier at an impedance of 2000 ohms plate to plate. What is Δi_b?

From (5d), and from (5b): $P_o = 10$ w, $\Delta i_b = 100$ ma.

Check List For Design Adequacy

1. Is the tube able to provide required power output within a conservative dissipation margin for all combinations of tolerances?
2. Does the circuit perform properly over an allowed range of line voltage variation?
3. Have minimum voltages, consistant with efficient operation, been selected throughout?
4. Has design been kept out of the low voltage erratic behavior area?
5. Is operation of the circuit independent of line supply frequency?
6. Is the design such that tubes and other components will not be damaged by failures in associated circuits? In other words, is the circuit safe with respect to failures in related circuits? Avalanche failures must be prevented.
7. Have environmental conditions been considered adequately?
8. Are ratings of chosen components adequate?
9. Has the tube check list been used to aid selection of tube?
10. Are shock or vibration serious considerations? If so, are tubes and components adequately designed and mounted to withstand the vibration, and mounted to provide adequate support and shock isolation?

Glossary Of Symbols Used

e_b	Instantaneous plate voltage*
$\Delta e_b = E_{bn} - E_{bp}$	(peak-to-peak)
E_{bb}	Plate supply voltage*
E_{bn}	Instantaneous plate voltage at negative bias limit
E_{bo}	Instantaneous plate voltage at static bias*
E_{bp}	Instantaneous plate voltage at positive bias limit
E_{bz}	Instantaneous plate voltage at plate current cut-off
E_{c2}	Screen-to-cathode voltage*
E_h	Heater voltage*
g_p	Plate conductance for triode
G_{M2}	Screen-to-plate transconductance
i_b	Instantaneous plate current*
$[i_b]$	Instantaneous plate current for $e_b = 1/2\ E_{bz}$
I_{bn}	Instantaneous plate current at negative bias limit
I_{bo}	Instantaneous plate current at static bias*
I_{bp}	Instantaneous plate current at positive bias limit
I_h	Heater current
P_{c2m}	Maximum screen power dissipation
P_o	Power output
P_{pm}	Maximum plate dissipation
X_{c2m}	Screen correction factor at maximum screen dissipation is usually equal to X_{c2p}
X_{c2p}	Correction factor at positive bias limit
X_p	Correction factor for plate current
Y	Conductance ratio used in tube selection; corrects for tube non-linearity
R_L	Lead resistance

$P_{pm} = 1/2\ E_{bz}\ [i_b]$, where $[i_b]$ is the current at $e_b = 1/2\ E_{bz}$

*An attempt has been made to extend the IRE definition in a consistent manner to fulfill the needs of the problem.

Selection of Triodes Based on g_p

The selection of the proper tube is based primarily on selection of a tube capable of providing the maximum required current with a sufficiently small difference of potential across the tube to provide efficient operation. For the triode, for example, the required g_p is

$$g_p = \gamma\, I_{bp}/E_{bp} \qquad (6)$$

Example E—For the tube considered in Example *A*, calculate the plate conductance required using $\gamma = 1.5$ and $\gamma = 2$.

Using (6), the values of g_p are 1940 and 2560 micromhos respectively.

The calculations of required plate conductance in example E and the calculations of screen-to-plate transconductance in later examples are based on taking the maximum plate current as the plate current change; i.e., neglecting the minimum plate current. This assumption of a negligible minimum plate current may require selection of a tube having a value of g_p or G_{M2} somewhat higher than indicated by the described design procedure, or a gamma closer to 2 than to 1.5.

Table 1 may now be examined to find triode combinations offering a plate conductance of approximately 2600 micromhos. The only tube which appears to be satisfactory is the *6AS7* tube.

Selection of Pentodes Based on G_{M2}

Selection of the proper pentode differs in one minor respect from that of the triode. The plate voltage change in the pentode circuit design is established exactly as in triodes. After the minimum plate voltage has been chosen, the screen voltage must be selected. The screen voltage required should be between 1.3 and 2 times the minimum plate voltage. (Or the plate voltage is 1/2 to 3/4 the screen coltage.) The G_{M2} required then would be

$$G_{M2} = \gamma\, I_{bp}/E_{c2} \qquad (7)$$

Example F—Determine the required G_{M2} for the amplifier considered in example C, if the minimum plate voltage is 50 volts. Take $\gamma = 2$. From Eq. $E_{c2} = E_{bp}$ (1.3), we get 67 v and from Eq. 7 $G_{m2} =$ 2600 μmhos.

Tubes meeting the requirement are the *6BQ6*, *6Y6*, and 6216.

Design for Reliability

Circuit design, whose objective is to design a circuit capable of reliable operation, should be based on the following steps:

1. Select the minimum plate voltage for the tube at maximum plate current and establish the required g_p or G_{M2}.
2. Where needed, select the screen voltage used.
3. Determine plate supply voltage if unspecified.
4. Select the load impedance if not specified.
5. Determine the maximum plate voltage at minimum plate current.
6. Determine g_p or G_{M2}.
7. Select trial tube from Table 1 or 2 on the basis of above steps.
8. Check the dissipations at the peak dissipation voltages to make certain that the tube is operating conservatively—dissipations should not exceed half the rated value.
9. Check distortion where important.
10. Check other tubes in a similar manner for the possibility of a better selection.

The application of the above steps to typical designs follows.

Triode Design—For efficient operation, the triode should be capable of providing the maximum required plate current with an instantaneous plate-to-cathode voltage not greater than one-quarter the total supply voltage.

Example G—A resistance-coupled amplifier is to be built to provide a half watt of power with a supply voltage of 250 v and a plate voltage at maximum plate current of 50 v (1/5 the supply voltage). Take, $\gamma = 1.5$, from Equations 4b and 6, $\triangle i_b = 20$ ma. and $g_p = 600$ μmho.

The following table condensed from Table 1 and manufacturer's data gives the data on some possible triode choices.

Tube	g_m	g_p	P_p	E_h	I_h	Tube size
6J5	4000	175	2.5	6.3	0.3	Octal
6SN7	4000/sect	175/sect	.5	6.3	0.6	Octal
	8000 tot	350 tot	5.0	6.3	0.6	Octal
12BH7	8000/sect	400/sect	2.5	6.3/12.6	0.6/0.3	Min. Nov.
	16000 tot	800 tot	5.0	6.3/12.6	0.6/0.3	Min. Nov.
5687	8000/sect	600/sect	4.2	6.3/12.6	0.9/0.45	Min. Nov.
	16000 tot	1200 tot	7.5	6.3/12.6	0.9/0.45	Min. Nov.

Evidently, the *12BH7* tube, if both sections were paralleled, would be a suitable choice. A single section of a *5687* tube also might prove satisfactory. The plate current at zero bias for the paralleled sections of the *12BH7* would be 24 ma, and that for a section of a *5687* tube 19 ma at 50 v. Calculating the maximum dissipation as indicated in Example A gives

$$P_{pm} = 1.56 \text{ watts}$$

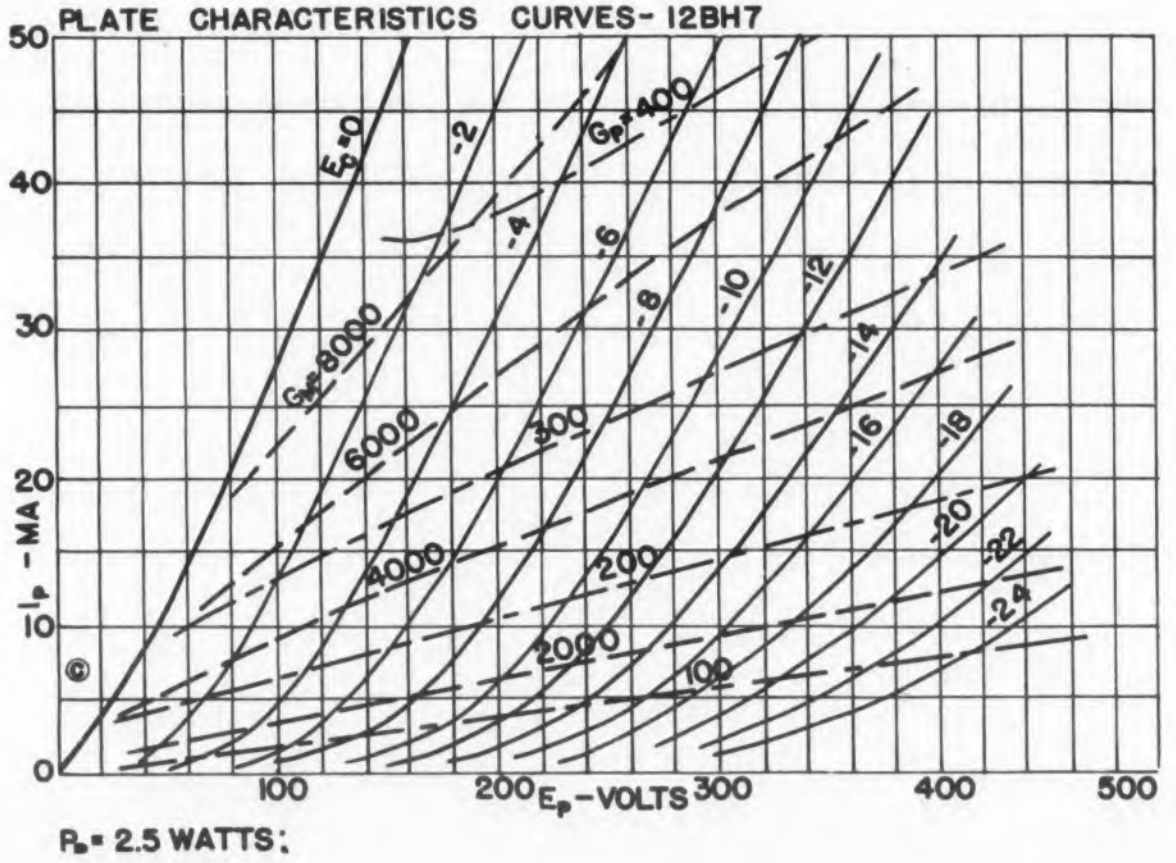
Pentode Design—For efficient operation, the plate voltage at maximum plate current for the pentode, as in the triode, should not exceed a quarter of the total plate supply voltage. The screen voltage may then be selected as in paragraph 1.6.

Example h—A pentode resistance type amplifier is required which is similar to the triode amplifier in Example G. Take the supply voltage as 250 v, the plate voltage at maximum plate current as 50 v, $\gamma = 1.5$, and the power developed as 1/2 w.

Equations:	Solution:
Eq. 4b	$\triangle i_b = 20$ ma
$E_{c2} = 1.33\, E_{bp}$	$E_{c2} = 67$ v
Eq. 7	$G_{M2} = 450$ μmho

From Table 2 and manufacturer's data some possible pentode choices could be *5840*, *6134*, *5686*, *6CM6*, *12BY7*, *6CL6*.

Clearly, tubes cited before the *5686* tube in the foregoing sentence have insufficient power handling capacity to meet the listed requirements. If a low transconductance tube (first grid) is satisfactory, either the *5686* or the *6CM6* tube might be chosen. If high transconductance were required, however, either the *12BY7* or the *6CL6* tube would be chosen. The zero bias plate currents I_{bp}, for the four tubes with 67 v on the screen are: *5686*, 14 ma; *6CM6*, 22 ma; *12BY7*, 18 ma; and *6CL6*, 23 ma. As might be expected, the *5686*



is marginal at $E_{c2} = 67$ v, but the rest would be satisfactory. Probably the screen voltage would actually be chosen to be 75 v.

Additional operating data on the amplifier are: $R_L = (E_{bn} - E_{bp})/(I_{bp} - I_{bn}) = 10{,}000$. Maximum dissipation: from Eq. 2, $P_{pm} = 1.56$ w and from Eq. 3, $P_{c2} = 0.56$ w.

Other Important Factors in Tube Selection

The design of tube circuits is dependent on both controlled parameters of the tube and uncontrolled parameters of the tube. Manufacturers keep different characteristics under surveillance with different tube types. These characteristics which are kept under surveillance are called controlled parameters. (Plate current and transconductance are typical controlled parameters.) In addition, design is dependent on the characteristics of the remaining elements of the circuit, resistors, capacitors, inductors, transformers, and supply voltages, in addition to stray couplings and a variety of potential stresses. The basic objective of good design is to keep as many of the important parameters and characteristics as possible as controlled parameters of the system, and to relegate the remainder to the category of uncontrolled parameters. The greater the number of significant parameters which are uncontrolled, and consequently have to be adjusted by trial and error, the more time-consuming is the design, and the less reliable the final result.

Consideration of power handling ability in relation to the power requirements of a circuit is one of the more important design problems. In particular, the design should permit, with ordinary environments, the tubes to develop the power required without allowing static dissipations in excess of half the rated dissipation of the tubes. In addition to power handling ability, the selection of the transconductance level for the control grid, and the figure of merit in relation to frequency response and bandwidth requirements, a large number of other factors may have to be considered. The following check list is included to aid the user in remembering some of the more important factors requiring consideration. Characteristics in the check list below are often uncontrolled parameters.

1. Cathode Interface Impedance
2. Cathode Current Drift with Time
3. Microphonics and Noise–Hum
4. Physical Size and Socketing Problems
5. Interelectrode Capacitances and Figure of Merit
6. Heater to Cathode Leakage
7. Heater to Cathode Voltage Rating
8. Internal Surface Leakage
9. Effects of Humidity, Ambient Temperature, and Altitude at which Equipment Must Operate
10. Reliability Characteristics Engineered into Components
11. Uncontrolled Tube Parameters such as Grid Current and Contact Potential
12. Sensitivity to Heater Voltage Variation and Similar Effects

CAREERS FOR ENGINEERS

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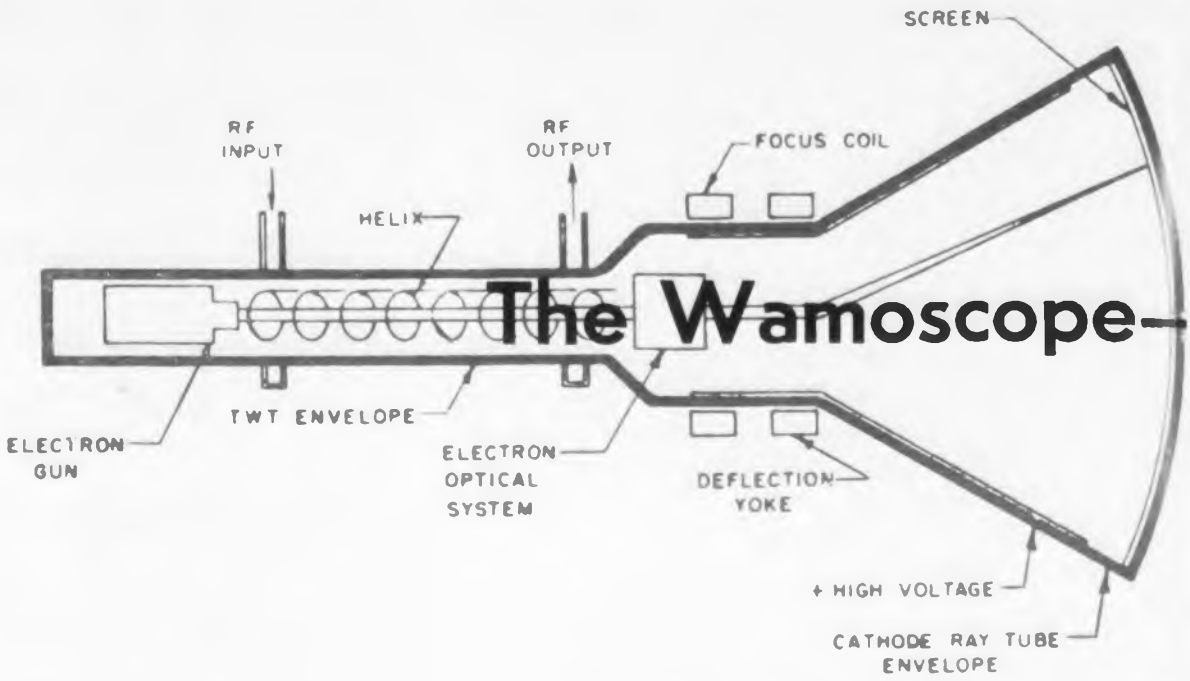
Producers of Scorpion F-89 Interceptors and Snark SM-62 Intercontinental Missiles

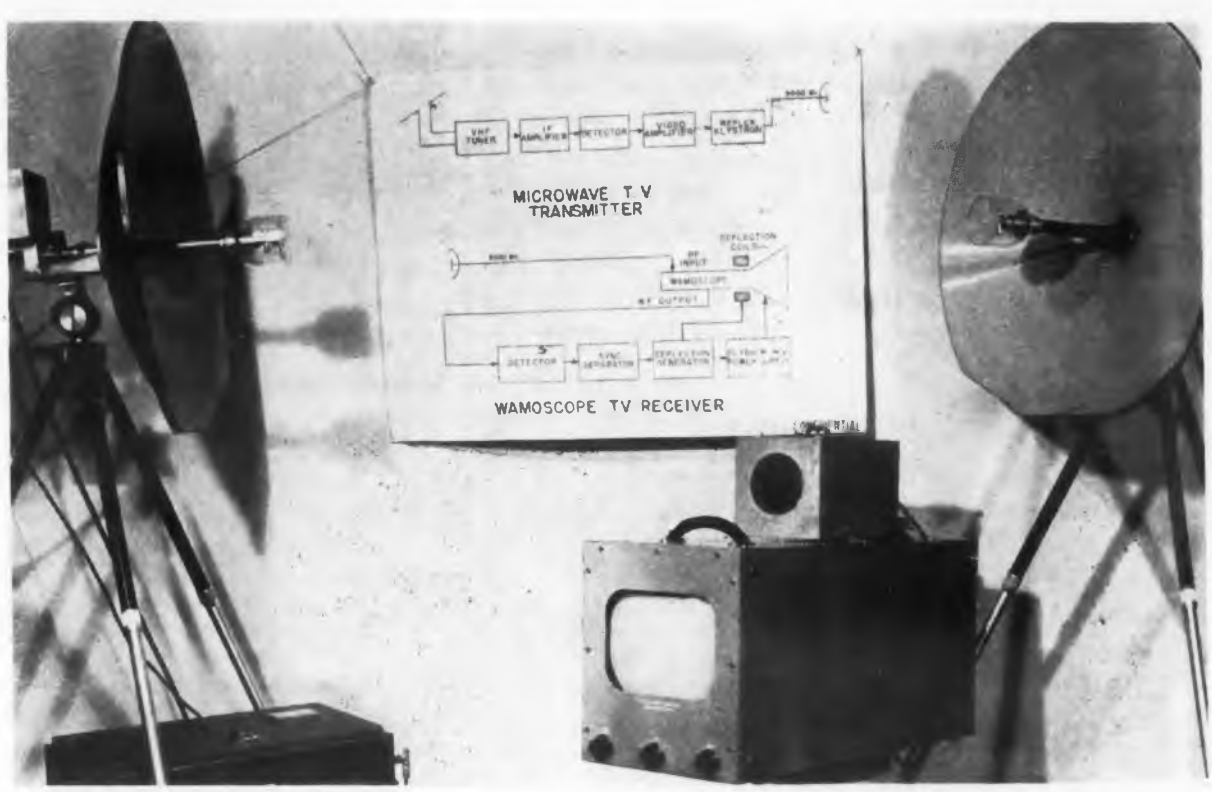
5-A-85

The Wamoscope—



RADICALLY new, this cathode-ray tube for radar, TV and other display applications incorporates most conventional receiver functions in a single package. Many of the tubes and components required by a conventional microwave receiver are completely eliminated. Known as the "Wamoscope", the new tube represents a significant step in the trend for simplification and increased reliability of electronic equipment.

Microwave signals pass directly from the antenna into the tube, where, in a single envelope, the signals are amplified, detected, and displayed on the tube's fluorescent screen. Compared with



Block diagram, photo center, indicates stages of entire TV circuit. Transmitter shown at photo bottom left, its radiating dipole and reflector above. Receiving antenna system at upper right. Wamoscope display at lower center. Loudspeaker rests on Wamoscope receiver housing.

A New Microwave Display Device

a conventional radar receiver, this eliminates the local oscillator, mixer, if amplifier, detector, video amplifier and all their associated circuitry.

Operation of the Wamoscope, developed by Sylvania Electric Products Inc., Bayside, New York, is based upon velocity-sorting the electrons which emerge from the end of the helix of the traveling wave tube section. A dc beam of suitable voltage is passed down the helix. With an rf input, the beam interacts with the rf fields on the helix so that the beam is velocity and current modulated in accordance with the amplitude of the rf signals. The velocity-modulated beam enters the region where the special electron-optical system is located. By applying a suitable bias voltage to an aperture in the electron-optical system, the electrons whose velocity is greater than the dc velocity, pass through the aperture and are allowed to impinge upon the screen of the cathode ray tube while slower electrons are deflected.

A wide selection of channels is possible in the Wamoscope, which operates in the microwave frequency range of 2000 to 4000 mc. The name is derived from "wave-modulated oscilloscope."

Pilot quantities of the tube have been produced, and are being used with Naval approval. Additional tube types, operating in different frequency bands and incorporating other features, are now under development.

For more information on this display device turn to the Reader's Service Card and circle 23.

Miniature Camera Tube

MIDGET televisors, made possible because of the availability of the miniature camera tube illustrated here, can play the role of a Lilliputian Cyclops. A watchful remote-controlled eye can survey areas too dangerous or inaccessible for human beings or snoop into confines concealed from the human eye. The spectral response of the miniature photoconductive camera tube 0.595 inches in diameter and 3.5 inches long closely approximates that of the human eye. Overall performance is comparable to the Vidicon TV pickup tube.

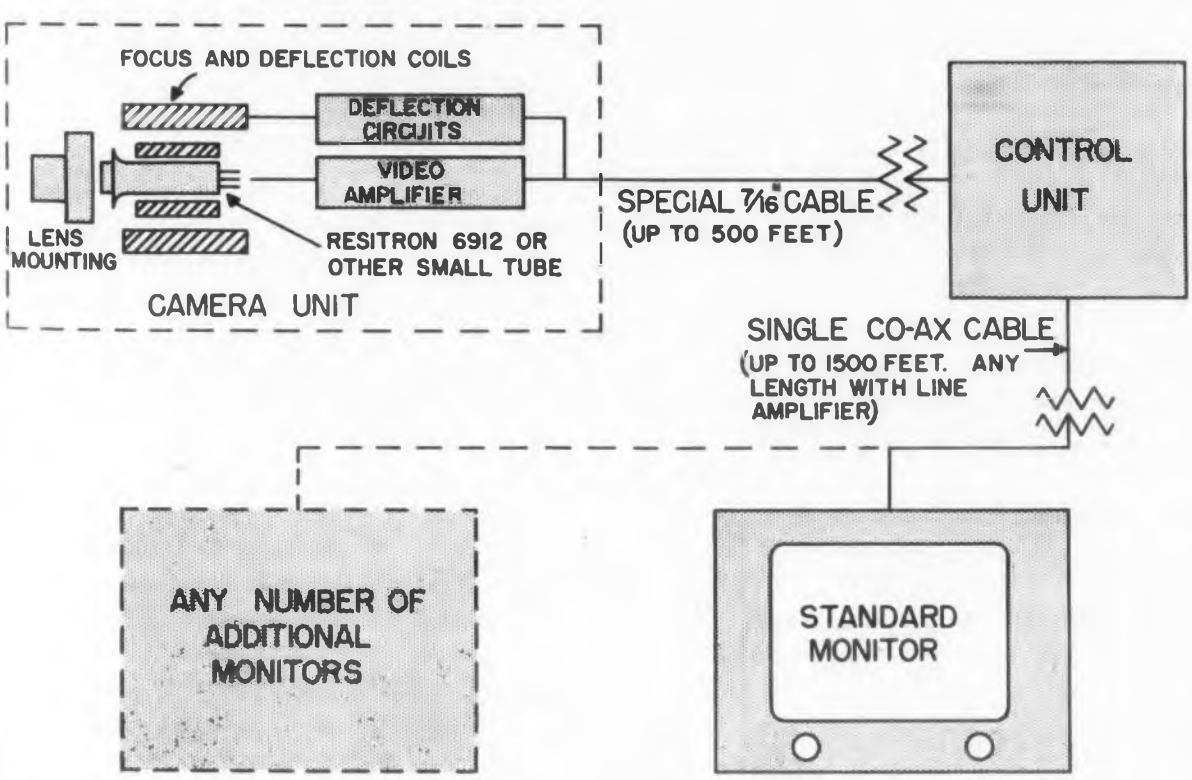
Magnetic focusing and deflection is used on the *6912* camera tube manufactured by Resitron Laboratories, Inc., 2908 Nebraska Ave., Santa Monica, Calif.; it is ideally suited for industrial or broadcast television. A complete TV setup is illustrated by the block diagram. The scanned target area is 6 mm by 8 mm. The signal electrode voltage for a dark curve of 0.02 μamp is 10 to 90 v. Maximum grid voltage rating is 320 v. The voltage for picture cut-off is 28 to 90 v. Heater voltage is 6.3 v ac and heater current is 0.6 amp.

The 5 by 2 by 1-3/4 in. camera illustrated was developed by Lockheed to aid in gathering flight test data. Possible uses include remote fire detectors, examination of controls both inside and outside the aircraft (the small camera offers a minimum of air resistance), and inspection of aircraft structures through hand-sized entry holes. Camera installations in wind tunnels have been used to show ice accumulation. The small camera can be put inside pipe lines to observe, for example, obstructions, and corrosion. The availability of the miniature tube will permit many equipment and system designers to build in monitoring features.

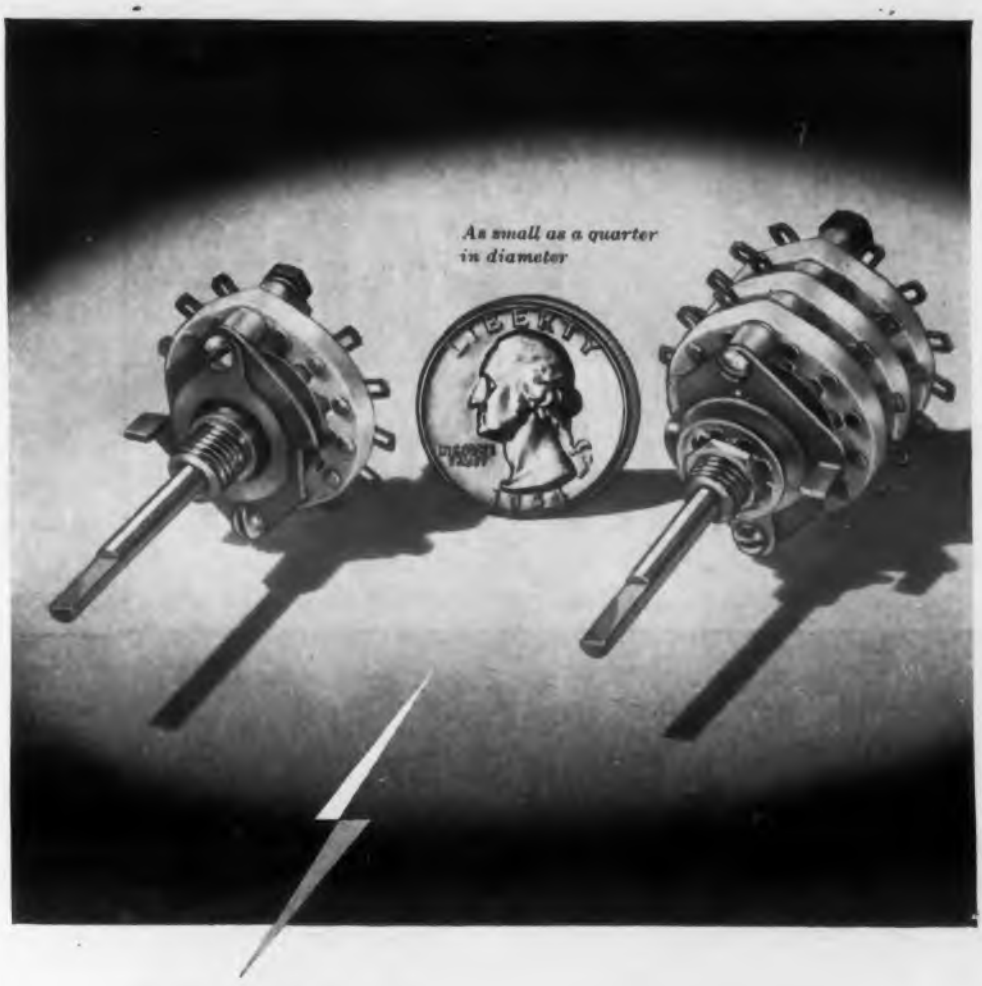
For more information on the miniature camera tubes and the availability of complete cameras turn to Reader's Service Card and circle 26.

Typical remote-control camera for use in TV circuit.

Tube photograph is actual size.



Block diagram showing miniature camera tube in TV system.



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Modern

TABLES presented in this series of articles make the design of three classes of practical networks simple. The tables give the element values for the normalized low-pass network with a Butterworth, Tschebyscheff, or Bessel-polynomial characteristic. To convert the normalized element values to practical design values requires only simple multiplications. The low-pass networks that are realized can also be transformed in a straightforward manner to serve high-pass, band-pass, or band-elimination functions. Parts I, II and III covered Butterworth characteristics several Tschebyscheff characteristics, and Bessel Functions (ED Sept. 15, Oct. 1, Oct. 15, 1956). In this Part IV, normalization, duality, reciprocity theorem, frequency transformations, and transformation of symmetrical networks are given. Additional Tschebyscheff characteristics are also included.

Normalization—The element values in the tables are normalized with respect to the load resistance R_1 and the radian frequency. In other words, the value of R_1 is considered as 1 ohm and that of the cutoff frequency (or $\omega_0=1t_0$ for the time-delay networks) is 1 radian per second. These frequency and impedance normalizations may be removed simply.

Since the impedance of the three different kinds of elements appearing in a network is given respectively by R, Ls, and $1/Cs$, we note that if the frequency is multiplied by a constant the resistance is unaffected, but that to maintain the impedance of the inductance and capacitance invariant, it is necessary to divide L and C by the same constant. This provides the simple rule for removal of the frequency normalization: to raise the radian frequency $\omega=1$ to $\omega=\omega_c$, divide all L's and C's in the network by ω_c. On the other hand, to raise the impedance level by a factor H we must multiply the impedance of each type of element by this factor, that is, multiply every R and L in the network by H, and divide every C by H. Thus we see only simple multiplications are involved.

The two rules may be combined into one operation: to raise the radian frequency to ω_c and the impedance level by H, we multiply every resistance by H, every inductance by H/ω_c, and every capacitance by $1/\omega_c H$).

Duality—The dual of a ladder network may always be realized simply. The impedance of every series arm is

Synthesis Network Design From Tables—IV

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replaced by the admittance of a shunt arm, and vice versa. In simpler terms, this means that every capacitance of C farads is replaced by the dual element which is an inductance of C henrys, every inductance of L henrys is replaced by a capacitance L farads, and every resistance of R ohms becomes a conductance of R ohms; if the original element is a series arm then the dual element becomes a shunt arm, whereas if the original element is a shunt arm then the dual element is a series arm. For example, the dual of the network in *a* of Fig. IV-1 is given by the one in *b*.

What are the characteristics of the dual network with respect to that of a given network? The impedances (admittances) of one network (both transfer and driving point) become admittances (impedances) of the other. Thus in Fig. IV-1a the input is a voltage source and the output a current so that the transfer function is the admittance $Y_{21}=I_2/E_1$. In the dual given by Fig. IV-1b the transfer impedance $Z'_{21}=E'_2/I'_1$, is the same rational function as Y_{21} of a.

It is therefore clear that the primed and unprimed values lead to dual networks.

Reciprocity Theorem—Often a network designed by the use of the tables does not have the configuration demanded in a particular problem. For example, a shunt capacitance may be desired at the output and a resistance at the input, but the network obtained has the form shown in Fig. IV-2a. By the use of the reciprocity theorem the network of Fig. IV-2b with the desired configuration may be obtained.

The reciprocity theorem states that the transfer impedance (or transfer admittance) remains unchanged if the excitation and measuring instrument change places. Thus in Fig. IV-2a we have the transfer impedance

$$Z_{21} = \frac{E_2}{I_1} = \frac{p(s)}{q(s)} \qquad (16)$$

where the excitation is a current source I_1 flowing into the input terminals and the output is a voltage (measured by a voltmeter across R). Now if the current source is placed across R and the voltmeter placed across C_4, then the conditions of the reciprocity theorem have been satisfied. Thus the transfer impedance of Fig. IV-2b is also equal to p/q.

It is therefore clear that by use of reciprocity a whole set of new network configurations may be obtained.

Frequency Transformations[8]—The tables give the element values for low-pass filters. However, corresponding characteristics may be obtained for the high-pass, band-pass, and band-elimination cases by the use of transformations of the frequency variable.

High-Pass Filters

A normalized low-pass filter characteristic is shown in Fig. IV-3a; the corresponding high-pass characteristic is given in Fig. IV-3b. The latter characteristic may be obtained from the former by the use of the transformation $s'=1/s$. Since by use of this transformation the impedance of an inductance Ls becomes the impedance L/s', the impedance of a capacitance $1/Cs$ becomes s'/C, and the value of a resistance remains unchanged, a simple rule for converting a low-pass ladder network to a high-pass one may be formulated. The rule is: replace every inductance of L henrys by a capacitance of $1/L$ farads; replace every capacitance of C farads by an inductance of $1/C$ henrys; and leave the resistances unchanged. Thus if the network in Fig. IV-4a has a low-pass characteristic, then the corresponding high-pass network is given in Fig. IV-46.

Band-Pass Filters

A low-pass filter of bandwidth ω_c may be converted to a band-pass filter of bandwidth $\omega_c=\omega_b-\omega_a$ by use of the frequency transformation

$$s = \frac{(s')^2 + \omega_0^2}{s'} \qquad (17)$$

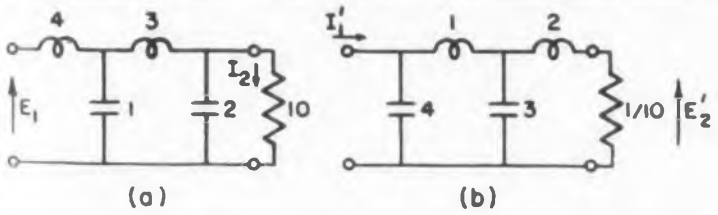

Fig. IV-1 Ladder network and its dual (values in ohms, henrys, and farads).

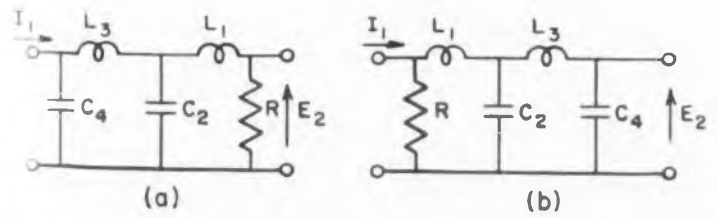

Fig. IV-2 Ladder network and one obtained from it by use of reciprocity theorem.

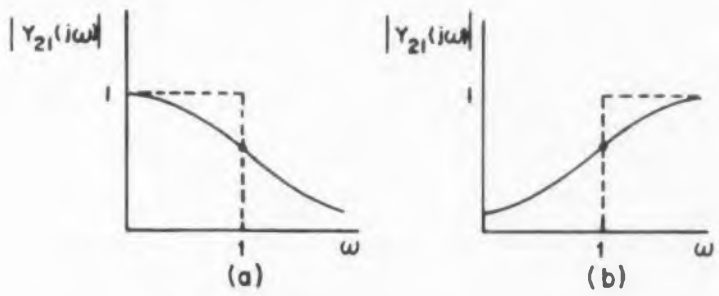

Fig. IV-3 Low-pass characteristic and the corresponding high-pass one obtained by a frequency transformation.

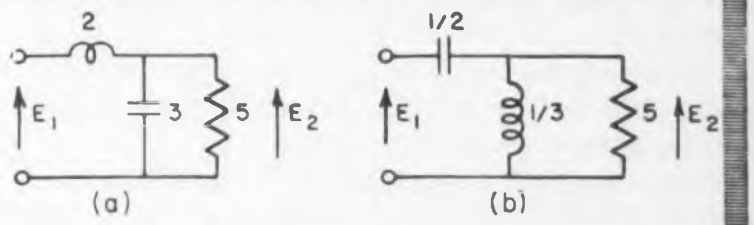

Fig. IV-4 Low-pass network and its corresponding high-pass network.

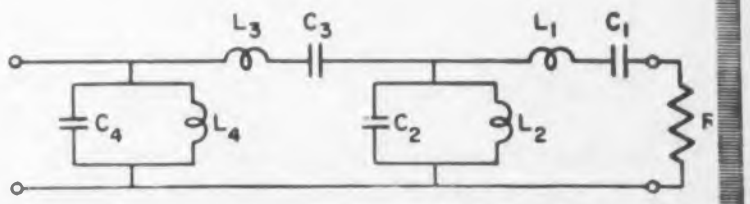

Fig. IV-5 Band-pass filter for example.

Thus the right-hand side of Eq. 17 is substituted for every s in the transfer function. Here ω_b is the upper frequency limit and ω_a is the lower frequency limit of the band, while ω_0 is the center frequency of the band. The band limits have geometric symmetry about the center frequency, that is, $\omega_a\omega_b=\omega^2_0$.

However, it is not necessary to actually carry out the transformation, since there is a simple rule for converting the low-pass network to a band-pass one: for each inductance in the network of L henrys add a capacitance in series with it of value $1/(\omega^2_0 L)$ farads; for each capacitance in the network of C farads add an inductance in parallel with it of $1/(\omega^2_0 C)$ henrys (that is, the added element always resonates with the original element at the center frequency ω_0); leave the resistances unchanged.

The complete process for converting a normalized low-pass filter to a desired band-pass one may be given as the following:

1. Determine the desired bandwith $\omega_c=\omega_b-\omega_a$ and the desired center frequency $\omega^2_0=\omega_a\omega_b$ from the given data.
2. Change the bandwidth of the low-pass filter to ω_c.
3. Perform the low-pass to band-pass transformation on the network.
4. Remove the level normalization from the resulting band-pass filter.

Example

Design an equal-ripple band-pass filter with the following characteristics:

a. The ripple in the pass band is 1 db.

b. The center frequency is f_0=1000 cy.

c. The bandwidth f_c measured at 1 db points is 100 cy.

d. At the frequencies corresponding to three times f_c the response is to be down approximately 50 db.

e. The network is driven by a current source and should have a load resistance of 1000 ohms.

In order to design this filter it is not necessary to find the actual frequencies at which the response is down 1 db and 50 db, but if we wished to find them we could use the formulas $f_a f_b=f_a(f_a+100)=10^6$ and $f_{50}(f_{50}+300)=10^6$, where f_a is the lower 1 db frequency and f_{50} is the lower 50 db frequency.

From Table II-2 we find that the 1 db ripple corresponds to 0.5088. We now calculate n and find that n=4 yields approximately 49 db attenuation at ω=3. Therefore using n= 4 and the primed values of Table II-2a, we find the element values:

L'_1=1.0495 $\qquad$ L'_3=1.9093

C'_2=1.4126 $\qquad$ C'_4=1.2817

The bandwidth is now changed to $\omega_c=2\pi$x100 by dividing the above values by ω_c. The network is then converted to the band-pass form and the impedance level raised to 1000 ohms. The final network given in Fig. IV-5 has the element values (in ohms, henrys, and farads:

R =1000 $\qquad$ L_3=3.04

L_1=1.67 $\qquad$ $C_3=8.33\text{x}10^{-9}$

$C_1=1.52\text{x}10^{-8}$ $\qquad$ $L_4=1.15\text{x}10^{-2}$

$L_2=1.41\text{x}10^{-2}$ $\qquad$ $C_4=2.20\text{x}10^{-6}$

$C_2=2.25\text{x}10^{-6}$

Band-Elimination Filters

The transformation from a low-pass to a band-elimination characteristic is given by

$$s=\frac{s'}{(s')^2+\omega_0^2} \tag{18}$$

As for the band-pass filter the transformation can be achieved by direct operation on the low-pass network. The rule follows:

a. Add a capacitance in parallel with each inductance in the low-pass network; the value of the capacitance is $1/\omega^2_0 L$), where L is the value of the original inductance.

b. Add an inductance in series with each capacitance of the network; the value of the inductance is $1/\omega^2_0 C$), where C is the value of the original capacitance.

c. Since the resistances are unaffected by the transformation, their values are not changed.

Transformation of Symmetrical Networks

It has been pointed out that the Butterworth and Tschebyscheff networks obtained for D=1 and n odd are symmetrical. This symmetry allows any specified resistance ratio $r=R_n R_1$ to be obtained simply; the method used transforms the symmetrical network to an unsymmetrical one with the desired resistance ratio.

If the symmetrical network is divided as it was in Fig. I-3, then the over-all transfer impedance is given in terms of the impedances of the component networks by[9]

$$Z_{21}=\frac{Z_{21a}\,Z_{21b}}{Z_a+Z_b} \tag{19}$$

The subscripts a and b have been used to designate the networks on the left and right, respectively. But because of the symmetry, the component networks are the same and consequently $Z_{21b}=Z_{21a}$ and $Z_b=Z_a$. Now suppose it is desired to increase the resistance ratio by r. If the impedance level of N_a is multiplied by r, the desired effect will have been accomplished. But this change also increases Z_{21a} and Z_a by r. Be-

Table IV-2 Zeros of Polynomials V_n derived from the Tschebyscheff Approximation

c) 2-db ripple (ϵ = 0.7647831, ϵ^2 = 0.5848932

n = 1	n = 2	n = 3	n = 4	n = 5	n = 6	n = 7	n = 8	n = 9	n = 10
-1.3075603	-0.4019082 ±j0.6893750	-0.3689108	-0.1048872 ±j0.9579530	-0.2183083	-0.0469732 ±j0.9817052	-0.1552958	-0.0264924 ±j0.9897870	-0.1206298	-0.0169758 ±j0.9934868
		-0.1844554 ±j0.9230771	-0.2532202 ±j0.3967971	-0.0674610 ±j0.9734557	-0.1283332 ±j0.7186581	-0.0345566 ±j0.9866139	-0.0754439 ±j0.8391009	-0.0209471 ±j0.9919471	-0.0767332 ±j0.7112580
				-0.1766151 ±j0.6016287	-0.1753064 ±j0.2630471	-0.0968253 ±j0.7912029	-0.1129098 ±j0.5606693	-0.0603149 ±j0.8723036	-0.0492657 ±j0.8962374
						-0.1399167 ±j0.4390845	-0.1331862 ±j0.1968809	-0.0924078 ±j0.6474475	-0.0966894 ±j0.4566558
								-0.1133549 ±j0.3444996	-0.1071810 ±j0.1573528

Table IV - 3 Polynomials V_n in Expanded Form $V_n = s^n + b_{n-1}s^{n-1} + \ldots + b_1 s + b_o$

c) 2-db ripple (ϵ = 0.7647831, ϵ^2 = 0.5848932)

n	b_o	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8	b_9
1	1.3075603									
2	0.6367681	0.8038164								
3	0.3268901	1.0221903	0.7378216							
4	0.2057651	0.5167981	1.2564819	0.7162150						
5	0.0817225	0.4593491	0.6934770	1.4995433	0.7064606					
6	0.0514413	0.2102706	0.7714618	0.8670149	1.7458587	0.7012257				
7	0.0204228	0.1660920	0.3825056	1.1444390	1.0392203	1.9935272	0.6978929			
8	0.0128603	0.0729373	0.3587043	0.5982214	1.5795807	1.2117121	2.2422529	0.6960646		
9	0.0051076	0.0543756	0.1684473	0.6444677	0.8568648	2.0767479	1.3837464	2.4912897	0.6946793	
10	0.0032151	0.0233347	0.1440057	0.3177560	1.0389104	1.1585287	2.6362507	1.5557424	2.7406032	0.6936904

cause $Z_b = Z_a$, however, the Z_{21} of the whole network is not changed except by a constant multiplier. For example, if $r = 10$ then the transfer impedance before the level change is

$$Z_{21} = \frac{(Z_{21a})^2}{2\,Z_a} \tag{20}$$

whereas after the change it is

$$Z'_{21} = \frac{10\,(Z_{21a})^2}{11\,Z_a} \tag{21}$$

which differs from Eq. 20 only by a constant multiplier.

An analogous situation of course holds for transfer admittances.

Acknowledgement: The author expresses his thanks to the members of the Mathematics Section, Systems Analysis Department, Hughes Aircraft Company, who carried through the calculations for almost all of the tables in this paper.

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8. Automatic Feedback Control System Synthesis, J. G. Truxal, McGraw-Hill Book Co., Inc., New York; 1955.
9. Synthesis of Transfer Functions with Poles Restricted to the Negative Real Axis, L. Weinberg, *Jour. Appl. Phys.*, vol 24, pp. 207-216; 1953.

Additional Tables and Data

Included in this last section are additional Tschebyscheff Filter Tables, IV-I and IV-2. The element values are given for a 2 db ripple factor. Refer to Part II ELECTRONIC DESIGN, Oct. 1, for background information.

In the future an attempt will be made to compute additional tables giving element values of other practical networks such as Bessel-polynomial networks with resistance terminations at both ends.

The substitution of a voltage for a current source (and the consequent change of system function from Z_{21} to Y_{21}) may be achieved by the use of a completely dual network (Part I). However, in many practical problems this dual may not be desired; we may wish to use a *voltage source* to drive a network with a shunt capacitance at both ends (Fig. I-2, Part I). This is simply realized by the application of Thevenin's theorem to the current source with its associated shunt conductance, which thus yields the desired network with a voltage source and its associated series R_n at the input. Analogously, the network forms of Fig. II-2, Part I, can be used with a current source at the input terminal pair.

As the reader may have noted, table for $D = 1/2$ can be obtained from the $D = 2$ tables by the application of reciprocity and an impedance level change. Both forms of the tables have been given for the convenience of the reader.

Table IV - 1
Element Values (in ohms, henrys, farads) for a Normalized Tschebyscheff Filter with 2 db Ripple ($\epsilon = 0.7648$, $\epsilon^2 = 0.5849$).

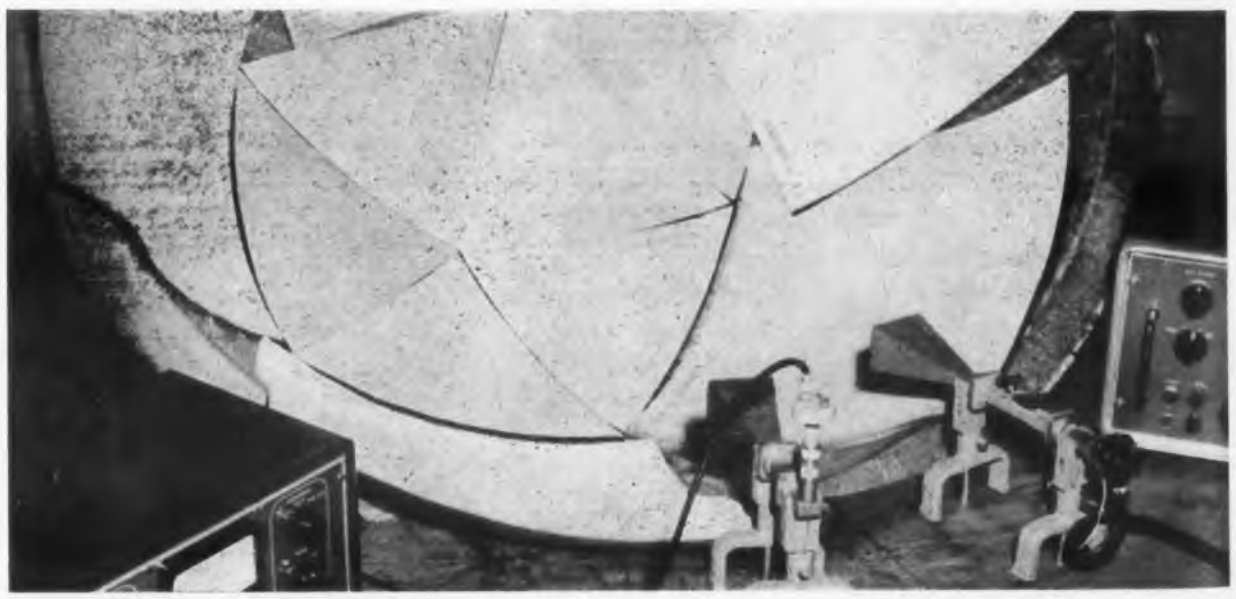
Value of n	C_1 or L'_1	L_2 or C'_2	C_3 or L'_3	L_4 or C'_4	C_5 or L'_5	L_6 or C'_6	C_7 or L'_7	L_8 or C'_8	C_9 or L'_9	L_{10} or C'_{10}	R_n or $1/R'_n$
a) D = 0 (For this case unprimed values correspond to a current-source input for n odd and to a voltage-source input for n even.)											
1	.7648										∞
2	1.2441	.9766									0
3	1.3553	1.2740	1.7717								∞
4	1.3962	1.3389	2.2169	1.1727							0
5	1.4155	1.3640	2.3049	1.4468	1.9004						∞
6	1.4261	1.3765	2.3383	1.4974	2.3304	1.2137					0
7	1.4328	1.3836	2.3551	1.5159	2.4063	1.4836	1.9379				∞
8	1.4366	1.3881	2.3645	1.5251	2.4332	1.5298	2.3646	1.2284			0
9	1.4395	1.3911	2.3707	1.5304	2.4463	1.5495	2.4386	1.4959	1.9553		∞
10	1.4416	1.3932	2.3748	1.5337	2.4538	1.5536	2.4607	1.5419	2.3794	1.2353	0
b) D = 1/2											
1	1.1472										2.00000
2	1.8661	.7887									.21131
3	2.0330	1.0393	2.2485								1.8083
4	2.0943	1.0911	2.8881	.8935							.21330
5	2.1233	1.1104	3.0129	1.1334	2.3671						1.7940
6	2.1391	1.1198	3.0590	1.1769	2.9929	.9141					.21367
7	2.1492	1.1250	3.0820	1.1922	3.1046	1.1524	2.4010				1.7902
8	2.1550	1.1284	3.0944	1.1996	3.1432	1.1938	3.0243	.9214			.21379
9	2.1593	1.1306	3.1026	1.2037	3.1616	1.2078	3.1314	1.1596	2.4146		1.7885
10	2.1623	1.1321	3.1081	1.2062	3.1720	1.2143	3.1676	1.2000	3.0380	.9248	.21385
c) D = 1											
1	1.5296										1.0000
2	2.4881	.6075									.24418
3	2.7107	.8327	2.7104								1.0000
4	2.7925	.8806	3.6063	.6819							.24418
5	2.8310	.8985	3.7827	.8985	2.8310						1.0000
6	2.8521	.9071	3.8467	.9393	3.7151	.6964					.24418
7	2.8655	.9119	3.8780	.9535	3.8780	.9119	2.8655				1.0000
8	2.8733	.9151	3.8948	.9605	3.9335	.9510	3.7477	.7016			.24418
9	2.8790	.9171	3.9056	.9643	3.9598	.9643	3.9056	.9171	2.8790		1.0000
10	2.8831	.9186	3.9128	.9667	3.9743	.9704	3.9589	.9554	3.7619	.7040	.24418
d) D = 2											
1	2.2943										.50000
2	3.7322	.3943									.21131
3	4.0660	.5747	3.6763								.55301
4	4.1887	.6160	5.1152	.4467							.21330
5	4.2465	.6318	5.4052	.6189	3.8092						.55741
6	4.2782	.6395	5.5083	.6536	5.2408	.4571					.21367
7	4.2983	.6437	5.5579	.6659	5.5174	.6284	3.8474				.55860
8	4.3099	.6466	5.5838	.6720	5.6110	.6616	5.2779	.4607			.21379
9	4.3185	.6484	5.6005	.6753	5.6546	.6730	5.5490	.6321	3.8619		.55913
10	4.3247	.6497	5.6115	.6774	5.6783	.6783	5.6406	.6647	5.2941	.4624	.21385
e) D = 3											
1	3.0591										.33333
2	4.9763	.2863									.17260
3	5.4214	.4330	4.6747								.38657
4	5.5849	.4682	6.6656	.3279							.17614
5	5.6620	.4819	7.0737	.4674	4.8230						.39133
6	5.7043	.4886	7.2175	.4966	6.8113	.3362					.17680
7	5.7311	.4924	7.2860	.5072	7.2067	.4750	4.8657				.39262
8	5.7466	.4948	7.3215	.5124	7.3404	.5029	6.8538	.3391			.17703
9	5.7581	.4964	7.3441	.5153	7.4022	.5126	7.2433	.4780	4.6815		.39319
10	5.7663	.4976	7.3590	.5171	7.4355	.5172	7.3753	.5054	6.8722	.3405	.17714

Note: Impart C of Table IV-1, for $n = 3$, L_3 should be equal to 2,7107 instead of 2,7104

Flexible Foam Microwave Absorber

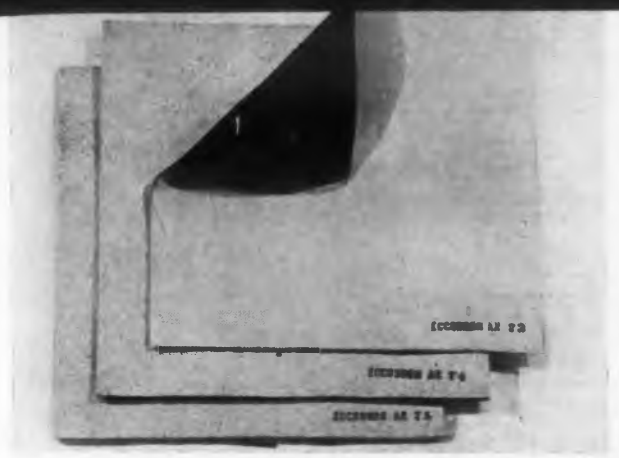
A new microwave absorbing material for lining antenna nacelles and enclosures has the unusual properties of flexibility and thinness, yet with a reflectivity of less than 2% of incident energy. Available for use in the region from 8600 to 35,000 megacycles, the material is broadbanded and therefore not frequency sensitive. Because it is made of plastic foam, the absorber will withstand high temperatures.

This Type AN Eccosorb light-weight flexible foam sheet broadband microwave absorber material is available from Emerson and Cuming, Inc., 869 Washington St., Canton, Mass. It complements their previously announced Type CH absorbers in that it is especially suitable for the



Reflectivity test set-up for flexible foam microwave absorbing material. Note how material takes on contour of surface to which it is bonded.

Performance curves of reflected power versus frequency for four types of AN Eccosorb. AN72 is thinnest and designed for K band. AN75 is thickest and is broadbanded from K through S band.



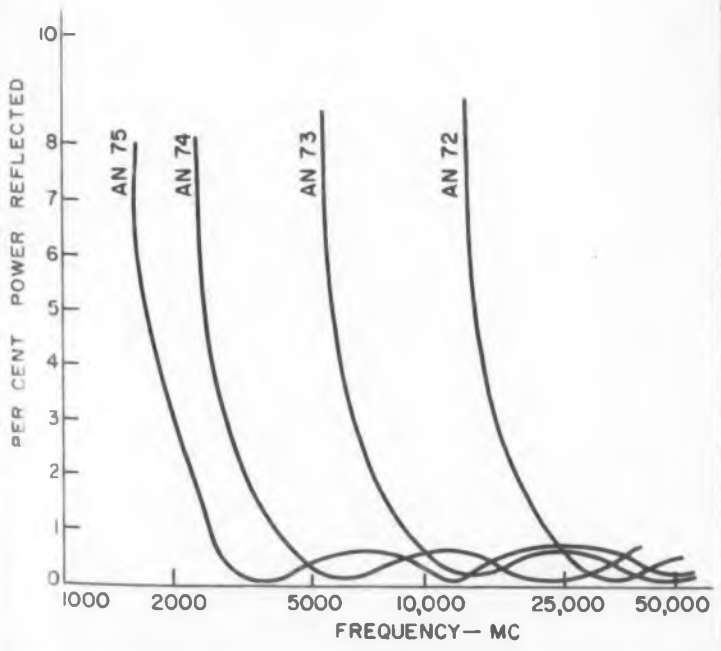
Flexible Foam AN Eccosorb. Available in sheet, the front surface is white, the back surface bronze. Able to take a three-dimensional contour, it is installed with cement.

higher frequency microwave regions where the greater thickness of the rigid foam CH material and its inflexibility make it hard to handle. Maximum thickness of the AN Eccosorb is 7/8 in. and it is available in thinner sheets for the higher frequencies. It can be fitted into corners as small as 1/8 in. radius. It is not designed for use at frequencies below S band, however.

Eccosorb AN is white surfaced for good light reflection and is useful from minus 94 to plus 300 F. Type AN 75 covers all bands from S through K, with AN 73 covering X through K. Nominally 3/8 in. thick, it weighs less than 2 oz per sq ft.

Minimizing weight and space aboard aircraft, particularly, Type AN Eccosorb can also be used in ground installations of antennas as well as in microwave darkrooms. Because of its flexibility, the absorber can be draped over and around posts, stands and equipment.

For further information about this product, fill out the Reader's Service Card and circle 30.



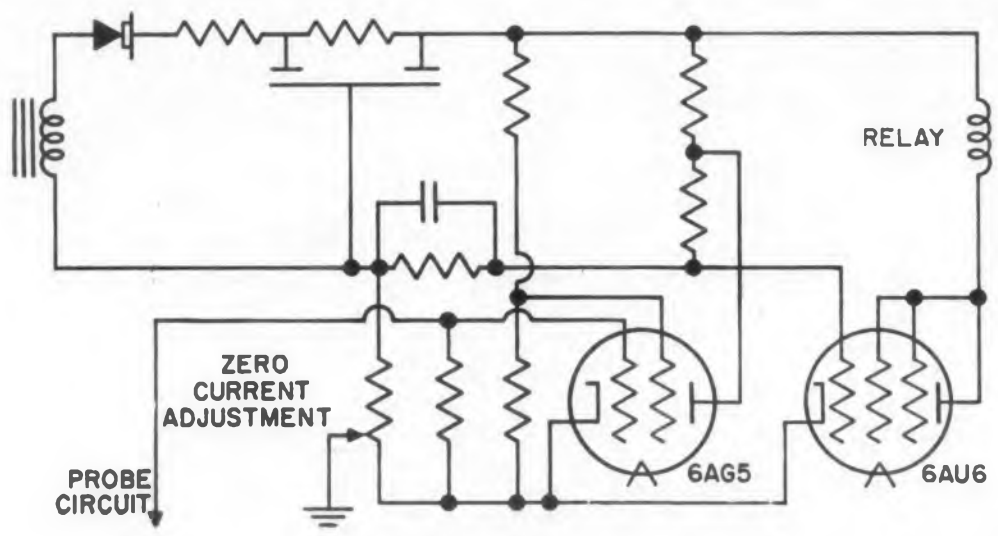
Electronic Automatic Digital Micrometer

BY adding a digital counter to a precision electronic micrometer, a tool has been developed that virtually eliminates the source of human error in measuring material thickness accurately. The direct heading, counter type automatic electronic digital micrometer described here permits measurements with laboratory accuracy, repeatability and speed, with no pressure on the work.

Similar to most micrometers, material thickness up to 1 in. (7/8 in. with standard micrometer tip) can be accommodated. The throat depth is 2 in., and the upper head is adjustable in height for work up to 2 in. The standard anvil is removed readily for the use of special fixtures. Measurement repeatability is 0.00002 in. Required power is 18 w, 115 v ac. This Electronic Micrometer, Model HDR, is manufactured by J. W. Dice Co., Englewood, N.J.

The micrometer spindle is rotated by a motor in the instrument column until contact is made between the spindle face and the work. This contact is sensed by an electronic circuit which operates a relay, instantly stopping the motor drive, and holding the reading until released by the operator. The 4-digit counter, also driven by the motor, indicates the micrometer screw position directly in units of ten-thousandths of an inch.

The patented circuit shown, for detecting metal-to-metal contact, has an important characteristic essential to precise operation of the micrometer. When contact is estab-



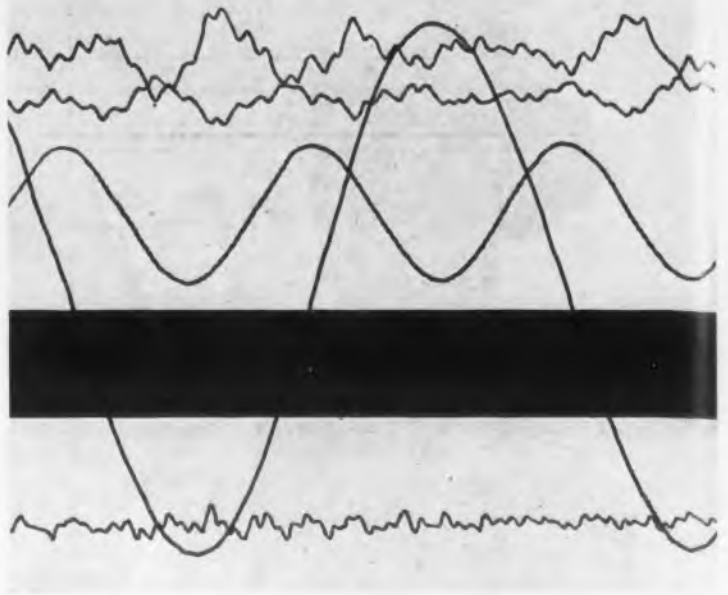
Schematic for Electronic Micrometer

lished with the work, no current flows; thus no arcing occurs upon opening of the probe circuit.

Trigger action is caused in the plate circuit of the *6AU6*, as the resistance changes in the probe circuit. Current through the relay coil changes little until contact resistance with the work falls to about 0.1 megohm. Further decrease in contact resistance to a few thousand ohms produces full swing in plate current. But actual contact resistance in operation is in the range of a fraction of an ohm. Thus, with the first instant of metal-to-metal contact, full circuit response occurs; with the first break in contact, the output swings all the way. The effect is similar to a flip-flop in performance. A displacement of less than 5 millionths of an inch at the micrometer tip produces a full swing in plate current.

The circuit is independent of wide variations in line voltage, temperature and leakage resistance, and is not affected by the aging of tubes. The zero-adjustment, once made, requires no additional change unless the *6AG5* is replaced. The electronic unit is enclosed within the instrument base and may be removed without disturbing the measuring system. The column and upper head can also be separated from the base for mounting on special stands; in this instance, the chassis may be relocated remotely.

For more information about this device, turn to Reader's Service Card and circle 33.



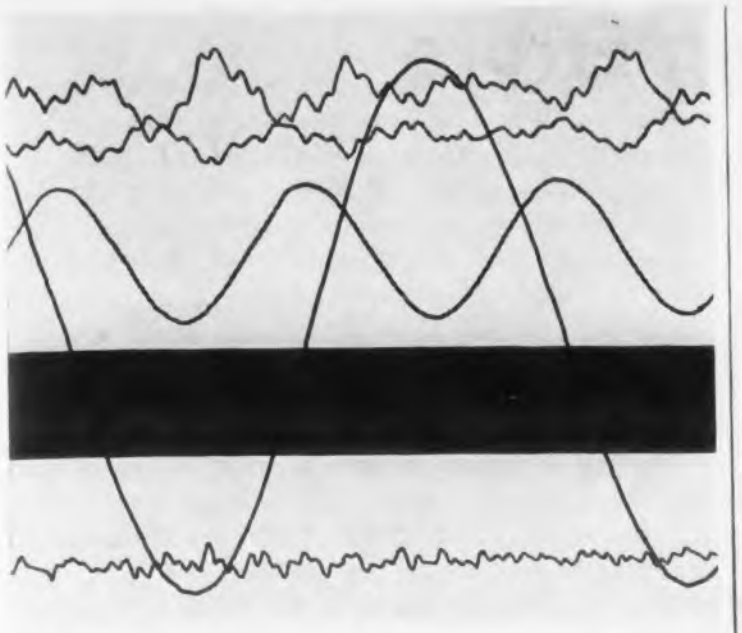
Artist's representation of typical waveforms.

Instant Printing

INSTANT permanent records are produced by a new light-beam oscillograph featuring flat frequency response to 2 kc from dc. The instrument utilizes an ultraviolet light source to operate low inertia mirror galvanometers. The recording principle is unique. No developers, powders, or inks are used. Up to six channels can be recorded on a six-inch chart with full overlapping of channels permissible, at chart speeds of 0.2, 1, 5, and 25 inches per second, minute, or hour. Two additional channels for timing are also available.

The instrument, developed by the Heiland Division of Minneapolis-Honeywell, 2500 E. Evans Ave., Denver, Col., can be loaded in daylight. It holds 100 feet of sensitive paper. The exposed paper is not impervious to sunlight, however short studies can be made of the raw output of the machine. If permanent records are desired, the paper must be fixed with a chemical. Storage time of raw exposed charts before fixing depends upon the amount of ultraviolet radiation present in the viewing area.

An added feature is a monitoring arrangement whereby the galvanometer light spots are viewed directly at the recording point on a calibrated view screen. A paper supply indicator shows the amount of unused paper remaining.



Dark band is h-f signal.

HF Oscillograph

No internal amplifiers, shaping circuits, compensation or peaking circuits are used in the instrument. Signal amplification will not be necessary for many applications. The equipment weighs 45 pounds, measures 10 in. high, 15 in. deep, by 10 in. wide, and operates on 115 v, 60 cycle power.

For further information about this product, fill out the Reader's Service Card and circle 36.

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

Location of Maximum Loading Errors in Potentiometers

D. A. Landauer
Engineer, Spectrol
Electronics Div. of Carrier Corp.

USUALLY the voltage output of a potentiometer varies linearly with shaft rotation. However, when a potentiometer contains a fixed resistance between the slider and either end, a non-linear output results. The maximum non-linearity, or error, occurs at some output value which varies with the magnitude of the ratio of load resistance to potentiometer resistance. This article tells how the point of maximum error can be found, explains why this point is important to know, and offers a graphical solution for a common range of load ratios.

The most familiar configuration for a loaded potentiometer circuit is that shown in Fig. 1. R is the potentiometer resistance, A is the load resistance, E is the total voltage applied across the control, e is the voltage from the slider to ground, and x is the shaft rotation expressed as a decimal part of the total. R and A are constants, $0 \leq e \leq E$, and $0 \leq x \leq 1$.

It can be readily shown that

$$e = \frac{Ex}{1 + \frac{R}{A}\,x\,(1 - x)} \tag{1}$$

This is the equation for the theoretical output voltage versus shaft rotation curve (neglecting any errors such as linearity, concentricity, etc.). See Fig. 2. When a potentiometer has an infinite load resistance, this equation reduces to

$$e = Ex \tag{2}$$

Therefore, the deviation from a theoretically perfect line (the loading error), which will be called e′, is simply the difference between Eq. 1 and 2. Therefore,

$$e' = Ex - \frac{Ex}{1 + \frac{R}{A}\,x\,(1 - x)} = \frac{Ex^2\,(1 - x)}{\frac{A}{R} + x\,(1 - x)} \tag{3}$$

Plotting e' versus x gives a cubic curve of error versus rotation as shown in Fig. 3. It has been shown [1] that this is the general shape of the curve for any loading ratio. In considering any one load ratio (and hence some one particular curve) it is apparent from Fig. 3 that the errors reach a maximum absolute value at one point. From Fig. 10 it can be seen that the maximum error occurs at about 2/3 rotation as the load ratio (A/R) increases. As the load ratio increases beyond 2/3 to infinity, the magnitude of the maximum error reduces, approaching zero. This maximum error point should actually be thought of as the 2/3 output voltage position rather than the 2/3 rotation point. In a sine function, for instance, 2/3 = the sine of 41° or 45% of the quadrant rather than 66%. Only in a linear potentiometer does the 2/3 output position coincide with the 2/3 rotation point.

The significance of this maximum error location is two-fold. First, the value of the maximum error must

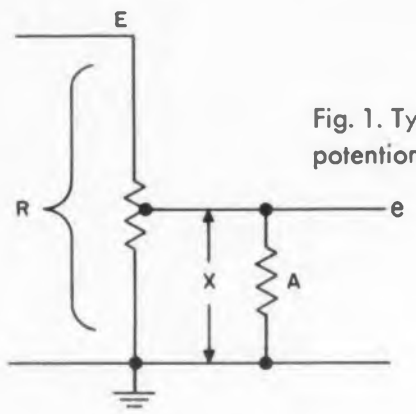


Fig. 1. Typical loaded potentiometer circuit.

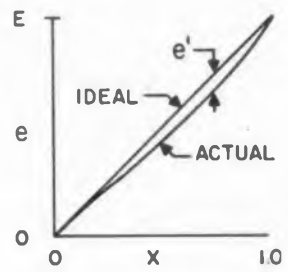


Fig. 2. Output voltage vs Shaft rotation curve for ideal and actual conditions.

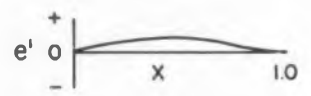


Fig. 3. Plot of loading error. The shape is as shown for any loading ratio.

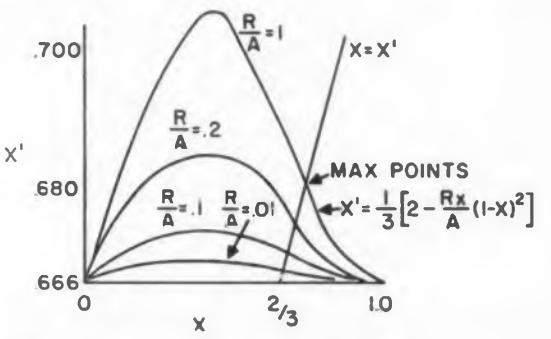


Fig. 5. Plots of Eq. 5 from which maximum error points can be determined as shown.

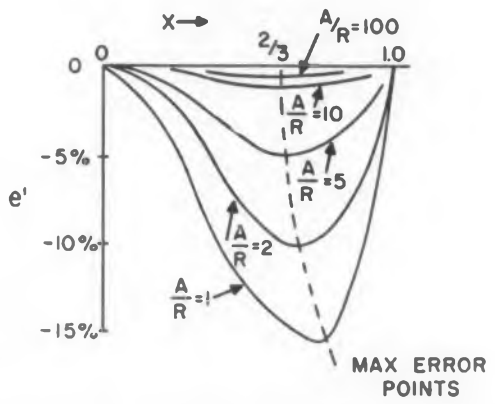


Fig. 4. Family of error vs rotation curves, using Eq. 3, for locating maximum error points.

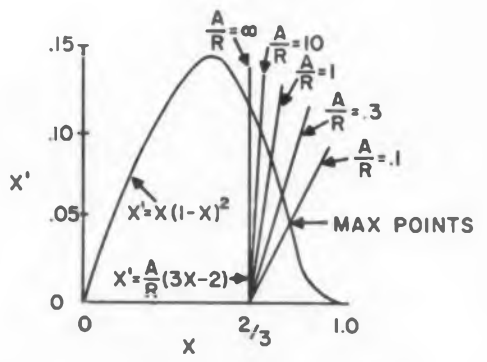


Fig. 6. An alternate to Fig. 5 using Eq. 5. See text.

Rules of Thumb

1. Maximum loading error occurs at approximately 2/3 full voltage output (not necessarily 2/3 shaft rotation).
2. Maximum loading error occurs at exactly the shaft position which satisfies either Eqs. 5 or 9, and approaches 2/3 as A/R approaches infinity.
3. The loading error curves for potentiometers loaded "up" or "down" are anti-symmetrical.
4. Loading error per cent and rotational location are independent of applied voltage.

be known to establish whether or not correction is necessary to maintain the desired conformity. If no correction is needed at the point of maximum error, no correction is necessary anywhere on the potentiometer. Also, if correction is found necessary, then location of the maximum error should be investigated for various characteristics depending on the corrective technique used (e.g. card width, wire size, spacing, tap point, etc.).

To find the maximum error location accurately, refer to Eq. 3. The maximum error occurs where $de'/dx = 0$.

$$\frac{de'}{dx} = E\left[1 - \frac{1}{1 + \frac{R}{A}\,x\,(1-x)}\right] + Ex\left\{\frac{\frac{R}{A}\,(1-2x)}{\left[1 + \frac{R}{A}\,x\,(1-x)\right]^2}\right\} \quad (4)$$

By equating de'/dx to zero, the E drops out (indicating that the maximum loading error location is independent of the applied voltage), and Eq. 4 reduces to

$$Rx\,(1-x)^2 = A\,(3x-2) \quad (5)$$

Finding Maximum Error Point

There are thus several ways of determining and checking the location of the maximum error. All methods to be described are graphic, since no unique answer is available algebraically. The following methods are suggested:

1. Plot a family of error versus rotation curves and mark the locus of maximum points. Use Eq. 3 for this and obtain plots as in Fig. 4.
2. Plot a family of

$$x' = \tfrac{1}{3}\left[2 + \left(\frac{R}{A}\right)x\,(1-x)^2\right]$$

curves and the line $x' = x$. x' is just a tool to separate the formula into two usable parts. The intersections of the line and the curves are the maximum error points. Eq. 5 is used and gives plots as in Fig. 5.

3. Plot an $x' = x\,(1-x)^2$ curve and some

$$x' = \left(\frac{A}{R}\right)(3x-2)$$

lines. Again the intersections are the points desired. This also comes from Eq. 5 but is plotted as in Fig. 6.

The first method is simplest, quickest, and least accurate. Methods 2 and 3 require more mathematical manipulation but offer discrete points.

Another frequently encountered loaded-potentiometer configuration is that shown in Fig 7, where the load is connected from the sliding arm to top of the control. e vs x and e' vs x for this configuration are shown in Figs. 8 and 9, respectively.

The formula for output voltage versus rotation for this "loaded up" circuit is

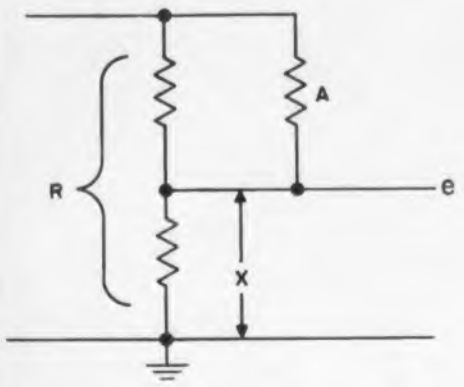


Fig. 7. "Loaded-up" potentiometer circuit, often found in practice.

Fig. 9. Loading error for "loaded-up" potentiometer.

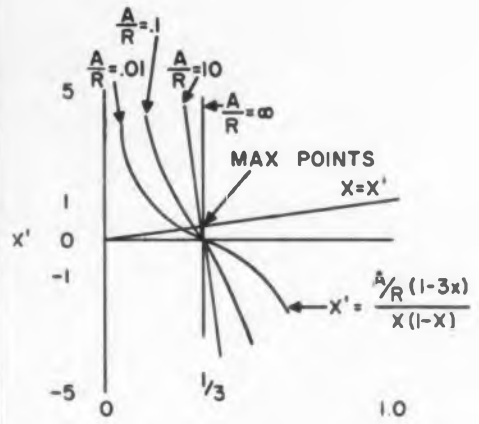


Fig. 11. Method 2. Alternative curves to those of Fig. 10 for finding maximum loading error points.

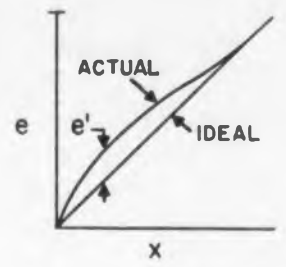


Fig. 8. Curves of e vs x for ideal and actual conditions. (Compare with Fig. 2).

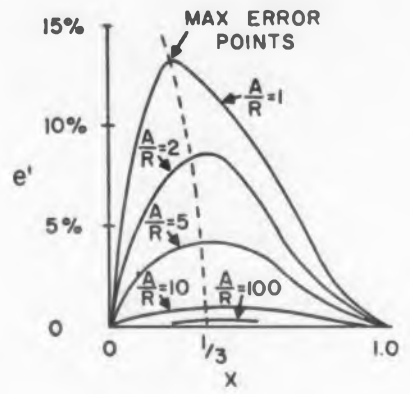


Fig. 10. Method 1. Error vs shaft rotation for various ratios R/A ("loaded-up" potentiometer).

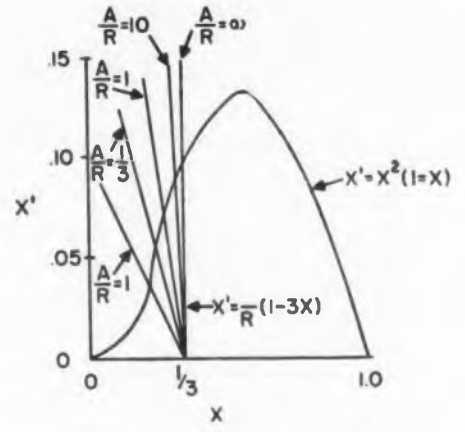


Fig. 12. Method 3. Second alternative method for finding points of maximum loading error (See text).

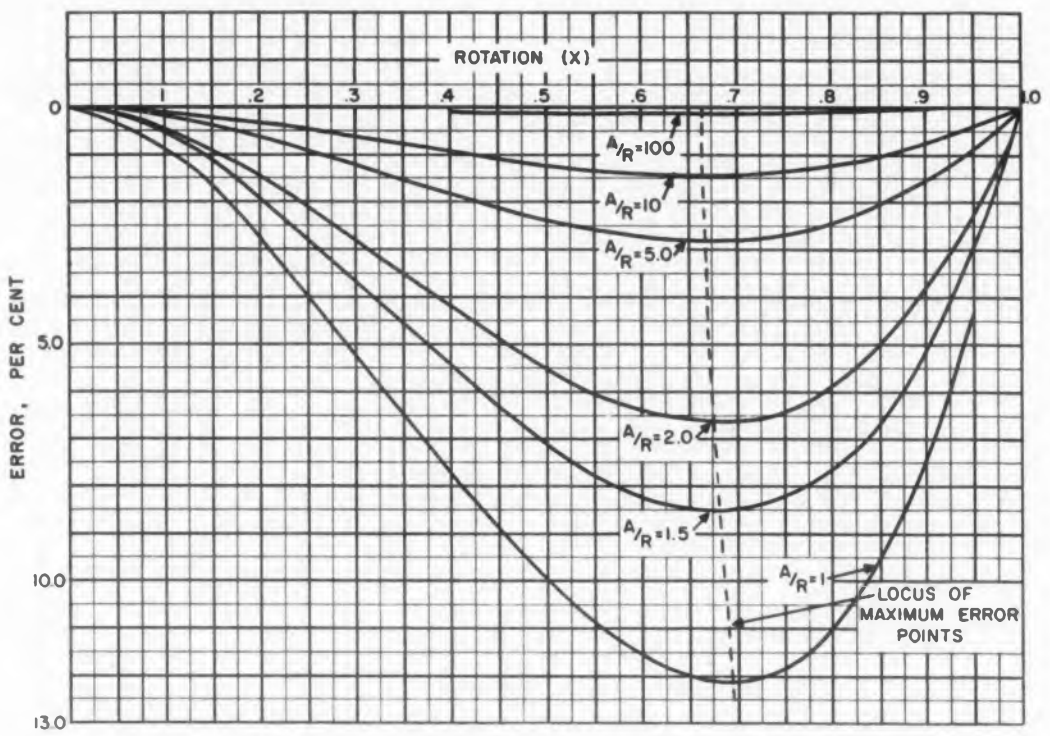


Fig. 13. Design curve for locating exact point of maximum loading error for either "loaded-down" or "loaded-up" condition.

$$e = \frac{Ex\left[1 + \frac{R}{A}(1 - x)\right]}{1 + \frac{R}{A}x(1 - x)} \quad (6)$$

The ideal potentiometer output is still expressed by Eq. 2; so the error versus rotation is Eq. 6 minus Eq. 2 or

$$e' = Ex\left[\frac{1+\frac{R}{A}(1-x)}{1+\frac{R}{A}x(1-x)} - 1\right] = \frac{ERx(1-x)^2}{1-\frac{R}{A}x(1-x)} \quad (7)$$

Again, the maximum error occurs when $de'/dx = 0$.

$$0 = \frac{de'}{dx} = E\left[\frac{1+\frac{R}{A}(1-x)}{1+\frac{R}{A}x(1-x)} - 1\right] + Ex \quad (8)$$

$$\left\{\frac{\left[1+\frac{R}{A}x(1-x)\right]\left[-\frac{R}{A}\right]-\left[1+\frac{R}{A}(1-x)\right]\left[\frac{R}{A}(1-2x)\right]}{\left[1+\frac{R}{A}x(1-x)\right]^2}\right\}$$

This reduces to

$$A(1 - 3x) = Rx^2(1 - x) \quad (9)$$

Again, there are three methods for solution.

1. Plot Eq. (3a) using various values for R/A. See Fig. 7.

2. Plot $x = x'$ and $x' = \dfrac{\frac{A}{R}(1 - 3x)}{x(1 - x)}$. See Fig. 8.

3. Plot $\frac{A}{R}(1 - 3x) = x'$ and $x' = x^2(1 - x)$. See Fig. 9.

In methods 2 and 3, the intersections are the points desired.

It will be observed by comparing Figs. 4 and 10 that the error curves for potentiometers loaded up or down (with any specific A/R value) are anti-symmetrical. Therefore, accurately drawn curves of Eqs. 3 and 7 can be used as a tool for quickly checking magnitude of loading error and maximum error location. Such a curve is drawn in Fig 13, for use in design planning.

Using the Curve

As an example of how Fig. 13 can be used in design, assume $A/R = 1$. From the curve, $e' = 12.2\%$ and $x = 0.69$.

References

1. Reducing Potentiometer Loading Error, L. A. Nettleton and F. E. Dole, *Review of Scientific Instruments*, Oct. 1946.
2. Compensating Pot Loading Errors, J. Gilbert, *Control Engineering*, Feb. 1955.
3. Characteristics of Precision Servo Computer Potentiometers, D. C. Duncan, *AIEE Conf.* Dec. 1951.

High-Frequency PNP Transistor

RADIO-FREQUENCY amplifiers can now be designed around this unusual high-gain, high-frequency pnp junction transistor. Outstanding stability well up into the short-wave bands is made possible by a design which reduces interelectrode capacitances to a very low order. A built-in accelerating field within the germanium element is the feature which permits a collector-transition capacitance of only 1.7 μμf.

These "drift" transistors, developed by Radio Corporation of America, Somerville, N.J., have an accelerating field produced by a carefully controlled distribution of impurities in the base region of the germanium crystal. The field propels the charge carriers from emitter to collector, which permits reduction of base resistance and collector-to-base capacitance. To reduce feedback capacitance even further, a fourth lead is situated between the collector and base leads and internally connected to the metal envelope. Acting as a shield, this extra lead minimizes interlead capacitance and reduces coupling to adjacent circuit components.

These various features enable the transistors to operate at radio frequencies with high input-circuit efficiency. Satisfactory gains in the AM broadcast band can be achieved without the use of a neutralizing network. In typical operation in a unilateralized commom-emitter type of circuit, the transistor can provide a power gain of 45 db at 1.5 mc, and 24 db at 10.7 mc. Operating in this circuit as a Class-A amplifier at 10.7 mc and at an ambient temperature of 25 C, it has a dc collector voltage of —9 v, a collector current of —1 ma and a base-to-emitter voltage of —.2 v, an input resistance of 170 ohms and an output resistance of 4.5 K ohms. The spot noise factor measured in a specific circuit is 8 db. Good signal-to-noise ratio and automatic gain control capabilities are maintained over a wide range of input signal levels.

Maximum ratings are a dc collector to base voltage of −35 v, an emitter-to-base voltage of −1 v, a collector current of −10 ma, and an emitter current of 10 ma. The collector dissipation for an ambient temperature of 70 C is 35 mw maximum, and the storage temperature range is from −55 to +85 C.

The transistors come in two types, the 2N47 and the 2N67, with the latter having a slightly larger feedback capacitance in a common-emitter type of circuit. Both come hermetically sealed in an insulated metal case with flexible leads. The leads may be soldered close to the glass stem if suitable precautions are taken, or they can be dip-soldered for use in printed circuitry.

Although designed specifically for use as radio-frequency amplifiers in commercial and military equipment, these transistors will undoubtedly find wide application as intermediate-frequency amplifiers or as mixer-oscillators in superheterodyne receivers.

For further information about this product fill out the Reader's Service Card and circle No. 42.

New Products

X-Y Recorders

Provide 0.2% Accuracy

Two X-Y recorders and plotters, both 11 x 17 in. flat-bed models, are offered with a full line of accessories. The Model 225 has a built-in electronic reference with 16 ranges from 0.5 mv to 50 v per inch on both axes. The Model 200 has 16 ranges covering 9.1-20 v per inch and is designed for external or internal reference. Maximum input resistance of the Model 225 is 2 megohms, and 1 megohm for the Model 220. Accuracy is 0.2 per cent full scale. Pen speed is 20 ips; carriage speed is 25 ips. Paper size is 11 x 16-1/2 in. graph paper with a 10 x 15 in. ruled area.

Electro Instruments, Inc., Dept. ED, 3794 Rosecrans St., San Diego 10, Calif.

CIRCLE 44 ON READER-SERVICE CARD FOR MORE INFORMATION

Fuse Resistor

Plug-In Unit

The Type FR functions as a resistor under normal conditions and as a fuse under abnormal conditions. Its construction provides the mechanical strength and simplicity of a complete unit.

It is particularly recommended as a surge-limiting resistor in voltage doubler circuits for TV receivers.

International Resistance Co., Dept. ED, 401 N. Broad St., Philadelphia 8, Pa.

CIRCLE 45 ON READER-SERVICE CARD FOR MORE INFORMATION

Tubeless DC Source

.01 Per Cent Regulation

This tubeless dc source provides 6 v dc and 2 v dc output voltages regulated to within ±.01 per cent.

A silicon diode is used as reference element, and a transistor amplifier provides the control current for the magnetic amplifier. The transistor amplifier is temperature-compensated for small ambient room changes.

Input voltage range of the Model MA6501 is 105 to 125 v ac, single phase, 60 cy. There are 3 output voltages; 6 v dc, adjustable internally ±5 per cent, 5 amp load; 6 v dc, 100 ma load; 2 v dc, 40-60 ma. Regulation is ±.01 per cent for line changes within ratings on all supplies. Ripple is 15 mv rms maximum on the 6 volt outputs, 5 mv rms maximum of the 2 volt output. Typical stability after a 30 min warm-up is .01 per cent for an 8 hr period. Weight of the standard unit is 60 lbs.

Sorensen & Co., Dept. ED, Fairfield Ave., Stamford, Conn.

CIRCLE 46 ON READER-SERVICE CARD FOR MORE INFORMATION

Electronic Switch

Wide Frequency Range

The electronic switch model ES-17 provides a wide range of frequency response for superimposing two separate signals on a single beam oscilloscope. Phase and frequency are compensated by 5 step, input attenuators. Input signal amplitudes range from 10 mv rms to 200 v rms.

The frequency response is dc to 4 mc at 6 db and the free running multivibrator is continuously variable from 20 cps.

Vanguard Instruments Corp., Dept. ED, 184 Casper St., Valley Stream, N.Y.

CIRCLE 47 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistor Oscillator

Battery Powered

A self-contained, battery powered unit, The Model J Transistor Oscillator is designed for locating trouble in carrier systems, audio circuits, and audio test equipment.

It provides pure, stable sine wave output voltages of 0, —13, —16 DBM at 1000 cy into 600 ohm line.

The oscillator uses a push-pull transistor and LC circuit inductively coupled to the output terminals by a separate transformer winding.

Distortion is less than 3 per cent, and frequency variation is less than 3 per cent at normal ambients under 125 F. Voltage output variation less than 4 per cent.

The 2-cell mercury battery, self-contained in the unit, has a life of 700 hrs with continuous use.

Stewart Bros., Dept. ED, 315 W. Walton Pl., Chicago 10, Ill.

CIRCLE 48 ON READER-SERVICE CARD FOR MORE INFORMATION

Teflon Products

Pipe, Tubing, Special Parts

Teflon pipe and tubing up to 4 in. diam and Teflon lined steel pipe in 2 in. sizes are now available from this firm. Rods and special machine parts of Teflon are also offered. These products can all be cut to desired lengths in the field and readily flanged.

Haveg Industries, Inc., Dept. ED, 900 Greenbank Rd., Wilmington 8, Del.

CIRCLE 49 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistor Reader

Portable Battery Operated

This instrument tests both pnp and npn low power junction transistors, permitting small signal Beta measurements to 250 using 2 scales, 0-50 and 0-250. The direct comparison method is used, against a known attenuation factor using a self-contained oscillator and linear amplifier with 5 per cent accuracy. Calibration requires no standard transistor.

The Model 101 measures collector cut-off current, I_{co}, in microamperes (rather than collector current), as leakage I_{co} measurements afford direct correlation with noise factor and are valid in determining damage or defective transistors. Both I_{co} and Beta measurements are directly comparable with transistor manufacturer's specifications. Internal transistors interchangeable with similar types without circuit alterations or factory calibration.

Durson Co., Dept. ED, 10416 National Blvd., Los Angeles 34, Calif.

CIRCLE 50 ON READER-SERVICE CARD FOR MORE INFORMATION

Sensitive Relay

Sealed Miniature

This relay is applicable where compactness, light weight are essential, or where external electromagnetic effects must be minimized. The Model 1081 is housed in a brass tinned finished case and is supplied for miniature 7 pin socket operation or with curved terminals for solder connection. For maximum shielding Mumetal cases can be furnished. Sensitivities as high as 50-0-50 μamp at a coil resistance of 2300 ohms are available. Non-magnetic contacts carry 35 ma at 6 v dc non-inductive at high-sensitivity. Loads up to 0.5 amp at 28 v dc non-inductive can be handled depending upon the moving coil sensitivity and number of operations. High and low contacts can be arranged for zero center, single pole, double throw operation or suppressed zero with one contact normally closed.

Weston Electrical Instrument Corp., Dept. ED, 614 Frelinghuysen Ave., Newark 5, N. J.

CIRCLE 51 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistor Transformers

Miniature Lightweights

Thirty-three new transformer types are now available from a complete line of transistor transformers. All are wound on nylon bobbins, with a Mylar outer wrap. Laminations are of nickel steel or silicon steel. Average weight is 1-1/4 oz with 2 sizes available, 3/4 x 5/8 x 5/8 in. and 1 x 3/4 x 3/4 in. They combine the needs of miniaturization, power handling capacity and improved frequency response.

Argonne Electronics Mfg. Corp., Dept. ED, 27 Thompson St., New York 13, N. Y.

CIRCLE 53 ON READER-SERVICE CARD

Cooling Electronic Tubes

Applications Up To 100 KW

Radio, radar and TV Klystron vacuum tube cooling is available for applications requiring the dissipation from 1 to 100 kw of heat.

The Fluid Cooler equipment complies with commercial and military requirements, and is designed for operation anywhere in the world.

Major components of this electronic tube cooling equipment, which use ambient air as a cooling medium, are: an extended surface cooling coil, a centrifugal or propeller fan, a high pressure circulating pump, and automatic safety controls to safeguard the tube.

The Trane Company, Dept. ED, La Crosse, Wisc.

CIRCLE 54 ON READER-SERVICE CARD

Dioxane Reagent

High-Purity Solvent

A new certified-reagent Grade Dioxane No. D-111 extends this reagent's usefulness to applications where a low iron, low peroxide, high purity solvent is a must. Typical Analysis of the new dioxane: water, 0.025 per cent; peroxides, 0.003 per cent; carbonyls, 0.004 per cent; iron and heavy metals, 0.0001 per cent.

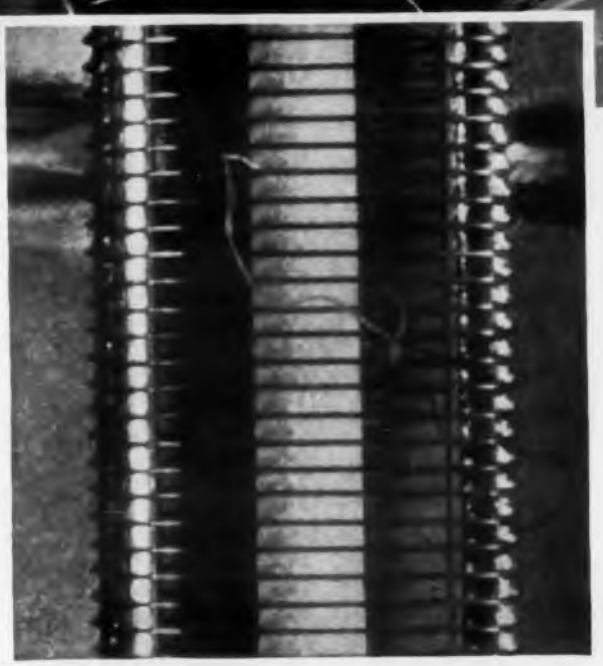
It will be available in quarts and gallons.

Fisher Scientific, 717 Forbes St., Pittsburgh 19, Pa.

CIRCLE 55 ON READER-SERVICE CARD

CIRCLE 56 ON READER-SERVICE CARD ➤

▲ **MANUFACTURED "UNDER GLASS"!** For optimum cleanliness, 6829's are assembled under glass-paneled protective hoods. All G-E employees who build 5-Star Tubes wear rubber finger cots, and their uniforms are lint-free Nylon and Dacron. These precautions are taken to ward off lint and dust, most frequent causes of intermittent tube "shorts".



▲ **LINT IS A TROUBLE-MAKER!** The unretouched microphoto above shows a strand of lint which easily can cause an inter-electrode short-circuit. Dust particles within a tube have the same harmful effect.

FIRST GENERAL ELECTRIC HAS LINT-FREE

▼ **1200 WORKERS ASSEMBLE 6829's AND OTHER HIGH-RELIABILITY TUBES** in this 5-Star building, located apart from the rest of G.E.'s Owensboro, Ky., tube factory. Because of the special white lintless uniforms, plus immaculately clean working conditions, "Operation Snow White" is aptly used to describe G-E 5-Star Tube manufacture. The entire assembly and inspection area is pressurized, with air that has been filtered, dehumidified and cooled.

▲ **SPECIALLY TESTED . . . BIASED TO CUT-OFF FOR LONG INTERVALS!** Life tests of G-E computer tubes under cut-off conditions, are made in order to be sure no "sleeping sickness", or failure to respond to grid input pulses, develops during inactivity. This is determined by means of periodic interface checks.

▲ **CHECKED FOR COMPUTER-SERVICE CHARACTERISTICS!** G-E computer tubes are specifically tested for those electrical qualities that closely affect tube operation in computer circuits. Among the characteristics checked are zero-bias plate current . . . cut-off performance . . . difference in cut-off between both triode sections.

5-STAR COMPUTER TUBE MANUFACTURE FOR ADDED RELIABILITY

Shock-resistant design—comprehensive cut-off tests—further establish Type 6829 as the most trustworthy tube you can apply in military computers!

General Electric, first to design and build a new line of tubes for computers, now pioneers the first 5-Star high-reliability tube for computer circuits —analog and binary—where airborne, gunnery, or field-transport conditions call for resistance to mechanical shock and vibration.

Type 6829 has the many 5-Star design features that give added strength, such as a compact, sturdy tube cage . . . double mica spacers . . . a double-staked getter. In addition, tube assembly is carried on in immaculate surroundings free from lint and dust, while special tests assure those electrical qualities that are essential in achieving computer dependability.

A 9-pin miniature, the 5-Star 6829 has similar characteristics to standard computer Type 5965. The new tube is designed for high-speed circuits—has high perveance, balanced, sharp cut-off qualities, and low heater power requirement (.45 amp).

Get the complete performance story! Write to *General Electric Company, Electronic Components Division, Schenectady 5, New York.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

162-1C1

Teflon-Base Coating

Is Anti-Static

The formula for "Gencote 108" utilizes Teflon as the base material, retaining all its characteristics, but reverses the electrical insulation feature to create electrical conduction. Thus, it is now possible to achieve an anti-stick, dry-lubricated, chemically inert surface that is anti-static as well.

The electrical resistance across this new coating, when applied in a 4 mil film, is approximately 1 ohm. Surfaces can be coated in multiples of 1/2 mil up to 10 mils, on any type metal or other materials which can withstand a temperature of 700 F, required for the baking process. As a result, electrically conductive surfaces can also be applied over an insulating base, such as glass, ceramics, and porcelain.

The anti-static feature: permits powders to flow freely; reduces friction between platens and film in cameras, eliminating static sparking; eliminates accidental detonation of explosives by static discharge in mechanical handling; has an unlimited range of other applications.

General Plastics Corp., Dept. ED, Paterson, N.J.

CIRCLE 57 ON READER-SERVICE CARD

Hydrogen Thyratron

For Mobile and Airborne Use

The BL-257 is a hydrogen thyratron that is electrically similar to an E37A but ruggedized for vibration and high impact service, especially in mobile and aircraft applications requiring moderately high power. The tube is conservatively rated for 5 g vibration from 60 to 500 cps, and 3 g from 500 to 1200 cps, and also for 60 g high impact shock in any direction.

Electrical ratings are 8.0 kv peak anode voltage, 90 amp peak current, and 100 ma maximum anode current. It is rated for an ambient temperature range of −50 to +90 C and for an altitude of 10,000 ft in air. The tube may be immersed in oil for high altitude application.

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

CIRCLE 58 ON READER-SERVICE CARD

◀ CIRCLE 56 ON READER-SERVICE CARD

Flyback Checker
Also Tests Condensers

The Model 124 "Flybacker Plus" is an accurate condenser checker in addition to being a highly sensitive flyback transformer and yoke tester. It accurately shows up leakage in mica capacitors.

Five easy reading scales include a separate scale for yokes and one for capacitors. The unit tests all flybacks, yokes, and condensers without disconnecting them from the circuit, or tests them individually (not connected to anything). Tests are made at operating conditions of above 200 v of pulsed power. The unit weighs 8 lb and has a size of 10 x 6 x 5 in.

Radio City Products Co., Inc., Dept. ED, Centre & Glendale Sts., Easton, Pa.

CIRCLE 62 ON READER-SERVICE CARD FOR MORE INFORMATION

Ceramic Capacitor
Sub-Miniature

This series of sub-miniature extended temperature range ceramic capacitors maintain over 90 per cent of capacitance through temperatures ranging from 55 to ±125 C. The capacitor is rated at 200 working volts dc. It employs a high density ceramic material which provides a very high dielectric constant per unit area.

The Val-Cap 2000K series capacitor is initially offered in 5 sizes ranging from 1/4 in x 1/4 in. x 0.050 thick with capacitance of 0.0033 μf, to 1/2 in x 3/4 in. x .080 thick with capacitance of 0.05 μf.

Valco Engineering Sales Co., Dept. ED, 2538 S. Highland Ave., Los Angeles 16, Calif.

CIRCLE 63 ON READER-SERVICE CARD FOR MORE INFORMATION

Polyurethane Plastic Material
Insulating Foam

"Gemfoam," a complete line of polyurethane plastic material for cushioning, padding and insulation, is now available in rolls, sheets or slabs in thicknesses from 1/8 in. to 12 in., and widths up to 48 in. The line includes 10 resiliencies, from very soft to very firm in any shade of the 7 basic colors.

Polyurethane foam products are light in weight, durable, odorless and resistant to corrosion and oxidation. They also have excellent acoustical and thermal insulating qualities.

Texas Foamed Plastics Corp., Dept. ED, Gonzales, Texas.

CIRCLE 64 ON READER-SERVICE CARD FOR MORE INFORMATION

Silicone Foam Rubber

Highly Resilient

A new material, silicone foam rubber, is light in weight and remains soft and resilient over a temperature range of 100 F to 480 F. Because of its interconnecting cell structure, the foam recovers shape instantly after being compressed for long periods at elevated temperatures, and can be readily molded into complex shapes.

Branded COHRfoam, the silicone rubber is inert to ozone and weathering, is non-sticking, non-corrosive, odorless and has good electrical properties. It will be offered in sheet form and custom moldings up to 8 in. thick.

Physical data on the foam include a specific gravity of 0.20 to 0.35, a compression deflection of 0.75 to 1.25 psi, a compression set of 14 per cent, and a flexibility from 100 F to 480 F.

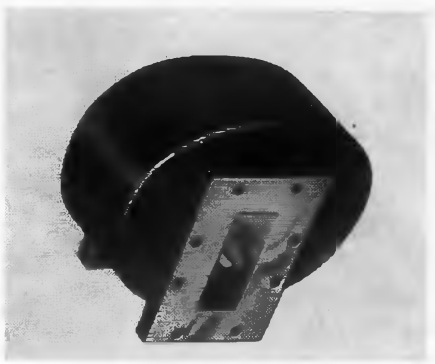
Anticipated uses for the foam include sound and vibration packing, and electrical and thermal insulation.

Connecticut Hard Rubber Co., Dept. ED, 407 East St., New Haven 9, Conn.

CIRCLE 66 ON READER-SERVICE CARD FOR MORE INFORMATION

X-Band Ferrite Isolator

Medium Power Miniature



Shown here is a 100 kw resonant absorption miniature X-band ferrite isolator. It insures high magnetron spectrum and power output by furnishing isolation between magnetron and RF energy reflected from line mismatches.

The uni-directional isolator has the ferrite material mounted directly on the waveguide wall. This, in conjunction with the full waveguide opening, permits the rapid conduction of heat away from the waveguide thus allowing operation at medium power levels without forced air cooling.

To cover the frequency range from 8500 to 9600 mcs, 4 units may be required with an isolation of 10 db min, insertion loss of 0.5 db max and input VSWR of less than 1.10.

Airtron Inc., Dept. ED, 1103 W. Elizabeth Ave., Linden, N. J.

CIRCLE 67 ON READER-SERVICE CARD FOR MORE INFORMATION

NEWEST PRINCIPLE

No wonder the new Silic-O-Netic Time Delay Relay has aroused such interest. It offers basic advantages as a delay device unequalled in its low price range.

The Silic-O-Netic Relay provides delay with no mechanical linkages . . . no mechanism to speak of. . . only one moving part, and that part is hermetically sealed, forever free of dirt and dust. It operates on a positive change in magnetic flux which is sharply defined as the movable core touches the pole piece. Moreover, the new Type A model has high speed contacts, affords good contact pressure.

in TIME DELAY RELAYS

Heinemann Silic-O-Netic Relays are already being used in dozens of volume applications where absolute dependability is essential. They are well worth your investigation.

Write for Bulletin T-5002

IT'S DIFFERENT...

No thermal elements . . . no aging, no fatigue . . . long-life stability.

Small size . . . Overall dimensions: $2\frac{1}{16}''$ x $1\frac{9}{16}''$ x $2''$.

Delay periods . . . $\frac{1}{4}$ to 120 seconds.

Low cost . . . achieved in 20 years of solenoid manufacturing experience.

HEINEMANN

ELECTRIC COMPANY

156 Plum St., Trenton 2, N. J.

CIRCLE 70 ON READER-SERVICE CARD FOR MORE INFORMATION

Frequency Calibrator

Precision Unit

The Type 1213-C Calibrator comprises, with power supply headphones, all the circuits necessary for the calibration of oscillators, receivers, and other wide-range devices up to frequencies above 1000 mc. It also provides square-wave markers for oscilloscope sweep-time calibration at intervals from 0.1 μsec to 100 μsec.

Features incorporated into this instrument include harmonic series with fundamentals of 10, 1, 0.1, and 0.01 mc, a crystal mixer good from low frequencies to frequencies above 1000 mc, an amplifier for audible beats, and a video-frequency amplifier output for sweep-time calibrations. The output can trigger pulse generators and oscilloscope sweeps, thus providing a stable driving source for timing pulse systems for various applications.

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

CIRCLE 71 ON READER-SERVICE CARD FOR MORE INFORMATION

Portable Pyrometer

Checks Many Instruments

A portable potentiometer pyrometer for checking and calibrating all types of industrial and laboratory temperature instruments, the "Pyrotest" 9B has interchangeable direct-reading scales. It can be used with as many as six types of thermocouples.

Equipped with a set of nine scales (six for temperature, and three for millivolts) the unit is essentially nine instruments in one. It may be used to check and calibrate any temperature recorder, indicator, or controller operating within 32-3215 F and employing any type of thermocouple. In addition, the unit measures the dc potentials of electrical equipment within a range of 0-155 mv.

Accuracy is 1/6 of 1 per cent of scale spans. Slide-wire resolution exceeds 4000 increments, and effective open scale length is 50-1/2 in., permitting the measurement of the slightest temperature or millivolt differences. The "Pyrotest" is completely self-contained with a built-in power supply. Weight is only 14 lb.

Technique Associates, Inc., Dept. ED, 211 E. South St., Indianapolis 25, Ind.

CIRCLE 72 ON READER-SERVICE CARD FOR MORE INFORMATION

Miniature DC Supplies

Operate from 115 V 400 CPS

Designed to supply regulated dc voltage for powering airborne electronic equipment from 115 v 400 cps single phase source, this new line of packaged power supplies operates reliably under aircraft and missile environments. Standard sizes are 100-600 v dc, up to 1000 ma.

Regulation, provided entirely through magnetic amplifiers, is 0.10 per cent, and ripple is 0.05 per cent. Units meet MIL-E-5272A and 1-6181B specs, and they are potted in hermetically sealed drawn steel cans. AN connectors or solder headers are available. Mounting is through studs projecting from the base.

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

CIRCLE 76 ON READER-SERVICE CARD FOR MORE INFORMATION

DC Hypot

With Range to 5000v

The Model 424 DC Hypot has been redesigned for increased efficiency and range of application. Continuously variable output voltage from 0-5000 v dc is provided and read on a 4-1/2 in. voltmeter connected directly across the high voltage output, accurate to 3 percent. For measuring leakage current, ranges of 0-5/10/50/100 μamp are provided on a 4-1/2 in. microammeter automatically protected against overload, and accurate to 3 percent.

Ripple of the unit is less than 1 per cent at rated voltage and current. Output terminates in two 5 ft. high voltage leads, with the "hot" lead equipped with a retractable tip rod. Controls include a continuously variable auto-transformer to vary output voltage, a "high voltage on" switch with pilot light, and a "filament on" switch with pilot light.

The case is a rack and panel type, 22 x 14-3/4 x 12-5/16 in. high, equipped with carrying handles and lid interlock. The unit can also be supplied with chassis only for panel mounting. Net weight is 25 lb. It is recommended for testing ignition harnesses, electronic components, and electrical machinery.

Associated Research, Inc., Dept. ED, 3758 W. Belmont Ave., Chicago 18, Ill.

CIRCLE 77 ON READER-SERVICE CARD FOR MORE INFORMATION

Servo Actuator
400 Cps Rotary Unit

The Servo Controlled Flat Package Actuator is designed for 400 cps airborne applications. It can be operated from magnetic, transistor, or vacuum tube amplifiers, and can be supplied in two output torque ratings: 100 in.-lb at stall and 50 in.-lb at 1.8 rmp; or 50 in.-lb stall and 25 in.-lb at 3.6 rpm.

This rotary actuator is available with or without ac tachometer feedback for stabilization purposes. Position feedback may be provided by either an internal potentiometer or synchro signals. Internal fixed stops and limit switches can be incorporated, if required.

Maximum overall dimensions excluding shaft extension are 6 x 3-9/16 x 1-3/4 in. deep. External electrical connections are made by means of an AN type connector mounted either on the side or recessed in the back of the actuator.

White-Rodgers Co., Dept. ED, 4407 Cook St., St. Louis 13, Mo.

CIRCLE 80 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetic Core Driver
Pulses TV Synchronizers

Using the binary storage principle of magnetic cores, the Model 1801 Sync-Pulser is a binary divider circuit which has been designed primarily as a subassembly for use in synchronizers of TV broadcast equipment. In this application it gives a 525 count synced to 60 cps, but units can be constructed for applications requiring other counts.

The magnetic divider consists of 10 identical binary stages whose inherent count of 2^{10}, or 1024 is modified by feedback to give a count of 525. The divider action is made possible by the square loop hysteresis characteristic of the magnetic cores used.

The 32-5 kc output is 22 v into 1000 ohms, the pulses 2 μsec wide at the base. The 60 cps output is a 7 v pulse into a high impedance load. The construction is that of a 7-tube subassembly 7-3/4 in. x 3-1/4 in. x 3 in. using printed wiring techniques.

Laboratory for Electronics Inc., Dept. ED, 75 Pitts St., Boston 14, Mass.

CIRCLE 81 ON READER-SERVICE CARD FOR MORE INFORMATION

Tantalum Capacitor
Transistor Adjunct

This ultrasmall capacitor is .095 in. in diam by 11/64 in. long, and has a capacitance range of .02 to 4 μf.

The size N capacitors are applicable for coupling, filter, and by-pass requirements at low voltage dc in transistorized equipment. They have a usable temperature range from —55 C to +85 C.

Capacitor construction consists of a tantalum wire anode, having a specially processed oxide film, contained in cylindrical silver case, which is the cathode (negative). The case is electrically live and has the negative wire lead fastened to the end. The case is filled with an electrolyte and sealed by a Teflon bushing.

The capacitors are aged and tested for capacitance, power factor, and dc leakage current.

Ohmite Mfg. Co., Dept. ED, 3639 Howard St., Skokie, Ill.

CIRCLE 84 ON READER-SERVICE CARD FOR MORE INFORMATION

Cable Breakout
For Military and Commercial Use

In this breakout there are 141 conductors, laid by a specially constructed planetary strander. Although terminating in a three-branch breakout, the cable permits continuous circuitry, as there is no junction in the breakout. Furthermore, circuits can be completed between any two or all three branches of the breakout without originating in the prime cable. Developed especially for missile wiring, it is also adaptable to commercial applications.

Sheathed in neoprene and watertight, the cable is fungus-proof, rodent-proof, and is not adversely effected by short term exposure to oils, acids, alcohol, ozone, and water, and long term exposure to sunlight. The cable has flexibility from —65 to 175 F. Connectors are sealed against moisture and dirt.

Pacific Automation Products, Inc., Dept. ED, 1000 Air Way, Glendale 1, Calif.

CIRCLE 85 ON READER-SERVICE CARD FOR MORE INFORMATION

Torque as low as 0.003 ounce inches achieved by Giannini in MICROTORQUE® and MINITORQUE® Precision Potentiometers

For extremely sensitive instrument applications where minimum torque is essential, specify Giannini Microtorque and Minitorque precision potentiometers. Highly reliable performance under the most rugged operating conditions is assured by Giannini's care for detail and production crafting.

By using sapphire jewel bearings . . . and precision ball bearings in certain Minitorque models, these 1 inch diameter instruments effect an unusually low coefficient of friction.

Available in 12 standard linear wiring types, the potentiometer output can, on special order, be designed to perform to a wide range of natural or empirical functions. All models employ non-corrosive precious metal windings and contacts . . . thereby permitting light brush pressures and ensuring long noise-free life.

Dependability, reliability, and ten years proven application success are your benefits, when you use Giannini Microtorque and Minitorque potentiometers—precision instruments "crafted with care."

For additional information, please write for Bulletins 85111 and 85151.

SPECIFICATIONS:

Torque	0.003 to 0.008 oz. in. depending on resistance and wiring type. (Sleeve bushing Minitorque 0.025 oz. in.)
Resistance Range	100 to 100,000 ohms.
Linearity	±0.5% (±0.25% on special order)
Power Rating	1.63 watts @ 25°C.
Shaft Diameter	Microtorque, 0.031 in., Minitorque, 0.125 in.

Giannini

G. M. GIANNINI & CO., INC., 918 EAST GREEN STREET, PASADENA, CALIFORNIA

CIRCLE 87 ON READER-SERVICE CARD FOR MORE INFORMATION

Probes

Extend VTVM Ranges

Two new probes for high voltage and rf are available for this firm's Model 777 Vacuum Tube Voltmeter. The high-voltage probe extends the dc voltage range to permit measurements to 50,000 v. The rf probe (illustrated) makes possible measurements up to 400 mc.

Phaostron Instrument and Electronic Co., Dept. ED, 151 Pasadena Ave., South Pasadena, Calif.

CIRCLE 88 ON READER-SERVICE CARD FOR MORE INFORMATION

Miniature Motor

Is Governor Controlled

Featuring a governor controlled planetary gear train with integral filter, this miniature motor, the 1700-9-1, has a length of only 2.912 in. from the mounting flange. Applications include use in timing units for telemetering, commutator switching, and kindred functions. The motor meets Noise Spec MIL-I-6181B. Load is 3 in.-oz; weight is 5-1/2 oz.; and output speed may be specified for 15, 20, 150, 300, 600, or 1800 rpm.

El Ray Motor Co., Inc., Dept. ED, 11747 Vose St., North Hollywood, Calif.

CIRCLE 89 ON READER-SERVICE CARD FOR MORE INFORMATION

Midget Infrared Oven

For Lab Use

Oven temperatures of 1000 F are possible in this compact radiant oven which employs thermal shock and impact resisting, pencil-thin quartz lamps. The unit shown is 16 in. deep with a 13-1/2 in. opening. It holds eight 1600 w quartz lamps. Each lamp is capable of providing an intensity of 100 w/in. of lamp length.

Fostoria Pressed Steel Corp., Dept. ED, Fostoria, Ohio.

CIRCLE 90 ON READER-SERVICE CARD FOR MORE INFORMATION

Printed Circuits

To Customer Specs

Printed circuit work of the type shown is available from this firm to customer specifications, particularly the kind which includes the complete assembly of the circuit.

The circuit illustrated is designed for computer applications. Featuring a handle which enables the entire circuit to be withdrawn and replaced as a plug-in assembly, this board illustrates the ease with which circuit functions may be unitized and made replaceable.

Laboratory for Electronics, Inc., Dept. ED, 75 Pitts St., Boston 14, Mass.

CIRCLE 93 ON READER-SERVICE CARD FOR MORE INFORMATION

300 W Tetrode

Withstands Rough Environments

The 4CX300A is a 300 w anode dissipation ceramic power transmitting tetrode 2-1/2 in. long x 1-1/2 in. diam. Developed specifically for severe environments, it is made entirely of ceramic and metal, incorporating ceramic support of internal electrodes.

This tube produces low noise output despite heavy accelerative forces from shock and vibration. Supported solely at its base by a standard Eimac air system socket, it will withstand repeated 11 millisec 50 G shocks in any plane, without internal shorts or mechanical damage. There are no major electrode resonances when the tube is vibrated from 30 cps to 2000 cps. The metal-ceramic inhibits deterioration of electrical characteristics while operating continuously at envelope temperatures of 250 C.

The tube operates at full ratings through 500 mc: 500 w output as a radio-frequency amplifier or oscillator, and 300 w output as a plate-modulated radio-frequency amplifier.

Eitel-McCullough, Inc., Dept. ED, San Bruno, Calif.

CIRCLE 94 ON READER-SERVICE CARD FOR MORE INFORMATION

CIRCLE 95 ON READER-SERVICE CARD

new members of the

PHILLIPS *family—a*

complete line of HERMETIC SEALS

backed by the engineering, the rigid quality control, the plant capacity needed for prompt delivery and unvarying quality

Single and Multi Terminal: Kovar and Compression Types

Crystal Bases

Condenser End Seals

Transistor Mounts

Customized Seals To Order

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INSULATED HIGH TEMPERATURE HOOK UP and LEAD WIRE

For MILITARY and COMMERCIAL END USE EQUIPMENT and ELECTRONIC COMPONENTS

Conforming to MIL-W-16878B

Lenz High Temperature Hook-Up and Lead Wires contain thermo-plastic insulation that will retain its high dielectric characteristics over a temperature range from —55° C to +105° C.

Type B ..... 600 Volts r.m.s.
Type C .....1000 Volts r.m.s.
Type D .....3000 Volts r.m.s.

This wire can be furnished in various jackets or shielding, and can be incorporated in multiple conductor cables. Available in solid colors or striping and built to Lenz unsurpassed standards.

Conforming to MIL-W-76A

General purpose Hook-Up and Lead Wires for internal wiring of electric and electronic equipment, with thermo-plastic insulation for use at temperatures to 80° C.

Type LW ..... 300 Volts r.m.s.
Type MW .....1000 Volts r.m.s.
Type HW .....3000 Volts r.m.s.

Can be furnished with nylon jackets, glass braid, lacquered, and shielding. Can be incorporated into multiple jacketed cables to suit your specifications. Available in solid colors or striping to meet your code requirements.

CONSULT LENZ FOR ALL YOUR ELECTRONIC WIRE AND CABLE NEEDS

In Lenz, you will find a dependable, experienced organization that will cooperate with you in the production of wires and cables to your requirements. Its high quality standards, intimate knowledge of the industry's needs and extensive facilities for wire insulating and cabling make Lenz an ideal source for all your wires and cables.

CABLES and WIRES

LENZ ELECTRIC MANUFACTURING CO.

1753 North Western Avenue Chicago 47, Illinois

CIRCLE 97 ON READER-SERVICE CARD FOR MORE INFORMATION

Vibrometer

Measures up to 20,000 Cps

The Model 12A Vibrometer conveniently and accurately measures acceleration, velocity, and displacement of mechanical vibrations from 3 cps to 20,000 cps. It measures displacement as small as 0.0001 in. and as great as 3.0 in., velocities from 0.03 ips to 1000 ips; and accelerations from 0.03 G to 780 G. When used with an oscilloscope, it permits quantitative analysis of impact shock and impulsive motions.

A polarity switch is provided for determining positive and negative peaks of vibration. A miniaturized, lightweight probe makes possible accurate measurements on small, low energy vibrating systems. Power required is 115 v, 50/60 cps, 60 w. Size of the unit is only 14 x 8 x 16 in., and weight is 22 lb.

Televiso Corp., Dept. ED, 1415 Golf Rd., Des Plaines, Ill.

CIRCLE 98 ON READER-SERVICE CARD FOR MORE INFORMATION

Test Equipment Calibrator

Has 1% Accuracy

A low-cost, laboratory-type test equipment calibrator with an accuracy of 1% or better in all of its voltage sections, the Model 750 Calibrator quickly checks test equipment accuracy, reveals how far any instrument may be off, and easily helps make necessary adjustments. It calibrates VOM, VTVM, and other meters, signal generators, sweep and marker generators, and oscilloscopes.

It supplies 2, 5, 25, 100, and 300 v dc, and 5, 25, 100 and 300 v ac to check voltage ranges; provides 10, 100, 1000, 10,000, and 100,000 ohms and 10 megohms to check resistance ranges; and supplies a crystal oscillator capable of generating harmonic frequencies well over 300 mc, with accuracy of 0.1%. Plugging in the proper crystal facilitates use as a marker generator in radio and TV receivers, helps to check the calibration on AM signal generators, or check and align the audio if system of receivers.

The calibrator operates on 110-120 v 60 cps and measures only 8-3/4 x 8 x 5-1/2 in. Weight is 6-3/4 lb.

B & K Manufacturing Co., Dept. ED, 3731 N. Southport Ave., Chicago 13, Ill.

CIRCLE 99 ON READER-SERVICE CARD FOR MORE INFORMATION

Thyratron Grid Pulser

Generates Spikes to 150 V

This universal grid pulser generates voltage spikes as high as 150 v to fire thyratron tubes at accurate phase points in response to low level input signals. The unit has two floating inputs to provide freedom in circuit design. Although it provides very fast half cycle response, it also minimizes thyratron misfiring due to pickup from relays or other random noise. It can be controlled by either ac or dc input signals, or by a variable resistor.

The grid pulser controls any size thyratron without additional bias supply. It provides extremely long life and trouble-free operation for industrial applications. It is rated 2.5 v 60 cps.

Hanson-Gorrill-Brian, Inc., Dept. ED, 85 Hazel St., Glen Cove, N.Y.

CIRCLE 103 ON READER-SERVICE CARD FOR MORE INFORMATION

Trimming Potentiometer

Rugged Miniature

This miniature trimming potentiometer features ruggedness, stability and long life. For maximum rigidity, body and cover are made of aluminum, the cover being precision fitted to the body.

Trade name Aero-Pots, the units are adjustable through 32 turns by a screw driver in a slotted shaft. The shaft is precision threaded, and operated under controlled torque derived from inherent frictional properties of special plastics. With the wiper supported on two sides, settings are stable under extreme vibration, acceleration and shock. Temperature characteristics are stabilized by the use of resistance wire having a low temperature coefficient.

Case dimensions are 1-1/4 in. long, 1/2 in. high, 3/8 in. wide, weight: 1/4 oz. Resistances range from 100 ohms to 50,000 ohms in one case size. Resolution, depending on resistance is 0.2 to 2 per cent. Linearity is 1 per cent, temperature range is 55 C to +125 C. Units are available with Teflon insulated wire leads, plug-in terminals, or solder terminals.

Aero Electronics Corp., Dept. ED, 2311 W. Burbank Blvd., Burbank, Calif.

CIRCLE 104 ON READER-SERVICE CARD FOR MORE INFORMATION

Foolproof! Shockproof!

"FLOATING BODY ISOLATION"

for double-lead screw locking

CONNECTORS

New, "Floating Body Isolation"* guarantees vibra-shock protection and operation by complete separation of electrical contact body from mechanical elements. For connector reliability and foolproof application.

- Unparalleled vibra-shock protection
- High environmental resistance
- Superior performance dependability
- Positive locking action
- Disengagement ease
- Melamine and alkyd molding compounds
- Aluminum cast brackets
- Connectors meet or surpass. MIL-Q 5923B and MIL-C 8384 specs

Patent No. 2,761,108
additional patents pending

Write TODAY for complete technical data:

U.S. COMPONENTS, Inc.

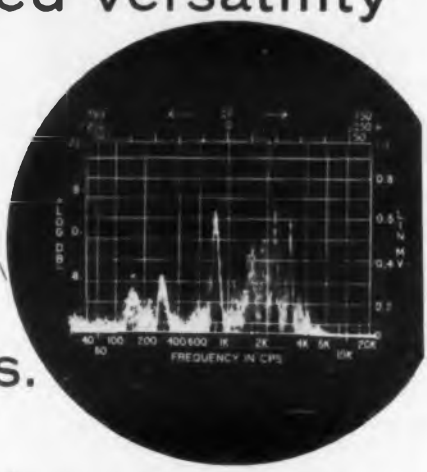
associated with
U.S. Tool & Mfg. Co., Inc.
454 East 148th Street, New York 55, N.Y.
CYpress 2-6525

CIRCLE 105 ON READER-SERVICE CARD FOR MORE INFORMATION

designed and perfected by PANORAMIC ...the leader:

NEW LP-1a

PANORAMIC SONIC ANALYZER LP-1a provides extended versatility and flexibility for accurate analysis of sounds, vibrations, audio waveforms.



Featuring an additional mode of operation, the new model LP-1a Panoramic Sonic Analyzer is designed to operate with an optional companion recorder permitting permanent recordings of waveform content over extended periods with significantly greater resolution.

SUMMARY DETAILS

- **Frequency Range:** 40 cps-20 kc logarithmic or any 5 kc, 1 kc or 200 cps linear segment centered anywhere between 0 cps and 20 kc.
- **Scanning Periods:** 1 second (internal)
  10 seconds, 3 minutes or 18 minutes (derived from recorder); usable only in linear frequency scan.
- **Resolution:** optimum dynamic on 1 second scan; static on 18 minute scan.

Find out today how LP-1a can speed up your laboratory and production operations; enable you to complete engineering projects with present personnel.

Write today for descriptive data sheets, prices and delivery schedules.

Panoramic Engineers are always available for discussion of SPECTRUM ANALYSIS problems. Special instruments to order.

PANORAMIC
RADIO PRODUCTS, INC.

15 S. Second Ave., Mount Vernon, N. Y.
Phone: MOunt Vernon 4-3970
Cables: Panoramic, Mt. Vernon, N. Y. State

CIRCLE 107 ON READER-SERVICE CARD FOR MORE INFORMATION

Ultra-Violet Source

Has Highly Adaptable Design

The "Blak-Ray" Model B-100 can be used in any method requiring a concentrated source of ultra-violet at 3660 angstrom units. The lamp head is attached to the base through a spring-tension arm which allows the ultra-violet beam to be rotated in a 180 deg arc. A trigger mechanism makes it easy to slip the light source from the base and maneuver it in hand with pistol-grip handle. For mounting over a lab table or in a booth, there is a convenient D-ring on the back of the lamp head.

The light source is a 100 w long wave ultra-violet bulb, either flood or spot type. A 5 in. rounded filter blocks out visible light. The spot bulbs emits a concentrated beam which will fluoresce an area of 15 ft diam from a distance of 30 ft; the flood will activate an area of 30 ft diam from 30 ft.

Black Light Corp. of America, Dept. ED, San Gabriel, Calif.

CIRCLE 108 ON READER-SERVICE CARD FOR MORE INFORMATION

Constant Voltage Supply

Adjustable DC

This unit combines a voltage transformer, a germanium rectifier, and a special high-capacitance filter section with a small choke to yield laboratory performance.

Output voltage from the DC Solavolt is regulated within 1 per cent with supply voltage variations up to 15 per cent. Ripple voltage is held within 0.10 per cent rms at full load and nominal input voltage. This assembly is able to handle transient or "pulse" loads up to twice the full load rating of the supply without failure due to severe voltage drop, and without damage to itself.

There are no tubes and all electrical circuits and terminals are insulated from ground, permitting operation at either polarity.

The unit is available in 6 models that provide output adjustable in different voltages ranges between 5 to 400 v, and currents up to 7 amps.

Sola Electric Co., Dept. ED, 4633 W. 16th St., Chicago 50, Ill.

CIRCLE 109 ON READER-SERVICE CARD FOR MORE INFORMATION

Digital Ohmeter

Has Oil-sealed Switches

A digital ohmmeter that provides automatic measurements, the Model 751 has oil-sealed stepping switches for a maximum trouble-free life.

Resistance values are displayed by four in-line luminous numerals 1 in. high, with automatically-shifting decimal point and automatically-varied resistance symbols. Permanent records can be made by connection of accessory digital recording systems.

Range of the instrument is from zero to 9.999 megohms with minimum resolution of 10 ohms. Sampling rate is 60 cps; response, 1 sec (average); and accuracy is ± 0.1 per cent of measured resistance or one digit, whichever is greater.

Weighing 40 lb, this digital ohmeter is available in rack mount and portable styles. The rack mount is 5-1/2 in. high, 19 in. wide and 15-1/4 in. deep; portable, 11 in. high, 8-1/4 in. wide, 15-1/4 in. deep.

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

CIRCLE 113 ON READER-SERVICE CARD FOR MORE INFORMATION

Vibration Amplifier

Built-In Calibration

A new Vibration Pick-up Preamplifier, designed as a link between any type of vibration pickup and one of the Brush AF Analyzers, provides absolute measurement of recording of acceleration, velocity or displacement.

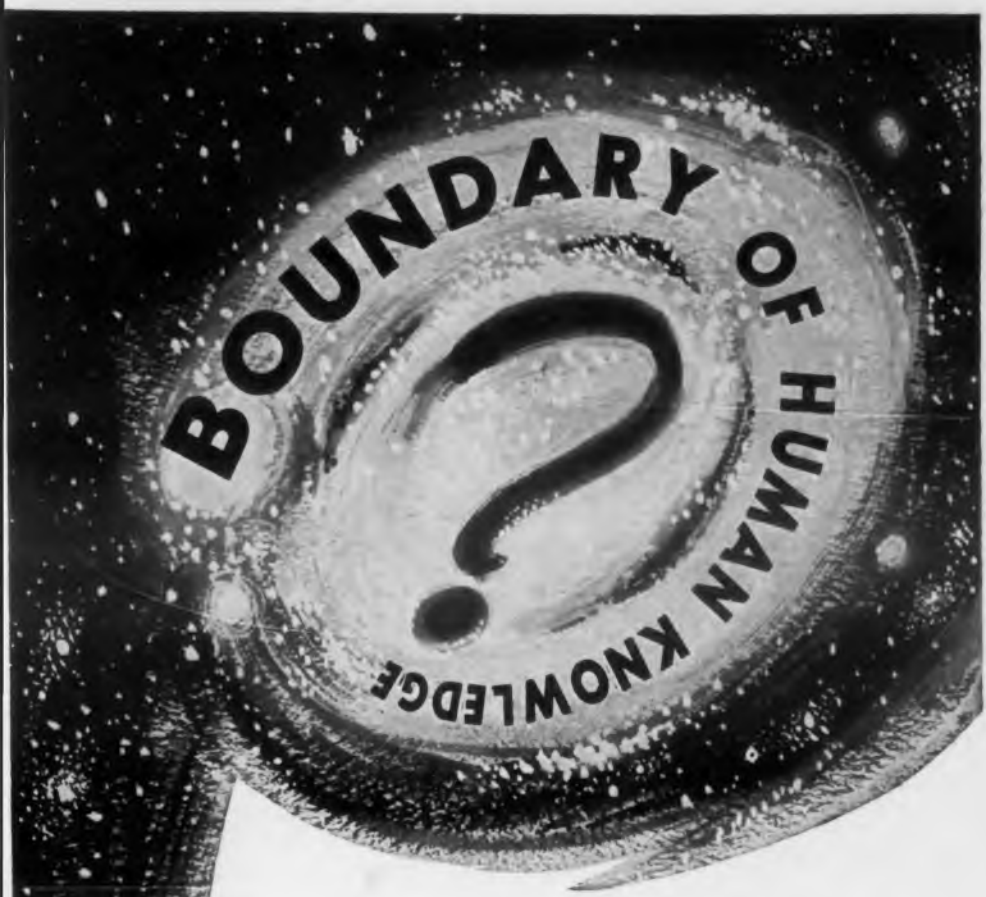
The Model BL-1606 has a two-stage preamplifier with high input impedance that allows vibration measurements to be carried out to very low frequencies at extended distances from the measuring instrument.

A built-in calibration unit, consisting of a vibrating disc suspended on a metal strip, which is brought into resonance at the line frequency, affords a direct and quick calibration of the combination accelerometer, preamplifier and measuring instrument before the measurements are carried out.

A set of integrating networks is provided for measurements of the velocity and displacement of the vibrations in consideration.

Brush Electronics Co., Dept. ED, 3405 Perkins Ave., Cleveland 14, Ohio.

CIRCLE 114 ON READER-SERVICE CARD FOR MORE INFORMATION



there is a breakthrough point!
. . . many of our present
assignments involve
seeking solutions
currently unknown!
perhaps YOU* have
the answers . . .

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MECHANICAL
AERONAUTICAL
PHYSICISTS
MATHEMATICIANS

INERTIAL GUIDANCE SYSTEMS . . .
gyroscopic devices
servomechanisms
electronic components
airborne digital computers

M I T

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68 Albany Street
Cambridge 39, Massachusetts

GRADUATE COURSES may be taken for credit while earning full pay . . .

CIRCLE 115 ON READER-SERVICE CARD FOR MORE INFORMATION

Precision Potentiometer

Multiple Ganged Sections

Series 5400 1-7/16 in. diameter precision potentiometers have been developed to fit A.I.A. dimensional standards.

Housed in a dimensionally stable one-piece plastic cup, the single-turn continuous-rotation unit can have 8 sections ganged on a common shaft at the factory, each with a maximum of 12 taps. The standard range of resistance is from 25 to 51,000 ohms, with a linearity tolerance of ±0.15% at 10,000 ohms and above.

Available with or without ball-bearings, for servo or bushing mounting, the Series 5400 has a power rating of 2.8 at 25 C ambient and 2 at 40 C ambient. Operating range is from −55 to +80 C. Electrical rotation is 354° ±2°.

Helipot Corp., Dept. ED, Newport Beach, Calif.

CIRCLE 118 ON READER-SERVICE CARD FOR MORE INFORMATION

TV Tube Mount

Cuts Material Costs

This impact-resistant television tube mount, fabricated of soft steel wire, is designed for low cost and to accelerate tube installation on the assembly line. During drop tests, where a TV set is dropped from 12 to 30 in. from various positions, this welded wire tube mount holds the tube intact, even after extensive cabinet damage. The soft, zinc-plated wire conforms closely to the tube contour. It will not etch glass, and consequently eliminates the necessity for gasket material previously required to prevent tube implosion or movement.

The simplified wire mount consists of two parallel contour wires (or one, depending on specifications) for the tube front, with four lightweight locating stampings and two adjustment stampings. A rear wire support is frequently used to complete the assembly.

E. H. Titchener & Co., Dept. ED, 67 Clinton St., Binghamton, N.Y.

CIRCLE 119 ON READER-SERVICE CARD FOR MORE INFORMATION

Solder Flux Kit

For Electronic Assemblies

A general purpose flux kit is available to provide the proper flux for specific soldering jobs. It contains 16 fluxes for electronic assemblies, printed circuits, tinning and hot solder dipping, stainless steel soldering and aluminum soldering.

Alpha Metals Inc., Dept. ED, 56 Water St., Jersey City, N. J.

CIRCLE 122 ON READER-SERVICE CARD

Waterproof Cloth Tape

High Tensile Strength

A colored waterproof cotton cloth tape, designated Permacel 68 combines excellent tensile strength with a high moisture resistance.

The pressure sensitive tape has an Adhesion 40 oz per in. of width to plastic, and 32 to steel, and a tensile strength of 60 lbs per in. of width. Colors are available for identification applications.

Permacel Tape Corp., Dept. ED, New Brunswick, N. J.

CIRCLE 123 ON READER-SERVICE CARD

UHF Receiver

A 16 Lb Military Type

This compact, lightweight, portable vhf receiver occupies less than 1/3 cu ft and weighs only 16 lb (approx). Developed for the military, it receives AM, FM, CW, and MCW signals in the 20-100 mc band. It may be operated from self-contained batteries or from a 24 v vehicular supply. It is intended for searching and monitoring the 20-100 mc spectrum, but with the proper DF antenna, it also provides direction-finding capabilities.

AM sensitivity varies from 0.3 to 0.4 μv over the frequency range. On FM, a 1.0 μv signal provides 30 db or more of quieting. The receiver uses 1.2 w of power, and can operate continuously for about 30 hr on one set of batteries. The components have been selected for stability in a range of −40 to +150 F. The receiver can be serviced easily; the various subassemblies can be pulled out and plugged in readily.

Radio Receptor Co., Inc., Dept. ED, Brooklyn, N.Y.

CIRCLE 124 ON READER-SERVICE CARD

CIRCLE 125 ON READER-SERVICE CARD ➤

S-Band Ferrite Isolator

Light Weight

Combining minimum size and weight, the S10/S18 ferrite load isolator provides 18 db isolation over a 300 mc band width from 2500 mc to 3000 mc. With waveguide flanges, maximum insertion loss is 1.0 db. Maximum input VSWR is 1.5. The isolator can handle up to 500 kw peak power and 250 w average without external cooling. With air or liquid cooling, power handling capacity is increased substantially.

Litton Industries, Components Div., Dept. ED, 5873 Rodeo Rd., Los Angeles 16, Calif.

CIRCLE 127 ON READER-SERVICE CARD FOR MORE INFORMATION

Silicon Diode Rectifier

Aircraft Transformer

This tubeless, motionless transformer-rectifier is designed for direct current equipment in aircraft with ac supply.

Offering a considerable saving in weight and size as compared with selenium rectifier-transformer combinations, the Model CW-1001 transformer-rectifier has an output of 50 amp at 27.5 v dc with an input of 115/200 v phase Wye 400 cy. Silicon power diodes are used in the unit, which weighs less than 4.8 lbs.

Electrosolids Corp., Dept. ED, 7436 Varna St., N. Hollywood, Calif.

CIRCLE 128 ON READER-SERVICE CARD FOR MORE INFORMATION

Flag Type Terminal

Has Insulation Support

This line of "Junior Faston" Flag Type Terminals employs an insulation support. The flag-type feature make the terminals easy to apply in unusual position applications and the insulation support absorbs wire vibration and adds strength to the connection. Similar in performance but smaller in size than the larger standard "Fastons," they accommodate wire sizes 22-14.

Aircraft-Marine Products, Inc., Dept. ED, Harrisburg, Pa.

CIRCLE 129 ON READER-SERVICE CARD FOR MORE INFORMATION

Strain Gage

Can Be Welded To Surfaces

This weldable high temperature strain gage has a dynamic test range to 1600 F. It can be spot welded and test-ready on flat or curved surfaces in less than 5 minutes. Available gages have a nominal resistance of 120 ohms and a gage factor of 1.80. Length and width dimensions of the two available gage types are 1.250 x 0.125 in. and 0.750 x 0.250 in.

Micro-Test, Inc., Dept. ED, 657 N. Spaulding Ave., Los Angeles 36, Calif.

CIRCLE 132 ON READER-SERVICE CARD FOR MORE INFORMATION

Pulse Generator

High Output

This pulse generator provides source of fast time rise pulses for a wide range of laboratory and test applications.

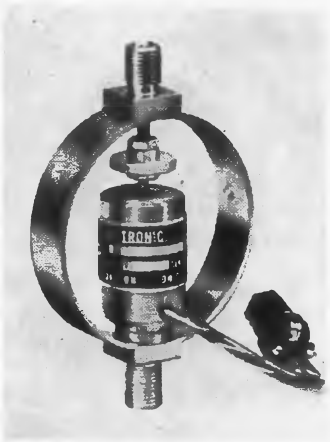
High output, consistent with good waveform, is available through optional use of an internal load resistor. Controls provide high resolution, utilizing multiple defade ranges for pulse spacing, delay, and width.

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

CIRCLE 133 ON READER-SERVICE CARD FOR MORE INFORMATION

Force Transducers

Wide Range



Combining the proving ring and differential transformer principles, these transducers provide an electrical output voltage that is proportional to applied force and exhibit high stability of calibration.

The Series 140 Force Transducers are available in 11 models with ranges from ±10 lbs to ±100,000 lbs, the units are accurate to 0.5 per cent. Excitation frequency range is 60 to 10,000 cps.

Daytronic Corp., Dept. ED, 216 S. Main St., Dayton 2, Ohio.

CIRCLE 134 ON READER-SERVICE CARD FOR MORE INFORMATION

WHEN YOU NEED RESISTORS WITH BETTER THAN MIL SPECS.

VICTOREEN CAN SUPPLY THEM

MIL specifications 10509A are good—but for appplications in a high temperature area where more than the normal life-expectancy is required, specify Victoreen carbon deposited resistors.

These resistors are made by depositing a pure crystalline carbon, by pyrolosis of hydro-carbon vapor, on specially prepared, smooth-textured ceramic bodies. Silver-plated brass caps make positive contact with the silvered ends of the element to provide terminals of highest conductivity. Elements are sealed in an inert-gas filled glass envelope.

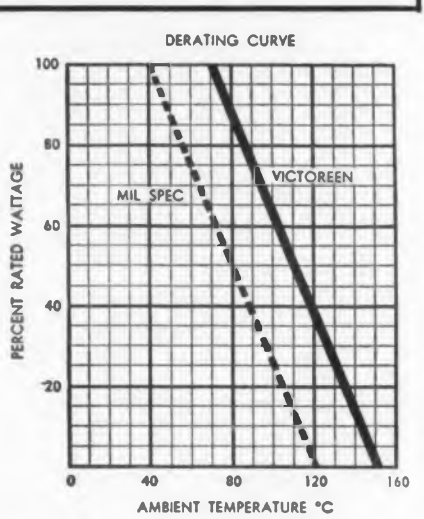
COMPARE THESE SPECIFICATIONS

MIL Paragraph		MIL 10509A Requirement	Victoreen Capabilities
3.3	Power Rating (Ambient Temperature)	40°C	70°C
3.7	Low Temperature Exposure (Change)	3%	1%
3.10	Moisture Resistance (Change)	5%	3%
3.4	Maximum Continuous Working Voltage at	40°C	70°C
4.6.10	Load Life (Test Condition)	40°C	100°C
4.6.10.2	Test Life Procedure (Minimum)	1000 hours	*2000 hours

*These units are being used in applications with life objective of 10,000 hours.

As shown in this derating curve, the Victoreen developed carbon deposited resistor is infinitely better than the commonly accepted types yet retains all the normal characteristics.

We invite your inquiry. Samples will be furnished for your testing.



COMPONENTS DIVISION

The Victoreen Instrument Co.

5807 HOUGH AVENUE • CLEVELAND 3, OHIO

CIRCLE 136 ON READER-SERVICE CARD FOR MORE INFORMATION

Transmitter Racks

Take 24 in. Panels

This line of heavy-duty transmitter racks is designed to accommodate 24 in. rack panels. The racks are 27 in. wide x 24 in. deep. They feature adjustable panel mounting angles 3/16 in. thick and tapped 12-24 on universal spacings.

Constructed of 16 gage steel with a 12 gage bottom and welded throughout, the racks have rear doors closed by a chrome handle.

Premier Metal Products Co., Dept. ED, 337 Manida St., New York 59, N.Y.

CIRCLE 137 ON READER-SERVICE CARD FOR MORE INFORMATION

AC Power Supply

Sub-Miniature

This miniature power supply has a size of only 2-1/2 x 2-1/2 x 3-3/4 in. Operating temperature range is –55 to 125 C. It has a rating of 2000 v at 5 ma with max current to 10 ma. Standard models have a frequency of 60 cps at 117 v; special models with frequencies to 400 cps are proportionately smaller in size. Standard models include 2-10 kv with higher voltages and temperatures upon request. All units are hermetically sealed and oiled filled.

The New Haven Electronics Co., Dept. ED, P.O. Box 888, New Haven, Conn.

CIRCLE 138 ON READER-SERVICE CARD FOR MORE INFORMATION

Rotary Potentiometer

in 100-50,000 Ohms Variations

The PRM123 is a sealed rotary type 1-5/16 in. diam rotary potentiometer. It is constructed as a single gang only, bushing mounted, sleeve bearing model in variations from 100 to 50,000 ohms of resistance.

Standard tolerances are ±3 per cent on resistance and ±0.3 per cent on independent linearity. Operating temperatures for standard models are –65 to 275 F. Rotation is 360 deg mechanical (continuous).

General Controls Co., Dept. ED, Glendale, Calif.

CIRCLE 139 ON READER-SERVICE CARD FOR MORE INFORMATION

Cabinet Slide

Aids Access to Equipment

A 300 per cent increase in bearing surfaces on "Chassis - Trak" cabinet slides facilitates access to electronic components. Mounted components can be pulled out on slides and locked in automatic "out" position. The "Basic" model tilts freely without position locks, while the "Detent" locks in six positions—at 45, 90, and 105 deg angles, tilted up or down.

Chassis-Trak Corp., Dept. 1-A, 6252 Iona Rd., Indianapolis, Ind.

CIRCLE 142 ON READER-SERVICE CARD FOR MORE INFORMATION

Teflon Terminals

Compact Press-Fit Units

With dielectric strength ranging from 1000 v to 2000 v/mil of thickness, these Teflon "Press-Fit" terminals permit placing a multiplicity of terminals in very limited space, such as on canned transformers, precision potentiometers, and coil assemblies. This is an encased transformer top with two banks of 10 terminals each, with terminals spaced only 1/4 in. between centers. Each feed-thru terminal has turret lugs for inside and outside wrap-around and soldered connections.

Sealectro Corp., Dept. ED, 610 Fayette Ave., Mamaroneck, N.Y.

CIRCLE 143 ON READER-SERVICE CARD FOR MORE INFORMATION

Exciter-Regulator

For Aircraft Application

This exciter voltage regulator, Model 05, is of the magnetic amplifier type. It supplies regulated excitation voltage for 8 kva alternator systems. It is designed to hold a 115 v ±1-1/2% rms exciter voltage over a range of 380-980 cps operating frequency. Operating life is 3000 hr or more, and the unit is primarily intended for B-1 alternator systems, which are standard for T-29, C-124, C-97, B-50, and other aircraft.

Cline Electric Manufacturing Co., Dept. ED, 3405 W. 47th St., Chicago 32, Ill.

CIRCLE 144 ON READER-SERVICE CARD FOR MORE INFORMATION
CIRCLE 145 ON READER-SERVICE CARD

11 million operations without a miss on low-energy switching test!

New test proves outstanding reliability of General Electric's Miniature relays

Laboratory tests using standard, production relays have confirmed the remarkable performance of General Electric Miniature relays on low-energy switching applications. These hermetically sealed relays made contact 11 million times without failure—switching 25 microamps at 50 millivolts—indicating permanent reliability.

This low-energy performance is combined with proved mechanical life. On one typical application, several of these relays continued to function after 300 million switching operations.

A key reason for this outstanding reliability is extremely high (40 to 55 grams) tip pressure—designed into all Miniature relays. Ample wear allowance provided by G-E engineers also contributes to extra-long life.

Description: Available in standard, current-sensitive, and voltage-sensitive models; in 2-, 3-, or 4-pole double-throw and 6-pole normally open forms. Rated 5 amps at 28 volts DC at 85C.

OTHER G-E RELAYS TO MEET YOUR NEEDS

1 **Micro-miniature relay:** Weighs .35 oz; rated 2 amps resistive at 28 v DC or 115 v AC. Also, current-sensitive model. Standard relays withstand ambient temp of 125C.

2 **2PDT sub-miniature relay:** 2 amps; .651 in. in diameter, 1.6 in. long; weighs one ounce. Withstands shock tests in excess of 50Gs. Available in wide variety of coil ratings.

3 **High-speed 4PDT relay:** Especially designed for use where operation as fast as 500 microseconds is required. Ideal for applications like ground-based radar, multiplexing of electronic signals, and computer circuits.

MAIL TODAY FOR SEALED-RELAY DATA

General Electric Co., Sect. E792-5, Schenectady 5, N. Y.

- ☐ Miniature—Bulletin GEA-6213
- ☐ Micro-miniature—Bulletin GEA-6346
- ☐ 2PDT sub-miniature—Bulletin GEA-6412
- ☐ High-speed 4PDT miniature—Bulletin GEA-6212
- ☐ HAVE G-E SALES ENGINEER CALL

NAME..... TITLE.....

COMPANY.....

ADDRESS.....

CITY..... STATE.....

GENERAL ELECTRIC

Rugged Midget Relay

Moisture Resistant

This relay features simplicity of design, ruggedness, and dependability.

In the Series 1100, the coils are completely sealed against moisture, corrosion, and from high humidity. For high-frequency use, special low-loss phenolic insulation is available.

Voltages range from 6 to 110 v dc, with resistances up to 11,000 ohms. Capacitance to ground is only 3 mmfd.

This two-ounce midget relay will withstand shock and vibration up to 10 G, and has a sensitivity of 2 w dc. Its silver contacts are rated up to 1 amp at 115 v ac non-inductive load.

Price Electric Corp., Dept. ED, Frederick, Md.

CIRCLE 147 ON READER-SERVICE CARD

Electrical Tape

Made of Rayon Reinforced Film

"Permacel 246," an electrical grade rayon reinforced film tape, has been added to the "2-in-1" line. It has high insulation resistance and high dielectric strength. The adhesive used is both pressure sensitive and heat curing. The tape's high tensile strength, tear strength, and shock resistance permit it to withstand breakage caused by high stresses which are prevalent in heavy duty electrical equipment. Uses include application in the production of heavy-duty equipment where anchoring is needed for heavy gage electrical wiring in the equipment coils and for banding armature coils prior to "forming."

Average basic properties are: tensile strength 225 lb/in. width; elongation 15%; adhesion strength 30 oz/in. width; thickness 12 mils; and impact strength of 150 in. lb. This tape has insulation resistance of 1000 megohms at 95% relative humidity, indirect electrolytic corrosion current of 1000 μmhos, and dielectric strength of 6000 v. The minimum curing cycle is 2 hr at 250 F or 1 hr at 300 F. It is available in widths ranging from 1/4 in. in rolls of 60 yd.

Permacel Tape Corp., Dept. ED, New Brunswick, N.J.

CIRCLE 148 ON READER-SERVICE CARD

CIRCLE 146 ON READER-SERVICE CARD

Video Signal Generator

Provides Keyed Signal

This is a versatile unit for use in testing telecasting studio, microwave and transmitter equipment. It provides a keyed composite video output signal (blanking, sync & video) throughout two continuously variable frequency ranges of 90 kc to 1.0 mc and 900 kc to 10 mc. There is no need to disable clamp circuits or dc restorers so that a realistic dynamic test is obtained.

In the Model VO3B, amplitude of sync, blanking and video are independently variable. A phase-locked sine wave (flat to within 0.5 db from 90 kc to 10 mc) serves as the video portion of the composite signal. Optionally externally-generated signals may be used as the video component.

It has a self-contained regulated power supply and may be used as portable or rack-mounted test equipment.

Foto-Video Labs., Inc., Dept. ED, Eagle Rock Bldg., 25 Amity St., Little Falls, N. J.

CIRCLE 151 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistorized Intercom

For Aircraft Use

Housed in a laminated-phenolic tube 6-1/2 in. long and 1 in. diam, the device consists of a high-gain, low-impedance microphone, the transistor - battery - operated amplifier, and highly sensitive rubber - cushioned earphones. A printed circuit board is used to hold all the amplifier components including the battery which is good for over 100 hours of use. The printed circuit makes extreme miniaturization possible and insures trouble-free performance.

The Goldak Co., Inc., Dept., ED, 1544 W. Glenoaks Blvd., Glendale 1, Calif.

CIRCLE 152 ON READER-SERVICE CARD FOR MORE INFORMATION

Correction:

The Coaxial Power Pad, manufactured by the Weinschel Engineering Corp., was erroneously rated in the September 1 issue. The correct rating is 30 watts.

A
NEW
SERIES OF

VERSATILE
PLUG-IN
CONNECTORS

Easy action precision machined contacts . . . Guide pin or machine screw mounting . . .Coax for new miniature cables . . . Full floating female contacts . . . High strength insulators . . . Rugged Design . . . Small size . . .

The standard series of connectors is offered in five sizes with various combinations of 3 to 17 power contacts and one or two coaxial contacts. The power contacts have an 8 ampere rating and a minimum sea level flashover voltage of 3500 volts RMS. The insulators are a new high strength polyester melamine laminate that has good arc resistance and low moisture absorption. The coaxial contacts are approximately 50-ohms impedance and generally satisfactory for frequencies up to 1,000 mc. Clamping parts, that require no soldering of the braid wires, are available in various sizes for coaxial cables from 1/16 OD up to 1/4 inch for RG-59/U etc. cables.

The basic connectors are supplied for standard machine screw mounting. A Guide Pin and Bushing Kit GK-1 is available that adapts the standard connectors to guide pin engagement and mounting. Cover and cable clamp assemblies are available for hand engagement of the connectors in patch cord or test applications.

The design of the connector parts is such that the pin and socket contacts, coaxial contacts, insulator, and guide mountings can be arranged to make practically any shape or size of connector. The flat insulators do not require molds. Therefore special shapes and combinations can be supplied promptly without special tooling charges.

In addition to the standard types, the parts are available separately. These parts can be readily assembled into special connectors by merely drilling standard size holes in the insulator plates and assembling the component parts.

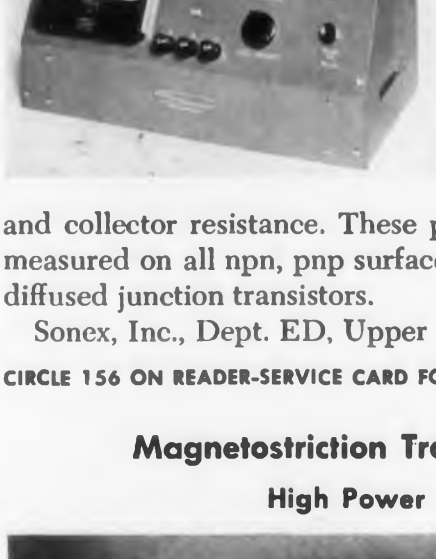
Write or call for descriptive folder.

DANBURY (DK) KNUDSEN
INCORPORATED
DANBURY, CONN.

CIRCLE 155 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistor Tester

Self-Calibrating



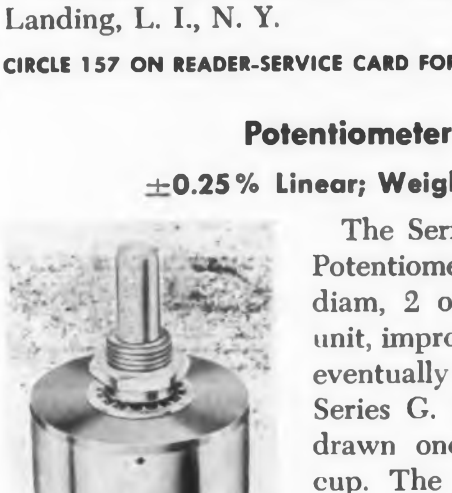
A general purpose Transistor Tester for laboratory, field, and industrial use, the Model TT-102 measures and reads small signal beta, collector leakage current, and collector resistance. These parameters may be measured on all npn, pnp surface barrier, grown or diffused junction transistors.

Sonex, Inc., Dept. ED, Upper Darby, Pa.

CIRCLE 156 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetostriction Transducer

High Power



The first high-power magnetostriction type transducer, Model AM-203B, is designed for large scale ultrasonic applications. Average rf power applied to the transducer is 66 w sq in. of radiating area, producing cavitation effects throughout a large volume of solution.

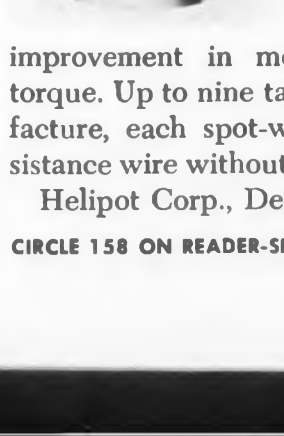
This 400 w unit operates at 25.9 kc and measures 4-3/8 in. diam x 4-5/8 in. H. Proper water cooling minimizes frequency drift and output loss. Each transducer features built-in biasing magnets eliminating separate dc bias supplies.

Acoustica Associates, Inc., Dept. ED, Glenwood Landing, L. I., N. Y.

CIRCLE 157 ON READER-SERVICE CARD FOR MORE INFORMATION

Potentiometer

±0.25% Linear; Weighs 2 oz



The Series 5300 Precision Potentiometer, a 1-1/2 in. diam, 2 oz, bushing-mount unit, improves upon and will eventually replace this firm's Series G. It is housed in a drawn one-piece aluminum cup. The unit is compact, extra rugged, and long-lived. It also offers considerable improvement in mechanical runout, noise, and torque. Up to nine taps can be added during manufacture, each spot-welded to a single turn of resistance wire without shorting out adjacent turns.

Helipot Corp., Dept. ED, Newport Beach, Calif.

CIRCLE 158 ON READER-SERVICE CARD FOR MORE INFORMATION

Mars Pencils Sponsors Tomorrow's Designs

MARS OUTSTANDING DESIGN SERIES—featured in the current advertising of J. S. Staedtler, Inc.—has attracted widespread attention among the users of fine drafting pencils. It has fulfilled our expectation that the men who appreciate the finest working tools are those with a lively creative interest in new designs, new projects, new ideas.

Concerned with unusual projects—*designs of the future*—Mars Outstanding Design Series provides a "showcase" for originality, for interesting work of engineers, architects, and students which so often lies buried. To stimulate you to send in *your* designs, Mars Pencils

will pay you $100

for any design accepted. This $100 is paid you simply for the right to reproduce your project in the Mars Outstanding Design Series. There are no strings attached. You will be given full credit. (See ad on this page—one of the ads in the current series.) All future rights to the design remain with you. You can reproduce it later wherever you like and sell or dispose of it as you wish.

The subject can be almost anything—aviation, space travel, autos, trains, buildings, engineering structures, household items, tools, machines, business equipment, etc. It should be a project that appeals to design-minded readers, be of broad interest, and be attractively presented. Do not submit a design that has been executed. As a matter of fact, the project does not need to have been planned for actual execution. It should, however, be something that is either feasible at present or a logical extension of current trends. It cannot be unrealistic or involve purely hypothetical alterations of natural laws.

There is no deadline for entries but the sooner you send yours in, the greater the probability of its use as one of the subjects in the 1957 Mars Outstanding Design Series.

It Is Simple To Submit a Design For Mars Outstanding Design Series

Just mail in an inexpensive photostat or photocopy of the subject—one you can spare, since it cannot be returned.

If your entry is accepted, we will ask you to send in a sharp photograph of the design, or the design itself, so that we can make a sharp photograph suitable for reproduction—after which it will be returned to you promptly.

Send your entry to:

J.S. STAEDTLER, INC.
DICAROLIS COURT, HACKENSACK, NEW JERSEY

CIRCLE 160 ON READER-SERVICE CARD

Transformers and Reactors

Variety of Toroidal Units

Expanded facilities at the west coast plant of this firm include additional equipment for making transformers and reactors that involve toroidal windings. In the past, the firm has produced miniature pulse transformers with ID's of 1/4 in. With the expanded facilities, the range will extend to sizes up to 4 in. OD.

Acme Electric Corp., Dept. ED, Cuba, N.Y.

CIRCLE 161 ON READER-SERVICE CARD FOR MORE INFORMATION

High Potential Tester

Provides Automatic Go, No-Go

This Go, No-Go instrument is intended for high speed test of slip ring assemblies, relays, electron tubes, synchros, and motors. Each electrode of the specimen is successively energized at high potential with respect to the others. Deterioration of the dielectric causes a current to flow which is monitored by a sensitive relay.

Theta Instrument Corp., Dept. ED, 204 Market St., E. Paterson, N.J.

CIRCLE 162 ON READER-SERVICE CARD FOR MORE INFORMATION

X-Band Rotary Joint

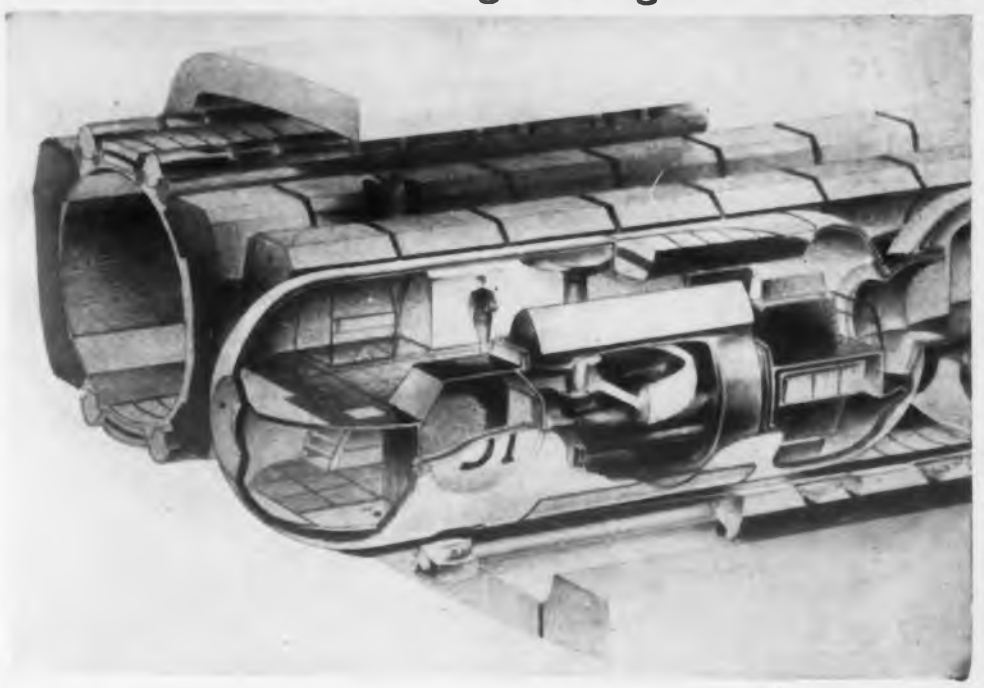
Takes 600 kw Peak

The Model H250T/S61 Rotary Joint is a broad band, high power waveguide coupler designed especially for operation under severe shock and vibration conditions. Capable of operating at 600 kw peak power for short intervals, it operates at 350 kw during extended use. Impact and vibration tests per MIL-T-17113 show unimpaired mechanical operation and no internal damage. Vswr is less than 1.10 over a frequency band of 8400-9600 mc. Change of vswr with rotation is less than 0.2 db.

Litton Industries, Components Div., Dept. ED, 5873 Rodeo Rd., Los Angeles 16, Calif.

CIRCLE 163 ON READER-SERVICE CARD FOR MORE INFORMATION

MARS outstanding design **SERIES**



man and motion:

The wonders of the future are still little whispers in men's minds, or maybe — like Detroit Designer Norman James' magnetically suspended inter-city train — a drawing on a piece of paper. Traveling in a vacuum in an air-tight tube, it floats in space, held by a system of magnets built into cars and tunnel. Propelled electrically by "rolled-out" motor, train acts as rotor, tunnel roof as stator. Converter aboard train changes light projected through windows into electrical energy.

No one knows which ideas will flower into reality. But it will be important in the future, as it is now, to use the best of tools when pencil and paper translate a dream into a project. And then, as now, there will be no finer tool than Mars—sketch to working drawing.

Mars has long been the standard of professionals. To the famous line of Mars-Technico push-button holders and leads, Mars-Lumograph pencils, and Tradition-Aquarell painting pencils, have recently been added these new products: the Mars Pocket-Technico for field use; the efficient Mars lead sharpener and "Draftsman's" Pencil Sharpener with the adjustable point-length feature; and — last but not least — the Mars-Lumochrom, the new colored *drafting* pencil which offers revolutionary drafting advantages. The fact that it blueprints perfectly is just one of its many important features.

The 2886 Mars-Lumograph drawing pencil, 19 degrees, EXEXB to 9H. The 1001 Mars-Technico push-button lead holder. 1904 Mars-Lumograph imported leads, 18 degrees, EXB to 9H. Mars-Lumochrom colored *drafting* pencil, 24 colors.

J.S. STAEDTLER, INC.
HACKENSACK, NEW JERSEY

at all good engineering and drawing material suppliers

CIRCLE 164 ON READER-SERVICE CARD FOR MORE INFORMATION

Power Transistor

Operates from 12 V Battery

The 2N235A, a germanium pnp audio power transistor, operates from a 12 v battery. It can readily dissipate 5 w at a 75 C mounting base temperature and 25 w at room temperature. The collector current rating is 2 amp at 75 C. Power gain is 30-40 db, and it has ac current gains up to 100 at 0.5 amp collector current and 50 at 2 amp.

Semiconductor Products, Red Bank Div., Bendix Aviation Corp., Dept. ED, 201 Westwood Ave., Long Branch, N.J.

CIRCLE 166 ON READER-SERVICE CARD FOR MORE INFORMATION

Oscillogram Reader

Converts Data to Shaft Rotations

The Oscillogram Reader converts amplitude measurements, as determined by the position of a horizontal cross-hair, into shaft rotations so that this information may be digitally converted for use by typewriters, printers, and punched card or tape devices. The basic measuring unit is provided by a precision leadscrew the length of which cannot vary with changes in voltage.

Coleman Engineering Co., Inc., Dept. ED, 6040 W. Jefferson Blvd., Los Angeles 16, Calif.

CIRCLE 167 ON READER-SERVICE CARD FOR MORE INFORMATION

Crystal Unit

Withstands 100 G Shock

With a frequency range of 200-500 kc, the Model ST 70X Crystal Unit meets a shock test of 100 G's. It will withstand vibration of 15 G's, 10-55 cps for 2 hrs, per MIL C 3098B; 5 G's, 5-500 cps for 45 minutes, per MIL E 05272A; and 3 G's, 500-1200 cps per MIL T 5422 (ASC). Storage temperatures are —65 to 135 C; operable temperature range is —55 to 120 C. Frequency excursion is low as ± 0.001 per cent over any given 30 C temperature range. This crystal has been developed primarily for missile requirements.

Bulova Watch Co., Electronics Div, Dept. ED, 40-06 62nd St., Woodside 77, N.Y.

CIRCLE 168 ON READER-SERVICE CARD FOR MORE INFORMATION

Small Antenna Lead-In

Coupler Bleeds off Static

This high-voltage ceramic capacitor, shunted by a printed bleed resistor, links antenna feed-in lined to the input of TV front-end tuners, and bleeds off static charges. The capacitor serves as an rf coupling between receiver and the antenna lines. The resistor bleeds off charges developed on the antenna system from precipitation static or inductive surges due to nearby lighting.

Capacity of the DN-96-10 is 470 mmf G.M.V. Solar Mfg. Corp., Dept. ED, E. 46th St. & Seville Ave., Los Angeles 58, Calif.

CIRCLE 169 ON READER-SERVICE CARD FOR MORE INFORMATION

Radar Test Set

Has Complete Instrumentation

This Radar Test Set combines all of the instrumentation necessary for complete check-out of radar and other microwave transmitters in the field or otherwise. Available in C-Band (5200-5900 mc), X-Band (8500-10,000 mc), and Ku-Band (15,000-17,000 mc) frequencies, it includes all necessary test functions in one self-contained unit.

Kearfott Company, Inc., Western Div., Dept. ED, 253 N. Vinedo Ave., Pasadena, Calif.

CIRCLE 170 ON READER-SERVICE CARD FOR MORE INFORMATION

Relay

Operates at 0.0035 amp

The HD-8 Sensitive Power Relay is a special purpose unit that allows extremely low surge current through the actuating coil, preventing damage to fine instrument control contacts. It requires only 0.0035 amp from an external contact (thermometer, contact-meter, probes, etc.) to operate. Power amplification is a high 17,300.

Ebert Electronics Corp., Dept. ED, 212-312 Jamaica Ave., Queens Village 28, N.Y.

CIRCLE 171 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Electrical Contacts and Contact Materials 174

A 28-page catalog details contact materials, material characteristics, types of contacts and applications. Technical information includes electrical and physical properties and applications of contacts made from various materials. The catalog also contains reference charts to facilitate selection of the most satisfactory contact material and type of contact. Baker & Co., Inc., 113 Astor St., Newark 5, N.J.

Aeronautical Research 175

Progress in aeronautical research over the last ten years has been outlined in a 67-page booklet. Amply illustrated, the brochure discusses technical programs for aerodynamics, aeroelasticity, aircraft design, atmospheric physics, combustion and propulsion, electronics, flight instrumentation, helicopters, materials, stability and control, structures, etc. Cornell Aeronautical Laboratory, Inc., of Cornell University, Buffalo 21, N.Y.

Oscillographic Recording Brochure 176

A 2-color 8-page brochure features Lino-Writ photo-recording papers. Illustrated with charts and photographs, the bulletin describes Lino-Writ 1, 2, and 3 papers and indicates the proper application of each. Included are relative paper speeds for tungsten, cathode-ray green, and cathode-ray blue exposures; complete processing data for both regular and rapid stabilization methods, by hand or automatic machine; time and temperature relationships; spectral response; paper thickness; and core and winding data. E. I. du Pont de Nemours & Co., du Pont Photo Prods. Dept., Wilmington 98, Del.

Temperature Controllers 181

Bulletin MC-133 offers information on the Series 53,000 temperature controller which is designed as an individual unit to be plugged into a separate power supply chassis. For multi-point control, the brochure shows how the requisite number of controllers can be plugged into a single power supply chassis, centralizing control and conserving space while maintaining a choice of locations for temperature adjusting controls. The illustrated bulletin also describes the thermistor sensing elements which permit control as close as 25 per cent of scale range, and lead wires 200 ft and more in length. Fenwal Inc., Ashland, Mass.

Vibration-Damped Fasteners 182

An illustrated brochure on Vibrex fasteners, which combine quick-release closures and vibration dampeners, has been issued. The bulletin lists information on different types of fasteners together with specific tensile strength, sealing and anti-vibration characteristics and also cites applications, including instrument mounting and panel fastening for metal or plastic fiberglas. A special leaflet covers the use of fasteners for vibrationproof quick-release mounting of printed circuits. Vibrex Fastener Corp., Mount Kisco, N.Y.

Report On Metalphoto Plates 183

The first of a series of reports on how specific segments of industry are using Metalphoto plates. In this report, applications used in industrial research laboratories are detailed. Printed from standard photographic negatives and developed and printed by standard photographic techniques, the plates are being used over the range from simple nameplates to highly intricate calculators. Metalphoto Corp., 6811 Superior Ave., Cleveland 3, O.

Automatic Machine Spec Sheets 184

Eleven illustrated specification sheets explaining the operation, dimensions, uses and adaptability of automatic and semi-automatic machines. Covered in the sheets are the automatic lamp finishing machine, automatic bottoming machine, continuous vacuum firing furnace, automatic crack-off and glazing machine, transistor metal-flanger subminiature button stem machine, cathode ray tube button stem machine, CRT neck splicing machine, self-centering tubular bulb sealing heads, miniature and subminiature sealing machine, sealed beam lamp single head equipment, and automatic pinch welder. Kahle Engineering Co., 1400 7th St., North Bergen, N.J.

Computers 187

Brochure No. 108 has been issued describing the advance design features of the 400 series analog computer. The brochure states in detail the problem system, time scale check system, plug-in servo padding turrets, 400 cycle high-performance servo, and automatic recording of recorder calibration data. Reeves Instrument Corp., 207 E. 91st St., New York 28, N. Y.

Metal Forgings 188

A 32-page booklet has been released giving design, properties and applications of brass, bronze, aluminum hot-pressed forgings. The booklet discusses design factors involved in specifying and producing forgings. Factors of strength, core size, flash line, projections, staggered lines, fillet, lettering, dimensional tolerances, and other problems are treated with text and photos. Titan Metal Mfg. Co., Customer Service Div., Dept. U-35, Bellefonte, Pa.

Threaded Connections 189

Newsletter No. 2 has been issued describing lubrication of threaded connections. The booklet includes a description of the causes of galling and seizing in threaded connections and power screws and procedures for lubrication to eliminate these problems. Descriptive charts show coefficients of friction. Alpha Molykote Corp., Stamford, Conn.

Generator Excitation System 190

Bulletin 5.08 has been published describing the "McHenry Excitation System, an advance in the technique of alternator regulation and control." The McHenry Excitation System provides extremely fast response, positive stability, close regulation, and low cost; it will simplify new designs; and it can be easily installed in existing equipment. Electric Regulator Co., Pearl St., Norwalk, Conn.

◀ CIRCLE 186 ON READER-SERVICE CARD

Nylon Fasteners 191

This catalog describes a complete line of nylon one-piece self-locking fasteners. The locking principle used in these fasteners consists of a nylon plug imbedded permanently in the threaded section. It can be applied to any male or female threaded part, making leakproof joint which cannot be jarred loose by shock or vibration. The nuts, bolts and screws eliminate the need for lock washers, jam nuts, safety wiring or other locking devices. Nylon's "plastic memory" feature enables a fastening to be repeatedly removed and reinstalled. The catalog lists and describes the complete range of nylon self-locking bolts and screws, set screws, etc. The Nylok Corp., 475 Fifth Ave., New York 17, N.Y.

Phenolic Molding Compounds 192

Bulletin CDC-324 describes the automatic molding applications of one-stage phenolic molding compound 12902. Cited are fast cure and other characteristics demonstrated in early applications, as well as technical data.

Brochure No. CDC-326 describes characteristics of general purpose phenolic molding compounds, 12920 and 12921.

Bulletin CDC-325 describes the high impact strength of phenolic molding compound, 12906. The bulletin describes cure speed, finish, pourability and performability and also contains technical data. General Electric, Chemical Materials Dept., 1 Plastics Ave., Pittsfield, Mass.

Wound Toroids 193

A 16-page catalog describing the complete line of wound toroids, including standards, miniature, subminiature and high-frequency toroids; "Adjustoroids," "Rotoroids," telemetering band-pass filters, miniaturized band-pass filters, communications filters, and side-band filters has been released. The catalog describes the various characteristics and uses of each of the toroids or filters, and is illustrated with photographs. Performance curves for inductance ranges and inductance changes with direct current are given for each product as well as charts and graph illustrations. Burnell & Company, Inc., 5 Warburton Ave., Yonkers 2, N.Y.

Ceramic Magnets 194

A review of the several characteristics of this permanent magnet material is given in Applied Magnetics, Vol. 4, No. 3. How its special properties have been used to advantage in electronics is also discussed. The Indiana Steel Products Co., Dept. AM, Valparaiso, Ind.

New small basic switch is low cost; directly interchangeable with AN3234 Specs

F2 SERIES

The new Electro-Snap F2 Series snap action switches are extra-compact with extremely high electrical capacity for their size. Mechanical and electrical life at 1/32" overtravel is 150,000 operations, minimum, with accurate repeatability and constant stability of tolerances. Self-aligning springs provide contact wiping action rare in a switch of this size.

Durable case of special plastic gives the switch an ambient temperature rating of −100° to +275° F. or +375° F. Available, *at low cost*, in three basic models with a wide selection of actuators.

SERIES F2 BASIC SWITCH: F2-3: Single Pole, Double Throw
F2-2: Single Pole, Normally Open; F2-1: Single Pole, Normally Closed

OPERATING CHARACTERISTICS

Electrical Rating: 10 AMP. 125/250 V. A.C. 60 cycles
30 V. D.C. inductive and resistive (6 AMP, 30 V. D.C. for Airborne Application)
Operating Force, 7 to 12 oz. — Movement Differential, .011 ± .002
Reset Force, 4 oz. Min. — Overtravel, 1/32 Min.
Pretravel, 3/64 Max.

WRITE FOR DETAILS IN DATA SHEET FS-11

ELECTRO-SNAP
SWITCH & MFG. CO.
4216 W. LAKE ST., CHICAGO 24, ILLINOIS

New simultaneous triple-pole switch interrupts 3-phase ac. circuits; 6-circuit control in a small package

MODEL K3-4

Triple-Pole, Double Throw
15 AMP., 125/250 V. A.C.
30 V., D.C. Res.
10 AMP., 30 V., D.C., Ind.
Overtravel, .015 Min.
Move. Diff., .028 ± .007
Mech. Life, 1,000,000 ops.
Elec. Life, 500,000 ops.

This completely new Electro-Snap triple-pole switch simultaneously reverses current flow through three windings of a 3-phase motor up to 1 H.P. and interrupts other types of multi-switching installations. Instantaneous "make" and "break" snap-action of the three poles is independent of the speed of actuation—even extremely slow moving cams can be used.

The K3-4 Series offers designers a wide variety of 3-phase circuit hookups for servo-controls, to limit movement of machine members and as a start-and-stop switch which formerly were possible only with complicated relays or a number of separate switches. A large selection of standard actuators is available.

WRITE FOR DETAILS IN DATA SHEET KS-11

ELECTRO-SNAP
SWITCH & MFG. CO.
4216 W. LAKE ST., CHICAGO 24, ILLINOIS

CIRCLE 196 ON READER-SERVICE CARD FOR MORE INFORMATION

Miniature Connectors 197

An 8-page catalog illustrates and describes a complete line of miniature electrical connectors. The catalog presents standard plugs and receptacles which are moisture-sealed, vibration-dampened and corrosion-resistant. All are quick-disconnects, operate from −67 to 250 F and have continuous dielectric separation. They meet applicable MIL-C-5015B requirements for instrument ratings. The connectors listed include the Spherical Orientation Connectors designed to self-align and mate in blind connections. The Deutsch Co., 7000 Avalon Blvd., Los Angeles, Calif.

Pulse Patterns 198

A 16-page technical bulletin providing information on tape-wound or ferrite cores has been released. Bulletin 136 discusses how reliable testing procedures are a must, and goes on to point out the need for equipment which not only tests how a core will meet specifications within all necessary ranges of tolerance, but also how it will eventually operate in the system for which it is intended. Burroughs Corp., Electronic Instruments Div., 1209 Vine St., Philadelphia 7, Pa.

Continuous Sheet Mica 199

Availability of a 16-page booklet, "What Every User of Electrical Insulation Should Know About ISOMICA" has been announced. This illustrated booklet describes the background and development of continuous sheet mica, and tells how it is made today. It includes detailed information about the various types of ISOMICA—molding, segment, heater and flexible plates; tapes, flexible combinations, tubes and capacitor grade as well as SAMICA, the untreated continuous sheet mica. Mica Insulator Co., PO Box 1076, Schenectady 1, N.Y.

Custom Transformers 200

A 26-page catalog describes and illustrates a variety of custom transformers together with engineering specifications. The regular units list open frame transformers, cased transformers and channel frame and end bell cased units. The special units comprise air core reactors, special heater transformers, special output transformers and special furnace transformers. The catalog includes price lists as well as specifications and diagrams. Nothelfer Winding Laboratories, Inc., 111 Albemarle Ave., Trenton, N.J.

Sweep Operation

of G-R Oscillators and Signal Generators with Simple, Inexpensive, Automatic

DIAL DRIVES

A number of manually-operated G-R oscillators and signal generators can be converted to sweep drive by means of the Type 908-P Synchronous Dial Drive which uses a synchronous motor that reverses when it touches adjustable stops.

Two drive speeds are available. One (Type 908-P1) is intended for use with graphic recorders where the synchronous motor provides a convenient time base; the other (Type 908-P2) has a higher speed particularly suitable for limited sweep applications with oscilloscopes.

Both of these drives can be attached readily to either the G-R Type 907 or Type 908 Dial. These dials can be used on many instruments not now equipped with them. The Type 908 Synchronous Dial Drive (either model) is moderately priced at $27.50.

Write for Complete Data

GENERAL RADIO Company

275 Massachusetts Avenue, Cambridge 39, Massachusetts, U.S.A.

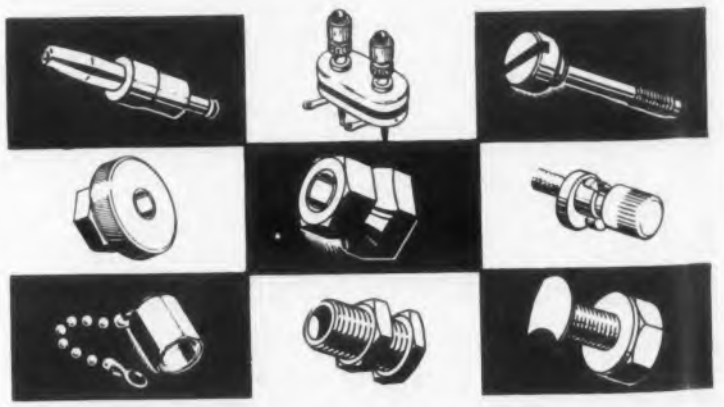
Broad Avenue at Linden, Ridgefield, N. J. **NEW YORK AREA** — 920 S. Michigan Ave. **CHICAGO 5**
1150 York Road, Abington, Pa. **PHILADELPHIA**
8055 13th St., Silver Spring, Md. **WASHINGTON, D. C.** — 1000 N. Seward St. **LOS ANGELES 38**

CIRCLE 201 ON READER-SERVICE CARD FOR MORE INFORMATION

DRESS UP with USECO

Dress Up your instrumentation with the finest electronic hardware from USECO. Increase sales appeal. Precision workmanship. Sparkling quality plating. All meet MIL specs. Prompt deliveries. 135 Jobbers and 31 Representatives to serve you. For name of nearest, write Dept. 7.

Complete line of standardized electronic hardware, terminal boards and etched circuits. Over 500 items. World's most complete stock of plated terminal lugs.



U. S. ENGINEERING CO., INC.
A Division of Litton Industries, Inc.
5873 RODEO ROAD • LOS ANGELES 16, CALIFORNIA

CIRCLE 202 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetic Control Systems 203

An 8-page illustrated booklet TD 52-670 on magnetic controls and logic functions for industrial control is available The booklet discusses the basic "and," "or," "not," and "memory" logic functions; the circuitry providing these functions, including the basic Ramey magnetic amplifier circuit; and current applications to industrial control. Westinghouse Electric Corp., P.O. Box 2099, Pittsburgh 30, Pa.

Vibration Mountings 204

A new 16-page bulletin entitled "Plate Form and Multiplane Mountings" contains engineering data, performance curves, specification tables, details on the design and use of plate mountings and multiplane mountings. The latter isolate vibration regardless of the direction of disturbing force. This feature makes them particularly useful to the aircraft and guided missile industry. A guide to selection and illustrated application and installation information is included. Lord Mfg. Co., 1635 W. 12th St., Erie, Penn.

Silver Bearing Soft Solders 205

A 2-page technical bulletin, No. 3, on silver bearing soft solders is now available. Included in the bulletin are a graph for determining proper alloy use and information on silver scavenging, alloy selection, applications and available alloys. Alpha Metals, Inc., 56 Water St., Jersey City, N.J.

Rotary Solenoids 206

An 8-page booklet has been prepared to describe and illustrate a line of high-torque rotary solenoids. The solenoids feature instant starting, very high torque in relation to size, uniform force throughout the stroke, and rugged construction. They function under extreme conditions of vibration thus meeting all military aircraft specifications. The booklet contains a dimensional chart, mechanical supplements and 8 complete engineering data charts. Oak Mfg. Co., 1260 N. Clybourn Ave., Chicago 10, Ill.

Regulated DC Power Supplies 207

This 3-page bulletin describes in detail the 2K series of transformers and chokes for electronically regulated power supplies. Schematics and block diagrams are included. Sterling Transformer Corp., 29[illegible] N. 7 St., Brooklyn, N.Y.

Photoelectric Controls 210

A revised bulletin, PA 561, is offered on photoelectric controls. The 24-page illustrated brochure contains detailed specifications, descriptive data and operational charts on "packaged" photoelectric systems for industrial control applications, including conveyor control, counting, inspecting and sorting, smoke detection and high-temperature measurement and control. Introduced is a line of miniature and subminiature photoelectric receivers and light sources which allow new control applications. Electronics Corp. of America, Photoswitch Div., 1 Memorial Drive, Cambridge 42, Mass.

Convergence Dot Generator 211

The model V-6 convergence dot generator, its features, applications and specifications, are described in an illustrated spec sheet. The unit is used for adjustment of the convergence of shadow mask tri-color kinescopes, and also checks linearity of color and monochrome monitors or receivers. Foto Video Laboratories, Inc., Eagle Rock Bldg., 25 Smith St., Little Falls, N.J.

Electric Ovens 212

A 4-page brochure illustrates and describes mechanical convection ovens, muffle furnaces, gravity type ovens, mechanical recirculating, and indicating pyrometers. Construction and listing of 8 models, with operating ranges, power requirements and prices are shown. Blue M Electric Co., 138th & Chatham St., Blue Island, Ill.

Digital Printers 213

Digital printers are the subject of a 12-page manual which covers all operating specifications. Details on many types of special calculating and printing techniques are also provided. Victor Adding Machine Co., 3900 N. Rockwell St., Chicago 18, Ill.

TV Quality Control 214

A quality control brochure describes the company's attention to product quality in television manufacturing. The booklet details in 16 pages the quality control steps taken in each of four sections on machines, materials, methods and men. Motorola Inc., 4545 W. Augusta Blvd., Chicago 51, Ill.

Low-Torque Gauges 217

A 4-page bulletin describes six models of Torque-Watch dial-reading gauges that measure extremely low torque (starting and moving) on such devices as potentiometers, servo mechanisms, spring mechanisms, gear trains, magnetic clutches, and small motors. The bulletin gives mechanical data and specifications, ranges and direction of measurable torque for each model; lists and illustrates features and uses. Waters Mfg., Inc., P. O. Box 368, So. Sudbury, Mass.

Printed Circuit Data Book 218

A 16-page copper clad technical data book has been released explaining the principles and some of the problems of printed circuitry. It advises on the proper selection of laminates, and tells how to make a printed circuit using both the photo engraving and silk screen methods. It also covers the subjects of plated circuits, plating through holes, flush circuit production and circuit fabricating. Formica Corp., subsidiary of American Cyanamid, 4614 Spring Grove Ave., Cincinnati 32, Ohio.

Automatic Instrumentation 219

A 12-page folder, No. 716, on automatic instrumentation components and systems is now available. Among the devices illustrated and described are resistance bridge indicator 101B, voltage ratio indicator 301B, miniature bridge balance BP-18A, warning system 401 RB and RBI systems for automatic digital recording of data. Fairchild Engine & Airplane Corp., Fairchild Electrotechnics Div., 118 E. 16th St., Costa Mesa, Calif.

Loudspeakers 220

A 24-page catalog, No. 1070, on Professional Series loudspeakers has just been issued. The catalog lists information on projectors drivers, rectangular horns, transformers, high fidelity and other equipment. Jensen Mfg. Co., 6601 S. Laramie Ave., Chicago 38, Ill.

Alnico Magnets 221

Catalog No. 200 describes and illustrates many of the stock-size Alnico magnets available. Horseshoes, rods, bars, discs and channels are shown together with dimensions and rated pulling power. Also included are representative costs of cut-to-size segments and their line of heavy duty, high powered retrieving magnets rated from 40 to 125 lbs pull. Park Magnet Co., Highland Park, Ill.

precision

TEFLON and KEL-F

parts

Quality controlled "from powder to part"—U.S.G. precision-molded or machined parts from TEFLON*, KEL-F†, BAKELITE° Fluorothene and other plastics meet exacting specifications, cut assembly costs, assure uniform density and dimensional stability, uniform electrical, chemical and physical characteristics of the highest quality.

Come to "Fluorocarbon Plastics Headquarters" for all your requirements—for precision parts or for the world's largest stock of sheets, tape, tubing, rods, bars, cylinders, beading, electrical spaghetti, extruded shapes, and the new Cementable Teflon tape and sheets.

Write for Catalog No. 300.

U S G BELMONT

* duPont's Trademark for its tetrafluorothylene resin.
† Kellogg's Trademark for its trifluorochloroethylene resin.
° Bakelite Trademark.

UNITED STATES GASKET CO.

CAMDEN 1, NEW JERSEY

CIRCLE 222 ON READER-SERVICE CARD FOR MORE INFORMATION

Polyethylene Pillows 224

Recently published is a 1-page catalog sheet describing the design and application of polyethylene pillows, devices to reduce evaporation of liquids in open vessels. The illustrated sheet lists prices and also gives information on polyethylene and polyvinyl chloride corrosion resistant tanks. American Agile Corp., P. O. Box 168, Bedford, Ohio.

Thermistor Overheat Detectors 225

An illustrated bulletin, MC-134 describes a line of thermistor overheat detectors for aviation service. The bulletin discusses the advantages of thermistor elements for temperature detection which include stability and compactness and permit leads up to 200 ft long and relatively simple circuitry. Applications are depicted, and physical and performance specifications are listed. Fenwal Inc., Ashland, Mass.

Retaining Rings 226

An illustrated catalog gives data and specifications on Industrial retaining rings. Listed in the catalog are 24 sizes in open type retaining rings for shafts measuring 1/25 to 1 in., 37 sizes in internal retaining rings conforming to NAS 50 for housings measuring 1/4 to 2-1/16 in. in diameter, and 48 sizes in external retaining rings conforming to NAS 51 which fit shafts from 1/8 to 2-1/4 in. Industrial Retaining Ring Co., Dept. P 29, 57 Cordier St., Irvington 11, N.J.

Hollow Aluminum Bar Stock 227

An illustrated technical brochure gives details on hollow aluminum bar stock. The 8-page publication discusses tolerances, mechanical properties and applications and offers case studies and comparison charts. Complete tables of the standard sizes available in round and hexagonal stock, listing the wall thicknesses, dimensions, and weight per foot are also included. Harvey Aluminum, 19200 S. Western Ave., Torrance, Calif.

Motors 228

Two 11-page catalogs GEC-1026A and GEC-1027A give buying information on a selected group of the company's motors. Included are application data, ratings and prices for fractional hp motors, integral-horsepower polyphase and single phase induction motors, motors and control, for part-winding starting, gear-motors and resilient-base integral-horsepower induction motors. General Electric Co., Schenectady 5, N.Y.

Receiving Tubes 231

Chart ETD-1163-C for quick selection of G-E series-string receiving tubes has been revised to include 600 and 450 ma controlled heater warm-up tubes. The chart classifies 52 tube types in the 600 ma series and 24 types in the 450 ma series according to elements, typical service, heater voltages, maximum ratings, and gives average characteristics. The 450 ma types are for use in medium to small size series-string TV receivers where reduced heater wattage eases ventilation design problems in compact cabinets. General Electric Tube Sales, 1 River Rd., Schenectady, N.Y.

TV Parts 232

A recent catalog lists component parts for TV multi-outlet systems for both color and black and white. Included are a complete line of amplifiers and pre-amplifiers, line splitters, and line taps, as well as the model 704A field strength meter, a portable precision testing instrument for balancing master antenna systems, checking cable losses and locating and orienting antennas. The catalog also explains free engineering and layout services. Jerrold Electronics Corp., 23rd & Chestnut Sts., Philadelphia 3, Pa.

Tape Playing Time Chart 233

A chart has been issued which shows playing time for standard lengths on reels of various sizes. Superseding previous charts, the sheet lists data for standard 1-1/2 mil tape except where 1 mil or 1/2 mil thickness is indicated. The first four columns, for speeds of 1-7/8 to 15 ips. show playing time for single-track tapes. The last two columns, headed 3-3/4 and 7-1/2 ips., are for dual-track recording and recorded tapes. ORRadio Industries, Inc., Shamrock Circle, Opelika, Ala.

Temperature Controls Catalog 234

MC-135 is a 6-page catalog outlinning the company's complete line of Thermoswitch temperature controls. Literature gives physical specifications, performance data and temperature ranges. Also described are modifications and special features, such as moisture-proof seals, armored cable, extended shell, and temperature-setting knob and dial, which can be supplied to adapt the switch to varied service requirements. Fenwal Inc., Ashland, Mass.

Electronic Systems Specialists

SYLVANIA'S rapid growth is almost twice that of the electronics industry as a whole... think what this can mean to *you* in opportunity and rapid advancement. And Sylvania helps underwrite your advanced studies in leading universities in both locations ...because we want you to assume greater responsibility and leadership. Here are some typical problems being solved by Sylvania engineers and physicists in our Buffalo, N. Y. and Waltham, Mass. laboratories.

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2. *If you know which bits of a code group are in error, can you modify the hamming code to use these data to provide maximum information capacity in a noisy channel?*

3. *Can you design a crystal mixer to operate with latest production type crystals and having a noise figure less than 12db above KTB operating in the "S"-band?*

AT WALTHAM:

4. *What are the statistical factors to be considered in calculating the detection probability of a search radar?*

5. *What is the effect of atmosphere turbulence on high gain antenna performance?*

6. *How is the sidelobe level of a radar antenna effected by random perturbations of phase and amplitude over the aperture?*

7. *How does the AGC bandwidth effect the accuracy of angle-tracking?*

If you believe that you can assist us in the solving of these problems, please write:

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Your inquiries will be answered within 2 weeks.

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Miniature Electrolytic Condensers 237

Bulletin H covers a complete line of miniature electrolytic condensers which are encased in solid-drawn single-ended aluminum cans spun on to plastic end plugs to give a moisture proof seal. Included are a dimension chart and data on tolerance, power factor and leakage current. Gary Wells Co., 3 Park Row, New York 38, N.Y.

FHP Electric Motor 238

A 4-page illustrated brochure describes features and applications of the AL-4 micromotor. Included are standard ratings, a dimensions diagram and a detailed cutaway photograph. The Redmond Co., Inc., Owosso, Mich.

Microlite Insulation 239

Form WML-5 provides information on Microlite insulation. The 4-page brochure tells how and of what Microlite is made and cites its uses which include heating and air conditioning systems, and industrial applications. L.O.F. Glass Fibers Co., 1810 Madison Ave., Toledo 1, Ohio.

Research and Engineering 240

An illustrated 4-page brochure describes the company's electronic research and development facilities. Infrared, electromechanical, optical, electronic, communication and navigation, and control and data systems engineering capabilities are cited. Fields of interest and completed contracts are listed. Servo Corp. of America, 20-20 Jericho Tpke., New Hyde Park, N.Y.

External Cotter Data 241

Dimensional data and price information of 14 standard external cotters are presented in a data sheet which is now available. Pin dimensions for each cotter are also given. Hunter Spring Co., Engineering Dept., Lansdale, Pa.

Coated Yarns 242

A 5-page folder describes application, properties and yarn data on glass and colored glass yarns coated with vinyl, teflon, and silicone. Data information is given according to yarn size and average yards per lb. Chemo Textiles, Inc., West Warwick, R.I.

Movies In Engineering 244

Information about recent advances in film sensitivity which have extended the scope of high speed movies for industry is provided in a 12-page booklet. Five illustrated case histories are used to show how such movies have helped to solve engineering problems. In addition to facts on lighting, speed selection, and lenses for a high speed camera, the pamphlet gives data on films for black-and-white movies in the visible spectrum, in full color, and by infrared radiation. Eastman Kodak Co., Rochester 4, N.Y.

Industrial Instrumentation 245

F-403 is a 4-page bulletin which illustrates and describes recording, indicating and controlling instruments required in industrial processing. The systems outlined feature four basic components that can be interchanged to perform a variety of functions, as well as minimize maintenance problems. Robertshaw-Fulton Controls Co., Fielden Instrument Div., 2920 N. 4th St., Philadelphia 33, Pa.

1957 Electronics Catalog 246

Over 27,000 items fill 356-pages in a 1957 catalog of nearly everything electronic. Among many others are detailed listings of test instruments, transistors, tools, wire, photo-electric components, nuclear instruments, sound-powered telephones, counters, program clocks, generators, radio amateur gear, phonographs and TV accessories. The catalog also has sections on recording equipment, electronic kits, technical books, and high fidelity and public address systems and components. There are 160 pages of rotogravure. Allied Radio Corp., 100 N. Western Ave., Chicago 80, Ill.

Electrical Contacts and Rivets 247

A list of 300 standard electrical contacts and rivets available in a wide range of precious and base metals including silver, gold, platinum, palladium, brass, steel, aluminum, copper, and precious and base metal alloys are tabulated in a 4-page specification bulletin. Many cold headed specialties are also illustrated. Deringer Metallurgical Corp., 8131 Monticello Ave., Skokie, Ill.

Patents

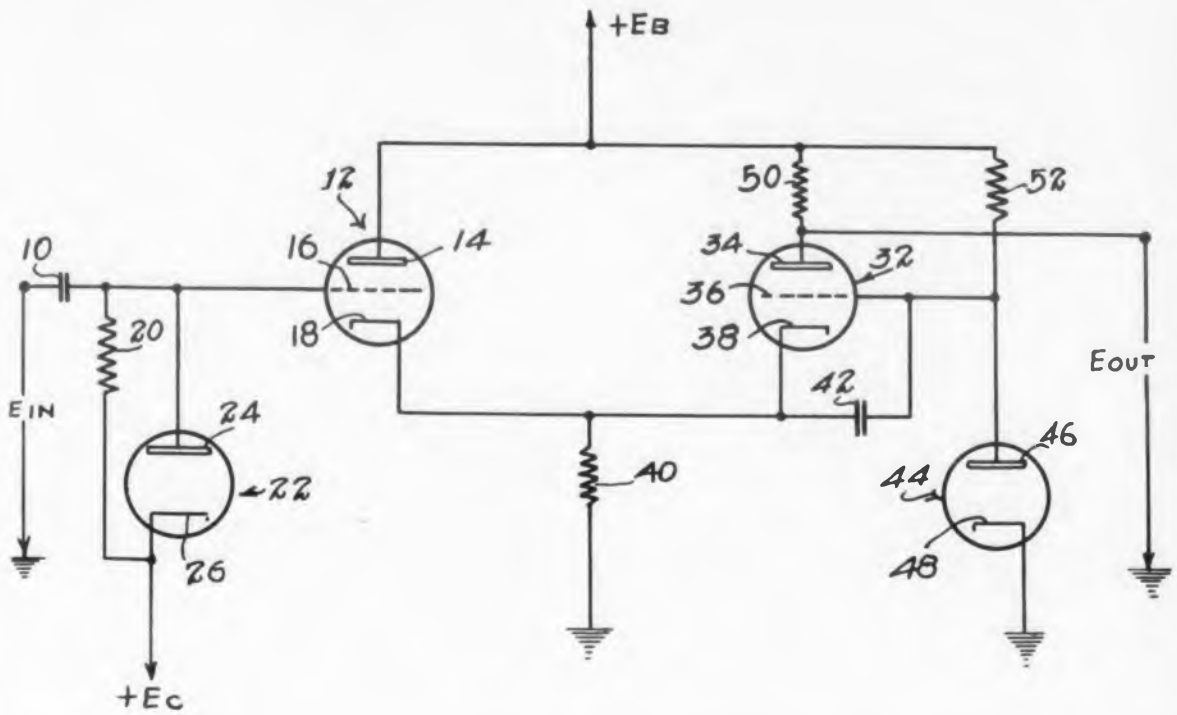
Pulse Width Discriminator Circuit
Patent No. 2,737,684. E. L. Hughes and Harold B. Rose. (Assigned to International Telemether Corp.)

A discriminator circuit is used to decode signals utilizing pulses of different time durations. A simple circuit for accomplishing this result is advantageous. Such a circuit is shown in the figure.

Negative-going input signals are applied at the input terminals and to the control grid *16* of the tube *12* through the condenser *10*. The diode *22* clamps the positive side of the input signal at the bias level E_c. Normally the tube *12* is conducting so that a negative-going pulse biases the tube *12* to non-conducting condition. The diode *44* normally maintains the control grid of the second tube *32* a little above ground potential. Since the tube *12* and the second tube *32* have the same cathode resistor *40*, the second tube *32* is normally biased to a non-conducting condition.

When a negative-going input pulse renders tube *12* non-conducting, the cathodes of both tubes go to ground potential and a negative-going pulse is transmitted through condenser *42* to the control grid of the second tube. With a negative potential across this condenser, the diode *44* becomes non-conducting. With the diode *44* cut off, the condenser *42* begins to charge in a positive direction through the resistor *52* from the power source $+E_b$. If the pulse is of short duration, the condenser does not have time to charge to a potential level to render the tube *32* conducting. Termination of the input pulse restores the circuit to initial condition without generation of an output signal.

If, now, a pulse of sufficiently long duration is applied at the input terminal, the condenser 42 charges to a potential, and hence places a potential on the control grid 36, that renders the tube 32 conducting. A pulse is then generated at the anode of the tube 32 to which the output terminal is connected. The tube 32 continues to conduct, until the end of the negative pulse at the input. Termination of the input pulse restores conduction through tube 12 and cuts off tube 32 to terminate the output pulse.



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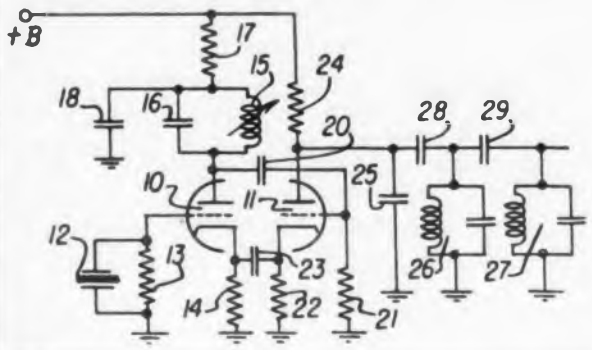
CIRCLE 347 ON READER-SERVICE CARD FOR MORE INFORMATION

Oscillator

Patent No. 2,740,891 W. W. Bowser (Assigned to Motorola, Inc.)

An oscillator which is to give accurate control of the frequency generated, utilizes a crystal to maintain frequency stability. It is impossible to manufacture crystals with such precision that they have precisely the desired frequency. As a consequence, it has been necessary to "warp" the crystal in order to shift the oscillator frequency to that desired. In prior circuits, such warping of the crystal rendered the oscillator circuit unstable. An oscillator which maintains its frequency stability, irrespective of some variation in its frequency from the natural frequency of the crystal, is advantageous. Also, in superheterodyne receivers it is easier to warp the oscillator frequency somewhat so that the received signal will have a frequency between that of the intermediate frequency amplifier and the discriminator which may be slightly mistuned.



In the circuit illustrated in the figure, the crystal *12* is in the grid circuit of tube section *10*. A tuned oscillator circuit *15*, *16* is used in the plate circuit. Feedback is obtained through a cathode follower tube section *11*, the control grid of which is coupled to the plate of the oscillator tube *10* by a coupling condenser *20*. Feedback is secured through the condenser *23* between the cathodes of the two tubes. Tuned circuits *26* and *27* may be provided in the output circuit for frequency multiplying.

The circuit illustrated has a relatively flat frequency characteristic over a relatively wide frequency range. It also provides a stable circuit irrespective of the fact that the oscillator generates a frequency which is not the same as the natural frequency of the crystal. The patent describes variations of the circuit by which a flatter frequency characteristic is secured over a wider frequency range. One such variation includes an inductor in series with the crystal. The circuits in addition to providing a highly stable oscillator in operation also gives adequate output.

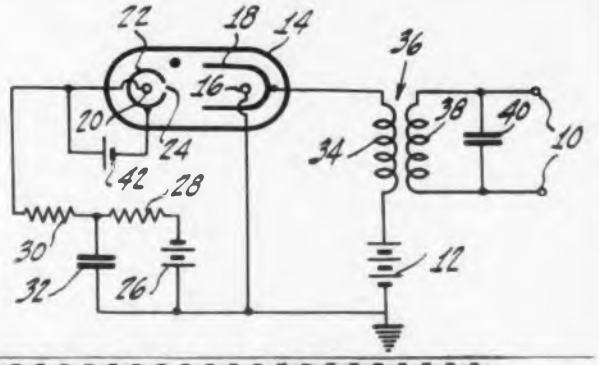
Electronic Inverter System

Patent No. 2,730,669. W. M. Webster, Jr. (Assigned to Radio Corp. of America.)

The conversion of a dc potential into an alternating voltage has been accomplished by the vibration of a reed contactor which makes and breaks the circuit. The vibration of the reed is secured electromagnetically. The voltage output from this type of inverter is not sinusoidal and requires additional circuit elements to give it this form. In addition, arcing deteriorates the contact surfaces of the reed and contact point. The circuit and tube accomplishes the conversion of a dc potential into an ac sinusoidal voltage wave entirely electronically.

The circuit uses a so-called separate function gas tube which separates the functions of ionizing the gas in the tube and of the conduction of current through the tube. This type of tube is illustrated in the figure and the ionization of the gas in the tube is secured by battery *26* which charges capacitor *32* through resistor *28*. The potential on the capacitor increases as it becomes charged until it reaches a potential to ionize the gas and current can pass through the tube between electrodes *20* and *16*. Electrode *22* is a so-called constricting electrode in that it surrounds cathode *20* and has a narrow slot *24* directed towards main cathode *16*. Current flow between cathodes *16* and *20* discharges the capacitor until the current becomes too low to support gas ionization. Consequently, current ceases and the capacitor again begins to charge from battery *26* for the next discharge.

When the gas within the tube is ionized, current flows between cathode *16* and anode *18* through the primary winding of transformer *36*. The dc potential is supplied by battery *12* whose potential is sufficient to support current flow when the gas is ionized but insufficient independently to ionize the gas. The output across tube terminals *10* is a sinusoidal wave. Battery *26*, however, supplies a potential sufficient to ionize the gas and controls the flow of current between electrodes *16* and *18* and the circuit including primary winding *34*. Capacitor *40* across the secondary winding of the transformer improves the wave form.



Books

Handbook of Basic Circuits TV-FM-AM
Matthew Mandl, The Macmillan Co., 60 Fifth Ave., New York, N.Y., 365 pages, $7.50.

A unique book which presents 136 commonly used TV, FM and AM circuits in a manner for easy reference. Each circuit is a representative one. Accordingly, the reader will find in this one volume virtually every one of the standard circuits, each presented in sufficient detail to provide a basis for recognition and understanding of any design variations he may meet. Because many basic circuits are common to other branches of electronics, the illustrations and descriptions are applicable to industrial and commercial electronics.

For each of the circuits described there are: (1) a schematic diagram, (2) a description of the place the circuit occupies in electronic equipment, (3) a discussion of the purpose of the circuit, and (4) a description of its characteristics and function. Mathematics and formulas have been held to a minimum, thus allowing discussions of circuit theory and applications to be kept as simple as possible.

Essential reference data will be found in the Appendixes. Included are: a classification of amplifiers, standards for color and for monochrome television, block diagrams of complete receivers and transmitters, and summaries of the operational theory of complete communications units.

Electrical Interference
A. P. Hale. Philosophical Library, 15 East 40 St., New York 16, N.Y., 122 pages, $4.75.

From a practical point of view, a valuable feature of the book is the series of TV displays showing the effects on the picture of different types of interference. Chapter headings are: Causes of Interference; Effects of Interference; Receiver Aerial Systems; Measurement of Interference Levels; Location of Sources of Interference; Avoidance of Interference; Basic Filters—Safety; Practical Filters—Faraday Cages.

Mechanical Design For Electronic Engineers
J. H. Garner. D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N.J., 223 pages, $5.00.

Written by a Britisher, this book discusses mechanical designs of electronic equipment and methods of production with which electronic designers should be familiar. It is especially interesting because of illustrations which show methods of construction different from practices generally encountered in the U. S.

Chapters include: Standard Rack Systems; Apparatus Cabinets; Chassis and Sub-Panel Construction; Accessibility For Servicing; Ventilation and Cooling; Anti-Vibration Mountings; Sheet-metal Working; Finishing Processes; Printed Circuits and Printed Components; Potting of Components; Labelling Panels and Cables; Soldering, Brazing and Stripping; Coil Winding; Codes of Practice and Specifications; Special Service Valves (tubes.).

Automatic Digital Computers
M. V. Wilkes. J. Wiley & Sons, 440 Fourth Ave., New York 16, N.Y., 305 pages, $7.00.

This book is intended to provide a general introduction to the principles underlying the design and use of digital computers. It covers the subject now generally known as "logical design" without entering into a detailed discussion of electronic circuit techniques. It also deals with the way in which programmes are constructed, and methods by which the machine itself can be made to assist the programmer in his task. Discussion of what operations need to be programmed to solve particular problems, the subject of numerical analysis, is outside the scope of this book. A typical machine is described in some detail. References are made to a number of other machines to illustrate specific points.

Commercial Waxes, A Symposium and Compilation
H. Bennett. Chemical Publishing Co., Inc., 212 Fifth Ave., New York, N.Y., 688 pages, $15.00.

A very thorough treatise on waxes, not directed to any specific industry, this second edition should be an excellent reference on the subject for it discusses all waxlike substances of various chemical compositions. Chemical properties, origin or manufacture and applications of waxes are covered in detail. A glossary and wax formulary are also included.

Abstract

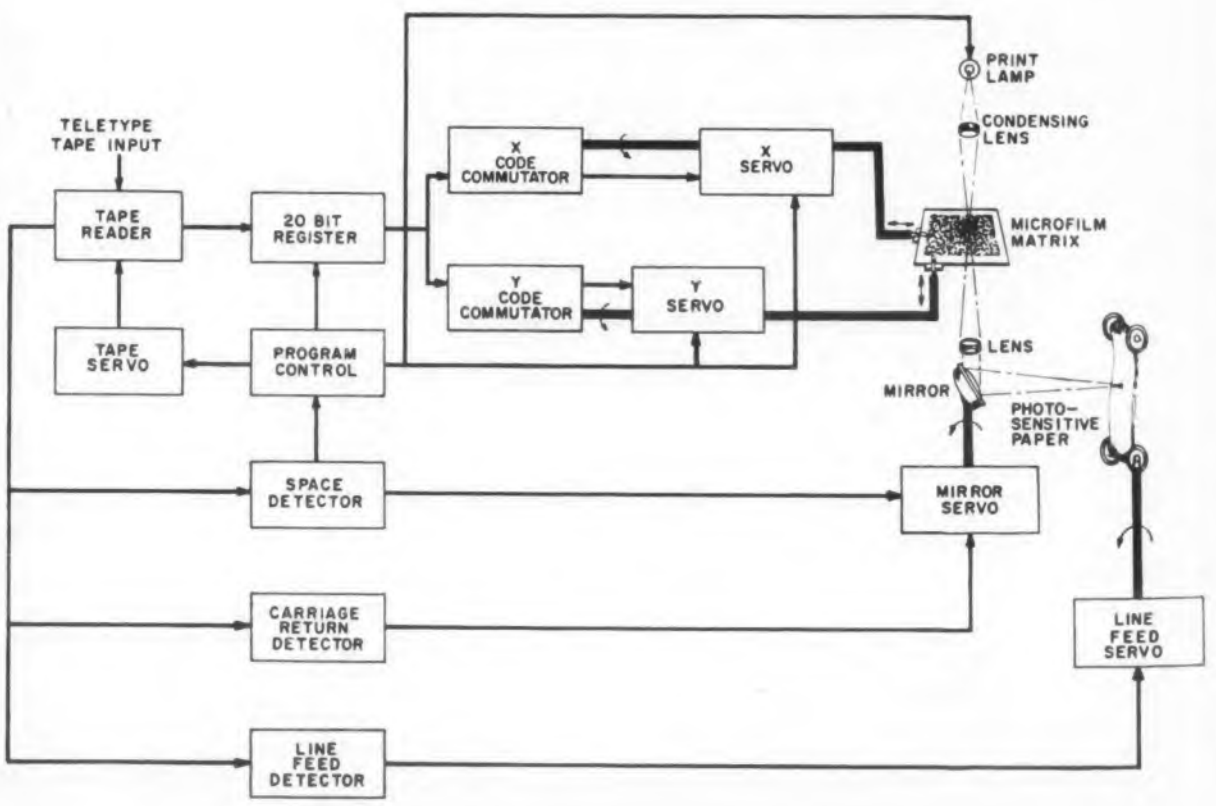
Automatic Micro-image File

THE data storage and retrieval device described here provides rapid access to any one of 10,000 information-containing frames recorded in miniature on a 10 in. square sheet of microfilm. Operating continuously, it automatically searches the microfilm and photographically prints out one frame every two seconds. Designed and built by M. L. Kuder of the electronic instrumentation laboratory of the National Bureau of Standards, the device is intended for use in Government agencies.

Particularly applicable where large volumes of data must be assembled in a predetermined sequence from a master random file, information may be in the form of pictures, drawings, fingerprints, sets of numbers, letters, or other symbols, or even single stages of electronic circuit diagrams. Quantity and kind of data are limited only by the size of the individual frame (1/10 in. square) and the photographic resolution of the film emulsion.

Input to the machine is from a perforated teletype tape containing the coded locations of the desired frames in the order in which they are to be printed out. The assembled data produced by the machine comes out on a 10 in. wide strip of photosensitive paper of any required length. Individual frames are enlarged to 1/2″ squares. Commercial automatic developing equipment processes the photographic paper.

The instrument is essentially a combination of digital computer electronic circuitry and a pair of precision servomechanisms that search X and Y axes of the matrix. The location of the desired frame is fed into a 20 bit (binary digit) register from the teletype tape. The register consists of a capacitor memory and coin-



Block diagram of automatic micro-image file system.

idence identification circuitry. The first 10 bits recorded in the register control the Y position selection while the second 10 bits control the X position.

The matrix is supported on a 10-in diam drum. The drum is servo-controlled in both linear and rotary axes of motion, corresponding to the X and Y axes of the matrix. The servos that shift the matrix to the chosen coordinates are mechanically coupled with precision gearing to two code commutators.

The code commutators, one associated with each axis, control the coordinate positions to which the matrix is located. These commutators are photoetched with one hundred 10-bit numbers corresponding to the standard teletype binary bit code. The two particular positions on the commutators are selected by a serial mechanical search with contacting brushes until a code combination is found that matches the binary bits recorded in the 20-bit register. Magnetic clutches and brakes provide rapid starting and stopping of the drum with uniform overtravel in locating every position on the matrix. A single induction motor supplies all motive power to the machine.

At the beginning of the cycle of operation, a teletype tape reader reads a 4-decimal-digit code. A space symbol is customarily inserted in the teletype tape following each 4-digit number. On detecting this space symbol, the machine's program control stops the tape reader, engages the magnetic clutches on the X and Y servos, and looks for the compatible code on the two coordinate axes. When the compatible code is found, the clutches disengage and magnetic brakes stop the drum. A print lamp is briefly turned on to make a photographic exposure of the selected microfilm frame on the photosensitive paper. When the exposure is completed, the teletype tape advances to the next instruction, the drum returns to its zero position, and the machine proceeds with the next search cycle.

Fifteen successive frames are printed in a row across the 10 in. width of the print paper by means of a step positioning mirror. This mirror performs a function similar to the character spacing on a typewriter: it automatically advances the image one space on the photographic paper for each printout. Upon completion of a line, a line-feed servo advances the paper a fixed amount.

The instrument recognizes two other symbols, the "carriage return" and the "line feed." These symbols instruct the machine to return the step positioning mirror to its zero position, and to advance the paper one line. Whenever these functions are desired, they can be inserted into the teletype tape.

Although the machine was primarily designed as an outscriber for obtaining programmed printing from a large file of negatives, it can temporarily be set up as an inscriber to prepare its own matrices of 10,000 frames each. Using the same machine to prepare a matrix insures that each frame will be accurately located whenever it is subsequently used.

Abstracted from the National Bureau of Standards Technical News Bulletin, *Volume 40, No. 7, July, 1956.*

Abstract

Laboratory Testing To Achieve Reliability

IN every company that is engaged in producing a complex system, or even a component of a complex system, there must be individuals who can design, install, and administer a system for achieving reliability. Such a system will always require coordination of men, materials, machines and money.

The probability of success of a complex system is roughly equal to the product of the probabilities of success of all the essential components. The well-known P-overall rule* states, for example, that if each component of a five hundred component system is 99% reliable, the system is only about 1% reliable. This means that to achieve acceptable system reliability, component reliability must be raised by orders of magnitude above that achieved by normal commercial practice.

Also, it is cheaper to make a poor component than to make a highly reliable one. Therefore, to obtain reliability, procurement methods must depart from the lowest bidder method of doing business. This departure has not taken place to a satisfactory extent, at least not in Government procurement.

Further, an engineering product can be made reliable if all modes of failure are known and understood, or if unknown modes are quickly revealed by direct feed-back from service failures. Unfortunately, in the case of complex systems there are many unknown modes, and feed-back is usually feeble. In the case of non-recoverable weapons, feed-back is almost entirely absent.

The ultimate cause of each case of unreliability is some form of human error. To achieve reliability, these errors must be recognized and then controlled.

In a traditional product such as an automobile, errors in design or workmanship cause easily recognized service failures. These failures are reported back very quickly through a sales organization with emphatic demands for immediate corrective action. Technically, corrective action is facilitated by a complete and accurate description of the condition under which failure occurred, and by the return of the failed part. Psychologically, corrective action is aided by easy identification of the responsible person and by the certainty of economic punishment if action is not rapid and effective.

By contrast to more traditional engineering products, consider the case of a part such as small precision snap-action switch that is sold to a gyro manufacturer, who sells to the Air Force. Suppose further that under battle conditions the part fails to function because of the combined effects of high altitude, low temperature, aircraft vibration, maneuvering acceleration, and gunfire shock. If the plane is shot down, the feed-back on the error that caused the failure is lost entirely. If the plane lands, and under static ground conditions the part operates satisfactorily, feed-back is still lost. Even if an Air Force maintenance man discovers and replaces a defective sub-assembly, the only feed-back may be an unsatisfactory material report stating that under certain unknown conditions, an unidentified part of the fire control system failed. With such meager information, it is not possible to identify the responsible manufacturing company, much less the responsible individual, and even if he were reached, he would not possess the facts required to generate corrective action.

This is the problem. The solution is to be found in the full and skillful exploitation of laboratory testing. The control of human errors that cause unreliability has much in common with the control of human errors in civilized communities. In each case, three major steps are required. These steps are (1) indoctrination or preaching of a gospel, (2) evolution of written laws, and (3) evolution of a system of law enforcement that includes a police force equipped for the scientific detection of errors and identification of authors.

In this general plan, reliability coordinators are required to preach the basic principles of reliability, and parts application and quality control engineers are required to write a system of laws in the form of specifications and classifications of defects. The job of police detective must be accomplished by experimental physicists or by test engineers.

The characteristics of the required system are dictated by the types of errors that must be detected and corrected, and by the existing industrial pattern of vendor-buyer relationships. Industrial procurement patterns vary somewhat in different areas and different industries, but the pattern of human errors is universal for all areas and all industries.

Long experience in design evaluation has shown that in complex systems subjected to varied environments, lack of knowledge, understanding or measurement of modes of failure is responsible for about half of all new design failures.

When all modes are known, the designer still may fail to provide an adequate margin between the strength of the part or the stress that will be experienced in service. This is the familiar "Inadequate safety factor error." In calculating safety factors, a single value is assigned to the strength of the part, and another single value to the maximum service stress.

If the part is such that strength variation from item to item is very small, and if maximum service stress is never exceeded, a moderate safety factor of, say, 1.5, provides for reliability. If this variance is not small, a moderate safety factor will not prevent the low strength items from causing failure. Therefore, a designer commits an error whenever he chooses a

*For a thorough treatment of this principle, see Robert Lusser "Basic Lecture on Reliability" obtainable from Redstone Arsenal, Huntsville, Alabama.

part that has inherently large strength variance.

Manufacturing errors include: defective materials or workmanship, inspection errors or limitations and process drift.

"Process drift" includes a wide variety of errors, such as machine tool wear, chemical composition changes, and so on. It is important because components for complex systems are qualified by tests on a first article. Unless subsequent production items are identical, the basis for acceptance becomes invalid.

To detect unknown modes of failure, the only possible procedure is to subject the component to laboratory simulations of every one of the adverse environments to which it will be subjected in service. If possible, the component must be made to function during the applications of the environment. If the adverse effects of several environments are additive, they must be applied simultaneously. For example, it is generally true that the effects of shock and extreme temperature are additive and therefore they should be applied simultaneously.

To measure the actual value of a safety margin, it is necessary to carry the test to failure. A very elementary example of this is the burst test on hydraulic components. To establish that a specified minimum value has been achieved, a nondestructive proof test may suffice.

To detect excessive variance, it is necessary to perform tests to failure, and to do so in a statistically designed experiment.

Control of unreliability in only qualitative terms is satisfactory for guidance in the choice of control methods, but it is not enough to permit decisions on how far reliability improvements must be pushed.

The answer can be provided in two steps. First, the systems engineer must give the component vendor a value for the highest probability of failure in service that can be permitted for each component. In a typical missile, the value might be 10^{-5}. In a radar system, it might be 10^{-6} failures per hour. Then the following can be applied.

$$P_f = \frac{P_o P_i + (1 - P_o) P_s}{1 - P_o + P_o P_i}$$

Where: P_f = Probability of occurrence of a component failure under specified conditions;
P_o = Probability of occurrence of a manufacturing error that will cause failure;
P_i = Probability of occurrence of inspection missing a manufacturing error;
P_s = Probability of occurrence of a strength-stress scatterband overlap.

The error detection system must be able to measure P_o, P_i, and P_s, and when these values are too high, the system must facilitate corrective action.

Abstracted from a talk presented by Leslie W. Ball, Technical Director, United ElectroDynamics Division, United Geophysical Corp., Pasadena, Calif., to the Engineering and Management Course at the University of California, Los Angles 31, Calif.

What the Russians Are Writing

J. George Adashko

Radiotekhnika i Electronika No. 1, 1956

Possibility of Extending the Similarity Concept to Multiresonator Magnetrons with Unequal Numbers of Resonators, I. E. Rogovin (20 pp, 4 figs).

The author derives the equations (similarity criteria) under which the phenomena that take place in the coupling space of a multi-cavity magnetron are similar, and determines the operating conditions under which a magnetron with a certain number of cavities can be considered similar to one with a different number of resonators.

Synchronization of Self-Excited Oscillator using Pulses with Sloping Edges, E. S. Voronin, R. V. Khokhlov (9 pp, 6 figs).

This article contains a theoretical discussion of the use of non-rectangular waveforms, including an analysis of the effects of varying the amplitude and frequency of the synchronizing voltage.

Mutual Synchronization of Reflex Klystrons, R. V. Khokhlov (10 pp, 5 figs).

The Van-der-Pol equations are used to describe the synchronization of reflex klystrons and to illustrate the possibility of a smooth transition from the oscillatory region of one klystron to that of the other.

Photocells and Photomultipliers with Magnesium Cathodes for Ultraviolet Rays, O. P. Dorf, N. G. Kokina, T. M. Lifshits, D. A. Shklover (8 pp, 5 figs).

This report discusses the absolute sensitivity and spectral characteristics of photocells made of magnesium containing various impurities. Experiments have shown that magnesium cells are not affected excessively by impurities, and that a cell with a magnesium cathode and an alloy (activated copper-aluminum-magnesium) emitter has enough sensitivity to record a flux of 10^{-15} watts at 253.7 micromicrons. Reference is made to work by Dunkelman (*J. Opt. Soc. Am.*, Feb. 1955, p 134), Hinteregger & Watanabe (*J. Opt. Soc. Am.*, July 1953, p. 604), and Wainfan, Walker, & Weissler (*J. Appl. Phys.*, Oct. 1953, p. 1318).

Effect of Secondary Electron Emission from Insulators on the Stability of Electron-Tube Parameters, N. V. Cherepnin (13 pp, 14 figs).

The secondary emission from the insulating material (mica) used in vacuum tubes liberates gases that eventually poison the oxide coating on the cathode and cause deterioration of the tube parameters. The article contains a thorough experimental discussion of the process and proposes measures for combatting its ill effects, which are particularly pronounced in miniature tubes. These measures are:

1. Reduce the length of the oxide coating of the cathode to a minimum, thereby reducing the effect of positive charges produced by secondary emission on the edges of the cathode.
2. Increase the surface resistance of the mica insulators and prevent the formation of conducting films by the metals and oxide salts liberated from the cathode. Reducing the cathode temperature is also effective.
3. Increase getter activity.
4. Reduce the working voltages of the electrodes.
5. Replace metal strips on the upper and lower mica members adjacent to the suppressor grids of pentodes or confining electrodes of beam-power tubes.

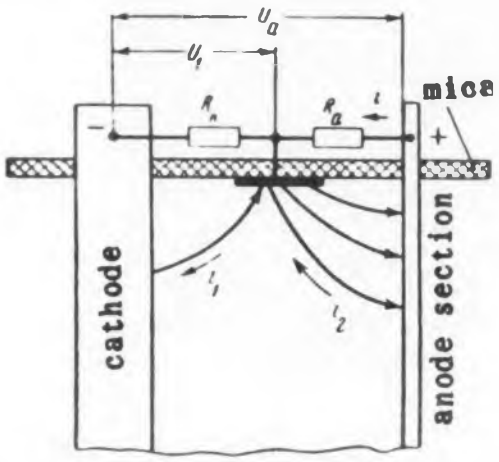


Fig. 1. Diagram of the path of secondary emission and its equivalent circuit. The ratio of the currents flowing into and from the insulator is defined as the emission factor and is a function of the potential U_1 of the emitting portion of the insulator.

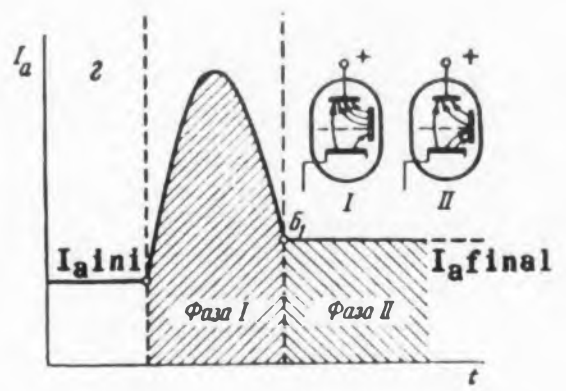


Fig. 2. It can be readily seen that the surface of the insulator is in equilibrium if $i_1 = i_2$, but not all equilibrium points are stable (point B is unstable). This leads to a discrete change in the plate current with time, as shown in the lowest curve, which indicates that after the transient (phase I) produced by the secondary emission the secondary current does not return to its initial value, but settles at a higher level (phase II).

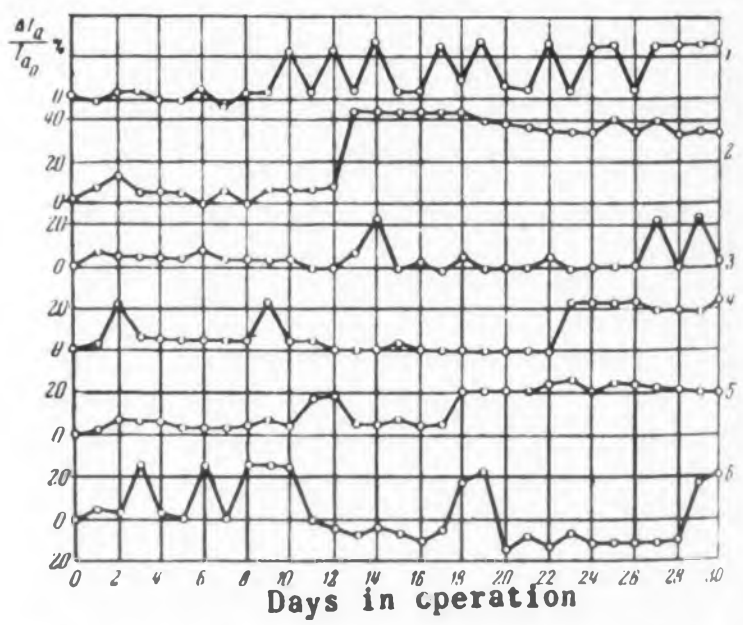


Fig. 3. Differences in plate current of the same 6N2P miniature dual-diode tube measured at intervals of 1-2 days (six tubes tested).

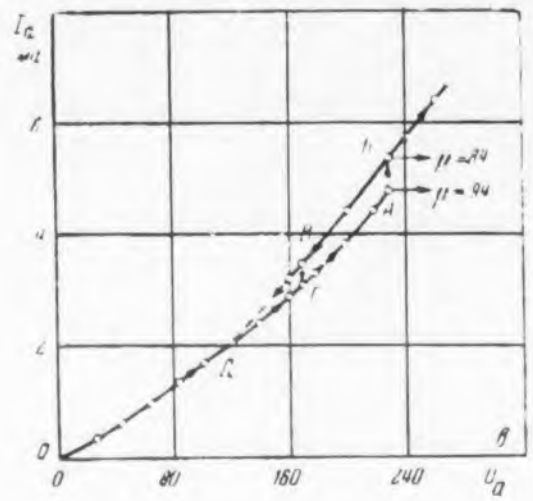


Fig. 4. The nominal amplification factor of the 6N2P tube is 100. In this case it dropped from 94 to 84 at an approximate plate voltage of 230.

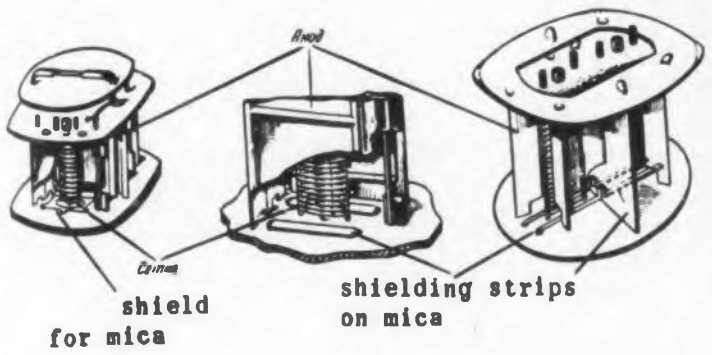


Fig. 5

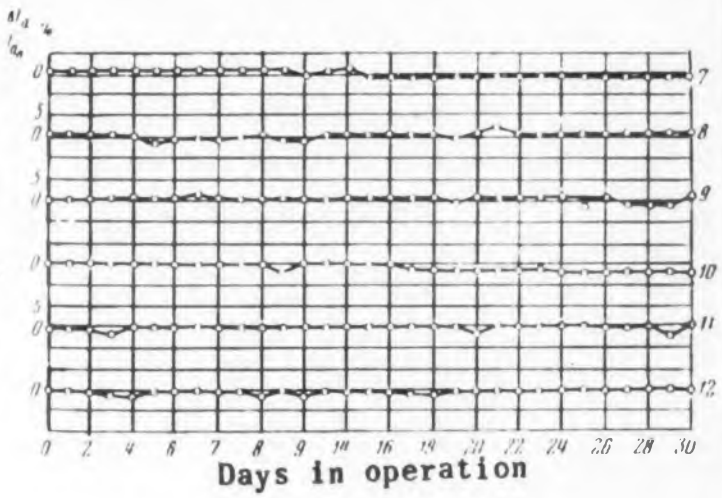


Fig. 6

Figs. 5-6. The secondary emission can be eliminated by using metal screens or strips connected to the cathode. The method used depends on the tube construction. Fig. 6 shows the resulting improvement (six tubes).

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Contact Ratings:	5 amp and 10 amp resistive at 30v d-c or 115v a-c	5 amp and 10 amp resistive at 30v d-c or 115v a-c
Weight (ounces):	1½	6
Size (inches):	1⅞ long 1 5/16 diam.	2⅝ long 2½ diam.
Ambient Range:	—65°F to 250°F	—65°F to 250°F
Vibration & Shock:	Designed to meet Spec. MIL E-5272A	Designed to meet Spec. MIL E-5272A

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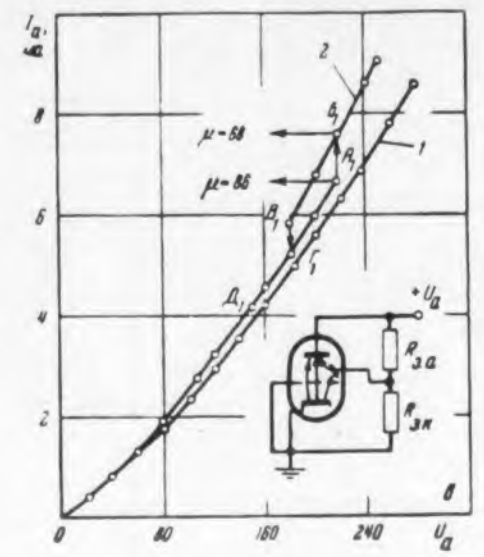

Fig. 7. Demonstration of effectiveness of shielding the mica insulator. If the shields are connected to the plate and cathode through high resistances, secondary emission can again be produced in the tube. Curve 1 is plotted for the case when the upper of the two resistors is infinite, i.e., when no charge can accumulate. Curve 2 is for both resistances finite and shows the re-appearance of secondary emission.

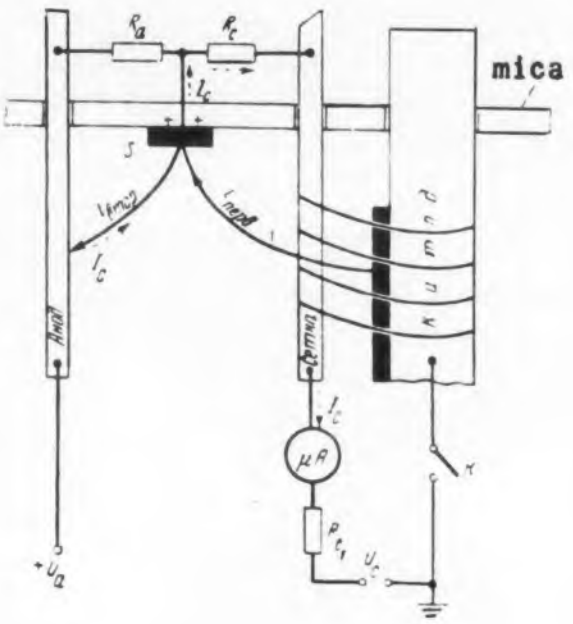

Fig. 8. Secondary emission is also responsible for an unstable inverse grid current in some tubes. The mechanism is illustrated in this figure.

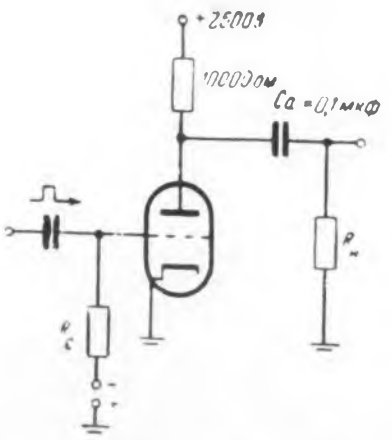

Fig. 9

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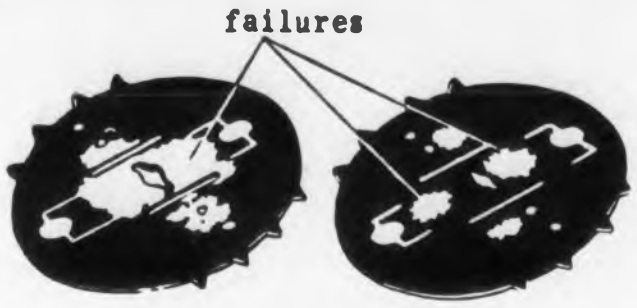

Fig. 10

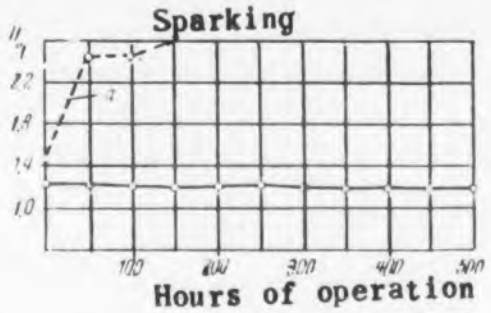

Fig. 11

Figs. 9-10-11. Secondary emission is most dangerous in high-voltage pulse-circuit tubes, such as the GI-3, used in the typical circuit of Fig. 9. Damage can occur to the mica, Fig. 10, and to the cathode of the tube, mostly because the gas and moisture liberated from the insulator cause the tube to spark over. Fig. 11 (curve a) shows that the pulse voltage rises to a dangerous value within 50 hours of operation, followed by sparking in 100 hours. Curve b shows the effect of shielding the mica.

Coherent Electron Beams in Synchrotrons at Centimeter Frequencies, A. M. Prokhorov (8 pp, 5 figs, 2 tables).

This appears to be the first experimental attempt to use a synchrotron to produce power at these wavelengths.

Effect of Semiconducting Film on the Attenuation of a Radio Wave in a Round Waveguide, V. V. Malin (4 pp, 3 figs).

The equations derived in this article are valid only if the film is much thinner than the surface layer of the metal and if the depth of penetration is much less than the wavelength and the thickness of the surface layer in the dielectric. Refers to Ramo and Whinnery (Russian translation, 1950).

Other Articles in this Issue:

"Self-Excited (Cold) Electron Emission and Cathodes," D. V. Zernov, M. I. Elinson (18 pp, 12 figs.); "Distribution of Durations of Overshoots of Normal Fluctuations," V. I. Tikhonov (11 pp, 2 figs., 2 tables); "Shot Effect in Semiconductors," L. I. Pervova (8 pp, 3 figs.).

What The Russians Are Writing

J. George Adashko

Avtomatika i Telemekhanika No. 3, 1956

Electronic Differential Analyzer of the G. M. Krzhyhanovskii Power Institute of the USSR Academy of Sciences, I. S. Bruk & N. N. Lenov (11 pp, 10 figs.). Detailed description of an electronic analog computer for ordinary linear and non-linear differential equations. The computer is housed in a cabinet equal to two and one-half relay racks. It contains 38 operational amplifiers, four multipliers, four functional converters, and one harmonic generator. With this number of components it is capable of solving differential equations of the 20-25th order. A power supply and long persistence CRT are furnished separately.

Among the interesting features of the analyzer is the automatic drift correction circuit (marked BY in Fig. 1), which is essentially a two-stage auxiliary amplifier included in the feedback loop of the operational amplifier (marked OY). The vibrator pulse-modulates the input signal e_1 and the common cathode resistor of the (main) operational amplifier combines the de-modulated amplified signal with the original one to produce the necessary drift correction. One auxiliary amplifier (BY) can be alternately switched to as many as 26 main operational amplifiers (OY). Fig. 2 shows the null drift of an integrator with (2) and without (1) the compensator.

Other interesting circuits are those used for function multiplications (Figs. 3, 4, and 5), the harmonic generator, which produces 8 multiples of the fundamental, and the functional converter which generates prescribed functions of the independent variable (time) which in turn is represented during the solution process by instantaneous values of voltage.

The output can either be photographed from the cathode ray tube (where the output is either shown as a function of time or as a phase-plane sweep) or recorded with a strip-chart oscillographs; the solution can also be stopped at any instant and quantities measured with ordinary instruments. The natural scale permits investigation of processes lasting from several seconds up to 5-10 minutes. Simulation of processes with an ac component down to 10 cy is possible.

The multiplier error does not exceed 1%, that of the function converter is less than 1.5%, and that of the harmonic generator is on the order of 0.2%.

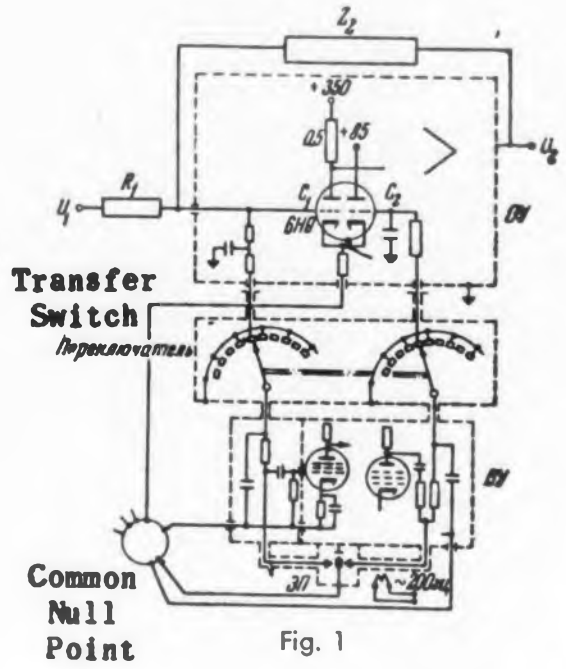

Fig. 1

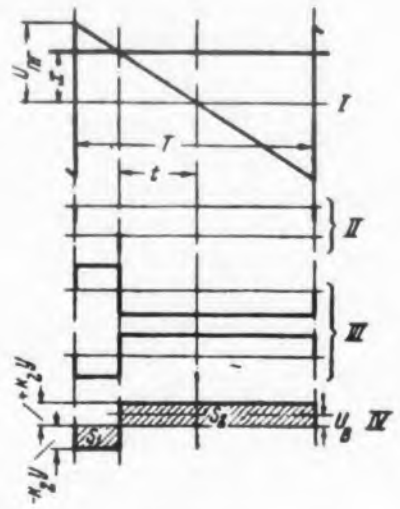

Fig. 3. Block diagram of multiplier. 1—Stable-frequency oscillator; 2—Pulse shaping circuit; 3—Sawtooth pulse generator; 4—Amplitude comparator; 5—Trigger circuit; 6—Sign-reversing amplifier; 7—Diode switch; 8—Operational amplifier

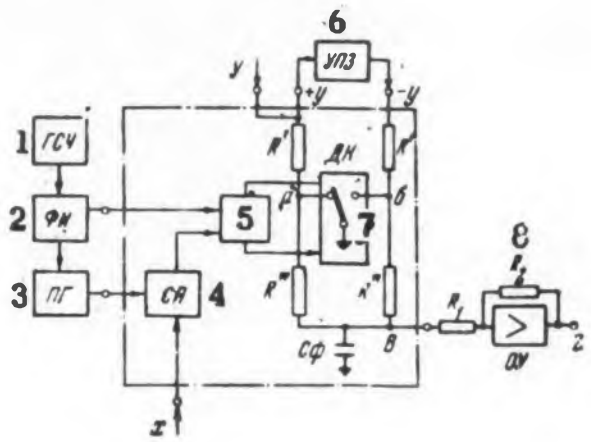

Fig. 4. Principle of operation of multiplier. I—Operation of amplitude comparator; II—Pulses at input of trigger; III—Pulses at output of trigger; IV—Output.

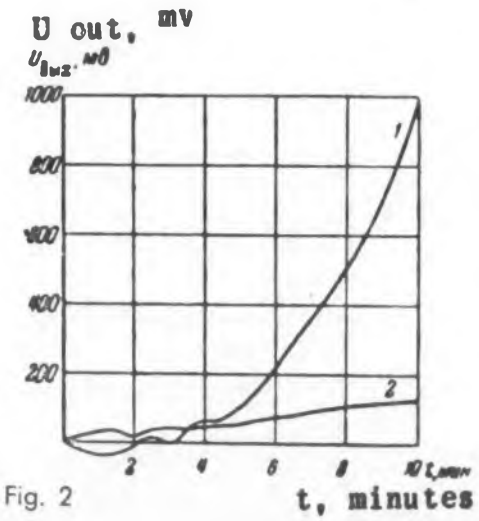

Fig. 2

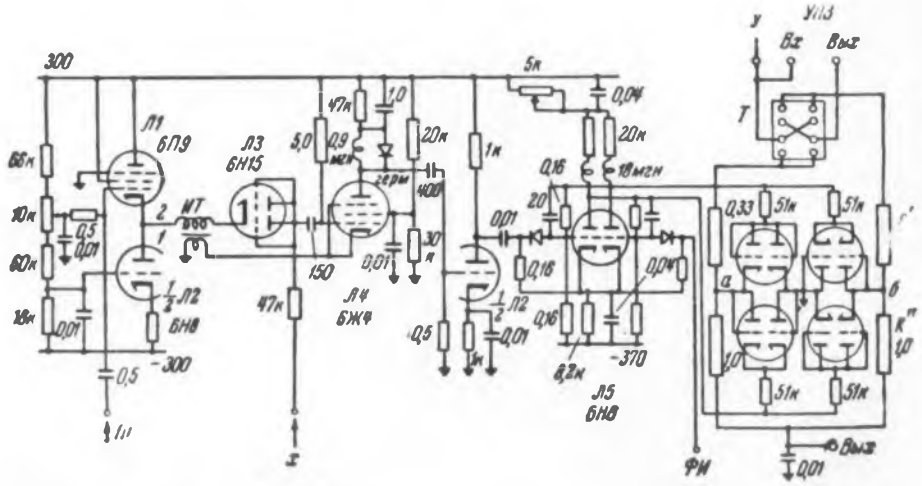

Fig. 5. Schematic of multiplier.

Procedure for Calculating Self-Excited Oscillations in Pneumatic Regulators. A. A. Abdulayev & E. M. Nadzhafov (16 pp; 15 figs).
Approximate frequency-response analysis of the behavior of the widely-used type 04 regulator.

High-Speed Magnetic Amplifiers for Servo Systems Employing AC Motors, A. I. Dem'ianchit (14 pp, 18 figs.)
Description of a newly developed full-wave magnetic amplifier stage which can be cascaded without increasing the time constant excessively. Comparison is made with half-wave amplifier circuits; the author concludes that the use of such amplifier jointly with transistor (or vacuum-tube) preamplifier stages will permit design of ac servo systems with an error-system sensitivity to 0.3 mv per angular minute. References are made to articles by C.W. Lufcy, H. H. Woodson, and P.W. Barnhart.

New Type of Servo System with Corrective Networks, L. N. Fitsner (10 pp, 7 figs).
Describes a particular servo system compensated by first and second-derivative voltages available from a dc analog computer. Refers to an article by Ziebolz and Paynter, "Possibilities of a Two-Time Scale Computing System for Control and Simulation of Dynamic Systems" (*Proc. Nat. Electronics Conf.* vol 1X, 1953), to an article by Moore, "Combination Open-Cycle Closed-Cycle System" (*Proc. IRE*, vol 39, No. 11, 1951), and to work by Ragazzini, Ruthel, and Rendel.

Electric Variable Speed Servo Drive, O. I. Aven, E. D. Demidenko, S. M. Domanitskii, and E. K. Krug (12 pp, 16 fig).
Description of a reversible servo drive using a 250 watt three-phase induction motor controlled by a two stage magnetic amplifier and a vacuum-tube phase-sensitive amplifier. It uses a filter network rather than a tachometer generator for velocity feedback.

Graphical-Analytic Method of Analysis of Characteristics of Magnetic Circuits subject to Joint Action of Constant and Alternating Fields, I. Ia. Lekhtman (10 pp. 10 figs).
Continuation of article in the Sept-Oct 1955 issue of Avtomatika and Telemekhaniga (see ELECTRONIC DESIGN, March 15 issue).

Remarks on the effect of the Presence of Liquids in the Ducts on the Equivalent Mass of the Moving Parts of Hydraulic Regulators, L. A. Zal'monzon (2 pp, 1 fig).
Book Reviews.

Bibliography of Russian and foreign literature on mathematical simulation (with analog computers), 1947-1954.
Very extensive (10 pp and more to come).

Russian Translations

Elektrosviaz' No. 4, 1956

Improving the Stability of Devices that Form a Single-Sideband Signal, A. M. Semenov & M. V. Verzunov (12 pp, 8 figs, 1 table).

One of the major problems in the design of single side-band transmitters is stable suppression of the carrier and second sideband. This article analyses the effect of the asymmetry of the balanced modulators employed for that purpose on the undesired frequency components. A rigorous analysis of the circuits involved is followed by a description of an experimental verification of the theoretical results. The asymmetry can be eliminated by employing current feedback in the af circuit.

Increased Interference between Two Lines Owing to Reflections from the Ends of a Third Line, P. K. Akul'shin (8 pp, 8 figs).

Increased crosstalk between two telephone lines may result from reflections induced by a third line which is not terminated by its characteristic impedance. Qualitative and quantitative effects of this phenomenon are discussed in detail.

Reducing Attenuation in Coaxial Cables, K. K. Sergeeva (6 pp, 4 figs).

Theoretically, the attenuation of a transmission line is minimum when $R/L = G/C$. In actual lines, however, R/L is usually much greater than G/C, and the attenuation can be reduced effectively only by increasing L. In a relatively narrow high-frequency band, say 30-100 kc, this can be done by stranding and twisting the inside conductor of a coaxial cable. Reference is made to an article by G. W. Howe, "The High-Frequency Resistance of Multiply Stranded Insulated Wire" *(Proc. Roy. Soc.*, Vol 93, No A 654).

Shifting Signal Spectra, A. Iu. Lev, B. I. Iakhinson (7 pp, 5 figs).

Discussion of the transformation occurring in a realizable signal when its spectrum is shifted along the frequency scale from one region to another. Determination of the conditions under which such a transformation is reversible. Also discussed are the possibility of effecting single sideband transmission by means of spectrum shifting, and the possibility of synthesizing a signal with shifted spectrum given the discrete ordinates of the initial signal. Refers to articles by D. Gabor *(J. Inst. Elec. Engr.* vol 93 part 3, 1946), Norgaard *(QST*, July 1948), Weaver *(Proc. IRE*, Apr. 1954), J. Kohlenberg *(J. Appl. Phys.* Dec. 1953).

New Method of Computing Losses Produced in Cylindrical Conductors by Proximity Effects, V. N. Kuleshov, (9 pp, 3 figs).

The Carson and Butterworth equations for the propagation of electromagnetic waves along parallel lines, taking the proximity effect into account, are valid only for frequencies up to 50 kc. Approximate equations valid up to 1 mc are derived by using a standing-wave representation of the solutions to Maxwell equations, with the proper boundary conditions imposed.

Harmonic Analysis of Asymmetric Pulses, S. I. Evtianov (11 pp, 9 figs).

Derives equations for the harmonics of asymmetrical plate-current pulses that occur when a vacuum-tube oscillator feeds a complex load. Refer to article by L. E. Dwork, "Maximum Tank Voltage in Class-C Amplifiers," *Proc. IRE*, No. 6, 1950.

On the Theory of the Ideal Receiver, A. A. Kharkevich (7 pp, 14 figs).

"An ideal receiver is one that picks out from among all the transmitted signals the desired transmitted signal where it is most likely to be found." The ideal receiver is alternately defined as one that chooses from among all the transmitted signals the one signal that is nearest the receiver. The article shows that either type of receiver can be the "better" one, depending on the applicable noise-distribution probability.

Procedure for Calculating the Channel Interference between Signals of Short-Wave Radiotelegraph Stations, V. M. Rozov (4 pp, 2 figs, 2 tables).

Experimental determination of effects of interference and fading on telegraph signals.

Monitoring Broadcast Transmission using Averaging (Volume) Meters and using Peak-Value Meters (6 pp, 8 figs).

Abstract made by B.S. Mints of an article by E. A. Pavel, A Gastell, M. Bidlingmaier in the West-German publication *Fernmeldetechnische Zeitschrift*, No. 4, 1955. Comparison of the peak-value level indicator used in Germany having an approximate integration time of 10 milliseconds (depth of modulation meter), with the standard U.S. VU meter, which has a 200 millisecond integration time. The comparison favors the peak-value meter over the VU meter, which usually reads 4-6 db too high.

Abstract—German

Phase Measurement with a Lissajous Ellipse

COVERING the frequency range from 50 cy to 30 mc, the phase meter described here has an accuracy of plus or minus one degree. It uses a Lissajous ellipse for the determination of the phase angle.

Fig. 1 indicates the relationship between the phase angle, the maximum a of the ellipse in the horizontal direction and the inter-section b with the horizontal axis.

$$\sin \varphi = \frac{b}{a} \qquad (1)$$

The maximum beam deflection is assumed to be the same for the two sinusoidal voltages whose phase angle is being measured.

Another expression for the phase angle can be obtained by measuring the large and small axes of the ellipse. If their values are 2A and 2B respectively, and if the maximum deflection is again a,

$$\sin \varphi = \frac{AB}{a^2} \qquad (2)$$

The meter to be described is based on the relationships shown in Fig. 2. Here p and q present distances measured on axes at 45 and 135 degrees respectively. For equal maximum deflections, p equals A and q equals B, and the phase angle can be computed from

$$\tan \varphi/_2 = B/A \qquad (3)$$

By plotting the function tan ($\varphi/_2$) along the B axis and selecting A equal to one, the phase angle can be read off directly.

Fig. 3 shows the block diagram of the complete instrument. The two input impedances are 75 ohms to match the most commonly used coaxial cable. Cathode follower stages provide separation in each channel between the input and an accurately calibrated attenuator. A switching arrangement permits direct application of the attenuator output voltages to individual deflection amplifiers for phase measurements up to 14 mc or conversion to an intermediate frequency of 1 mc, thereby extending the range of the instrument to 30 mc. A band pass filter of 200 kc bandwidth is provided for each channel and a separate discriminator permits measurement of the intermediate fre-

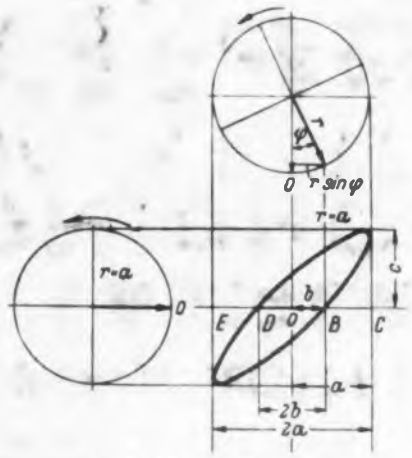

Fig. 1. Lissajou's ellipse.

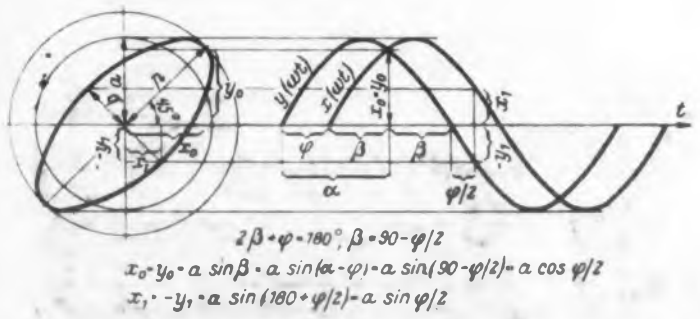

Fig. 2. Relationship between phase shift and Lissajous figure used in the phase meter.

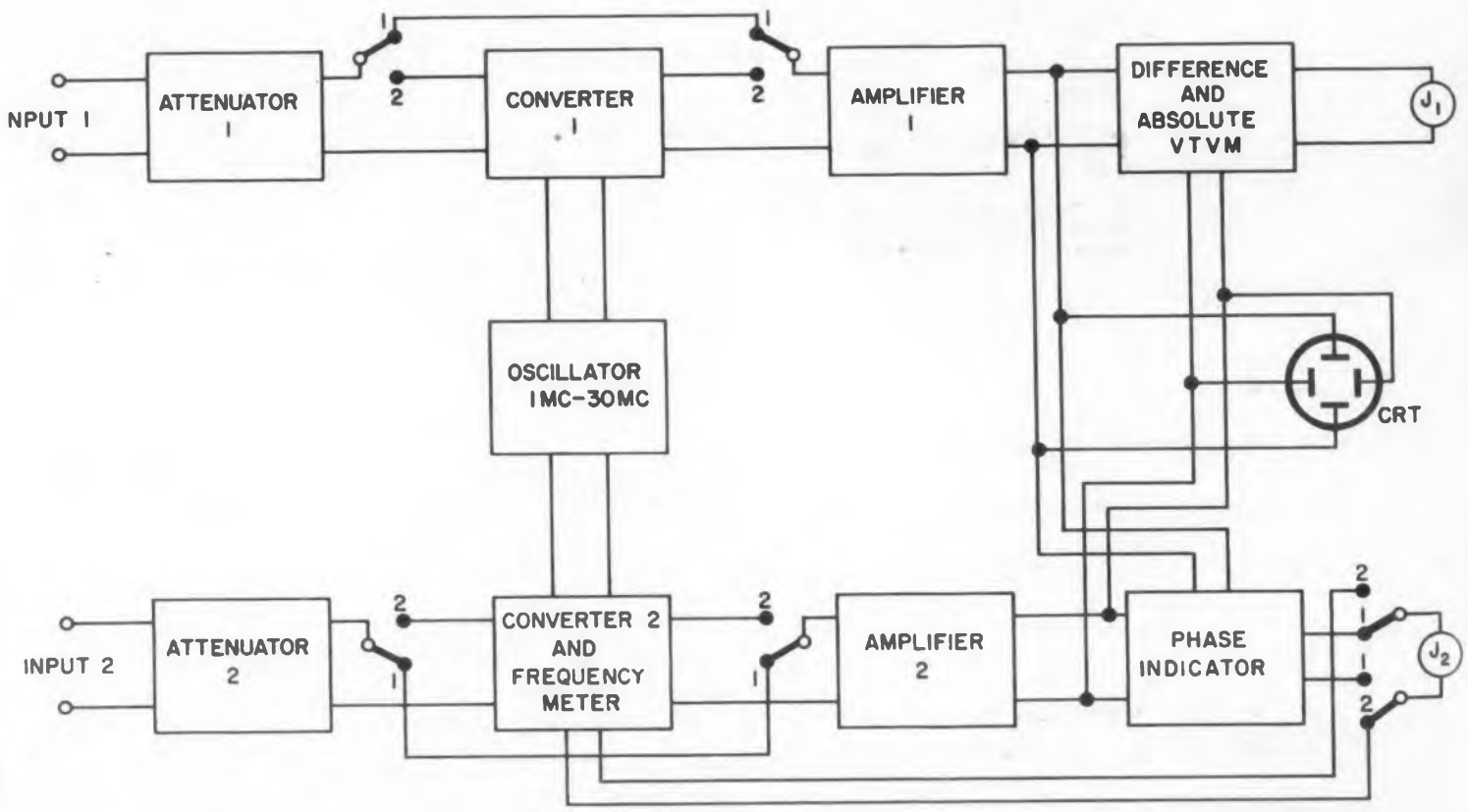

Fig. 3. Block diagram of phase meter.

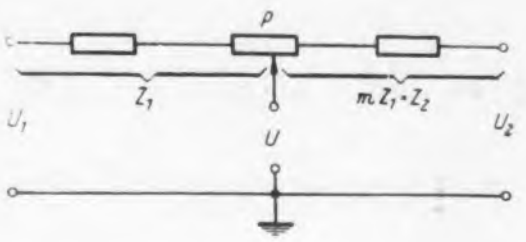

Fig. 4. Simple method for phase measurement with an indicating instrument.

quency to plus or minus 5 kc, to insure accurate location of the intermediate frequency in the center of the band pass filter. Equal deflections in both x and y directions are obtained with the aid of a difference amplifier vacuum tube voltmeter, while the absolute value of the deflection voltage is adjusted with an off-set zero type vacuum tube voltmeter. The latter adjustment is required to make A equal to unity.

A ten centimeter diameter cathode ray tube is being used, but the diameter of the circle enclosing the ellipse is limited to four centimeters in order to limit geometrical distortion in the cathode ray tube. An optical magnification of five times permits accurate positioning and adjusting of the ellipse. An electronic magnifier increases the deflection sensitivity of both plates by a factor of approximately five. This is achieved by reducing the electron gun voltages in the cathode ray tube without appreciably increasing the spot diameter. An ellipse with a small axis of 0.1 cm can thus still be measured, resulting in an accuracy of about ten minutes of arc per phase angles of the order of a few degrees.

Phase shifts up to ten degrees can also be read on a separate phase indicating instrument. The circuit is illustrated in Fig. 4. The input voltages U_1 and U_2 are kept constant and the potentiometer p is adjusted to make

$$\frac{U_2}{U_1} = \frac{Z_2}{Z_1} = m \qquad (4)$$

The voltage U, which is measured with a vacuum tube volt meter, is then a function of the phase angle, permitting direct calibration of the meter scale in degrees.

$$U = \frac{2m}{1 + m} U, \sin \varphi/2 \qquad (5)$$

An extension of the phase meter for the direct indication of a phase angle on the cathode ray tube screen is also mentioned.

Abstracted from an article by O. Macek, "A Phase Meter for the Frequency Range from 50 cy to 30 mc," Frequenz, vol. 10, pp. 147-152; May 1956.

BOURNS now offers an expanded line of TRIMPOTS®

...7 stock models of sub-miniature potentiometers to serve many special needs—at no extra cost!

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The self-locking shaft holds stable settings under extreme environmental conditions. All parts are corrosion resistant. Every unit is inspected 100% for guaranteed specifications. Resistances: 10 to 20,000 ohms, with resolutions as low as 0.2%.

Now, to give designers greater latitude, BOURNS has developed and is manufacturing the following standard models—variations of the Model 120.

120 *TRIMPOT*
—Carbon
Infinite resolution is provided by the carbon element. Resistances are higher, ranging from 20,000 ohms to 1 megohm.

130 *TRIMPOT*
—Solder Lug
For wiring direct to the instrument, using soldering iron or dip soldering techniques. Usable range of 98%.

132 *TRIMR*
— Variable Resistor
High resistances—up to 50,000 ohms in a wirewound rheostat.

209 *TWINPOT*
—Dual Potentiometer
Two outputs electrically independent, and controlled simultaneously by one adjustment.

160 *TRIMPOT*
—High Temperature
Operates at 175°C. High power rating: 0.6 watt at 50°C.

230 *TRIMPOT*
—Humidity-proof
Completely sealed, unit meets MIL-E-5272A Specifications for humidity.

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Report Briefs

Sonar Automatic Data Processing

Called the Digiter, a system has been developed for automatic processing of sonar data at sea, and may have applications in studies other than sonar. Instrumentation is described which prints automatically the acoustic level of a sonar signal in decibels, accurate to ± 0.2 db and having a dynamic range of 50 db. The associated range may also be printed. *PB121220 Sonar Digital Recorder—"Digiter," Pieper and Tillman, Naval Research Laboratory, OTS, US Dept. of Commerce, Washington 25, D.C., June 1956, 10 pp. 50 cents.*

Low Noise Converter

To reduce noise in VHF receivers, a 215 to 225 mc converter has been designed and developed by the Naval Research Laboratory. The converter achieves a low noise figure in the receiver equipment which was unattainable with previous tubes. Using a GL6299 triode (GE manufacture), the converter tunes the desired frequency range while the noise figure remains essentially constant. Improvement in the noise figure is due to low losses, low equivalent noise resistance, and low transit time conductance of the tubes. *PB121214 A Low Noise 215-225 Mc Converter, L. Hoffman, Naval Research Laboratory, OTS, US Dept. of Commerce, Washington 25, D.C., June 1956, 7 pp. 50 cents.*

VLF Ground-Wave Propagation Curves

Curves presented in this publication provide basic information on ground-wave propagation in the low, very low, and ultra-low frequency bands. Several extensions were made to the formulas of Van der Pol and Bremmer. Ground conductivity values of 4, 0.01, and 0.001 mhos per meter were chosen, corresponding to sea water, well-conducting land, and poorly conducting land, and the field strength and phase values were computed at the selected frequencies. Range was from 1 to 1500 miles. *Amplitude and Phase Curves for Ground-Wave Propagation in the Band 200 Cycles Per Second to 500 Kilocycles, Wait and Howe, NBS Circular 574, May 1956, 17 pp. 20 cents.*

Digital Computer Survey

Eighty-four different domestic digital electronic computing systems are described. The survey treats engineering characteristics, logical features, operating experiences, cost factors, and personnel requirements. An analysis of the computer field, a discussion of trends and a complete glossary of computer engineering and programming terminology are included. *PB111996, OTS, US Dept. of Commerce, Washington 25, D.C., 272 pp. $4.75.*

Printed Circuit Packaging Techniques

Covering the period of '52 to '54, this report indicates a five step procedure to provide adequate Auto-Sembled systems with regard to circuitry, ruggedization, climatic protection, thermal adequacy, size and weight, maintenance, and integration. The procedure consists of the selection of a system, selection of techniques, design, fabrication and analysis. Methods of predicting the size and weight of a package are included and estimates of ruggedization and thermal adequacy. *PB111714, Packaging and Integrating Printed Circuit Electronic Assemblies, Final Report, Part II, OTS, Dept. of Commerce, Washington 25, D.C., 95 pp. $3.75.*

RF Wattmeter

Covers the investigation, development and design of an rf wattmeter to be used in field and depot testing. The Wattmeter AN/URM-73(XA1) measures power in the high and medium power ranges over the 20 to 1000 mc frequency band. In order to obtain the best system to measure rf power in the most accurate manner consistent with simplicity of design and reliability of operations, several methods were evaluated. The one finally evolved was the one using a high-power precision attenuator and a heater-thermocouple detector delivering dc voltage to a panel meter. *Radiation, Inc. for USAF, July 1955, Order PB121096, OTS, US Dept. of Commerce, Washington 25, D.C., 81 pp. $2.25.*

Waveform Generator

Describes development of a periodic waveform generator in which the magnitude, slope, polarity, and points of inflection may be controlled at will by simple resistance or voltage changes. It is composed of standard magnetic cores, diodes and resistors, with switching transistors added for special applications. With supplementary circuit additions, power outputs in the watts range may be supplied to low impedance loads. When used with a compatible analogue computer system, it provides output transfer functions which may be tailored to any complexity desired. *C. B. House, Naval Research Lab., May 1956, Order PB121157, OTS, US Dept. of Commerce, Washington 25, D.C., 10 pp. 50 cents.*

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Standards and Specs

Sherman H. Hubelbank

Terminals

MIL-T-0015659D (Ships), Terminals: Lug, Solder Type, Copper, 18 April 1956

This limited coordination spec has been prepared by BuShips based upon currently available information, but it has not been approved for distribution as a revision of MIL-T-15659A.

MIL-E-16366B (Ships), Electrical Clamps and Lug Terminals: Pressure Grip, Amendment 2, 4 April 1956

A cable connector for a 349,000 circular mil cable was added by this amendment.

Parts

MIL-STD-242A (Ships), Electronic Equipment Parts (Selected Standards), 4 May 1956

A list of selected standard parts covering the following major categories is contained in this standards manual: acoustic parts, cables, capacitors, insulators, cable clamps, rf connectors, control knobs, electromechanical parts, power plugs, resistors, switches and tip jacks, transformers, chokes, filters, tubes, transitors, quartz crytals, attenuators, and waveguides. This standard is mandatory for use on BuShips contracts by both the prime contractor and all subcontractors in the design of new electronic and associated electrical equipment where specs MIL-E-16400, MIL-E-19100, and MIL-I-983 are specified. In general, this standard makes an excellent reference for electronic component parts.

Resistors

MIL-R-19438 (NOrd), Precision Wire Wound Variable Resistor, 1 May 1956

The design requirements of accurate wire wound variable resistors having a maximum resistance tolerance of 2 per cent are established by this spec. These resistors are suitable for continuous full load operation at any ambient temperature up to 65 C.

MIL-R-19365 (Ships), Resistors, Adjustable, Wirewound Power (One Ferrule, One Tab Terminal), 8 May 1956

Power-type wirewound, adjustable resistors with one ferrule and one tab terminal used in electrical, electronic, communication, and associated equipment are covered by this spec. These resistors have an effective resistance range of 100 to 3000 ohms and a resistance tolerance of plus or minus 5%. A typical type designation for a resistor covered in this spec is RX10G100.

ADN-CAP-1, Type Designations and Color Coding of Capacitors, 31 July 1956

Compiled from six capacitor specs, this Application Design Note represents a departure from the previous practice of dealing with individual components. Specs MIL-C-5A, JAN-C-20A, MIL-C-91A, MIL-C-11015A, and MIL-C-11272A were used as the source for this ADN. A tabulation of the type designations appearing in the six specs is included to show the meaning and order of appearance of each of the symbols. Also included are charts showing capacitance tolerance color coding and value and capacitor characteristics, in addition to capacitor coding illustrations.

Capacitors

MIL-C-25A, Capacitors, Fixed, Paper-Dielectric, Direct-Current (Hermetically Sealed in Metallic Cases), 5 July 1956

1000 v rated types have been added for styles CPO4, CPO5, CPO8, CPO9, and CP10, by this revision. Style CP11 was not affected. The statement that polarization is not required during the performance of the moisture resistance test has been deleted. The duration of the life test for 1000 volt characteristic capacitors is 500 hours with 120% of rated voltage applied.

Waveguides

MIL-W-3970, Waveguide Assemblies, Rigid, 20 July 1956

Rigid waveguide assemblies, such as bends, corners, and twists, for general Armed Services application in conjunction with standard rf transmission lines are covered in this recently issued spec.

Batteries

MIL-B-15072A, Amendment 1, Batteries, Storage, Lead-Acid, Portable (Except For Aircraft And Automotive Vehicles), 18 July 1956

Requirements for clamp terminals have been added and pin-type terminals have been deleted. Filler plug requirements have also been added. Twenty three "MS" standards have been added covering batteries, and three additional ones have been added covering battery terminal clamps and battery filler plugs.

Shipboard Enclosures

MIL-E-2036B (Navy), Enclosures For Electric and Electronic Equipment (Naval Shipboard Use), Amendment 3, 16 May 1956

Disconnect switches are now included under this spec. Enclosed, self-ventilated enclosures are no longer considered to be Class 1 enclosures. Splashproof and splashproof protected enclousres are no longer considered to be Class 2 enclosures. The requirements for approved joints and bolts and spacing have been revised. Requirements for spray-tightness and water-tightness have been added, as have been requirements for welding.

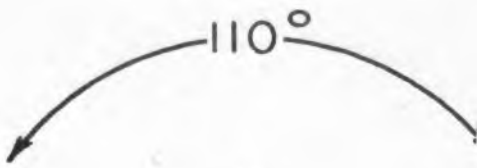
ADVERTISING INDEX

November 1, 1956

CIRCLE 292 ON READER-SERVICE CARD ➤

New "110-deg

SHORT PICTURE TUBE



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Introducing a new dimension in picture tube design for black-and-white TV receivers, RCA-21CEP4 opens new possibilities for designers looking for a compact tube capable of producing big, high-quality pictures—*in a smaller cabinet*. Here, RCA has successfully incorporated wide-angle 110° deflection and "straight"-gun design into a compact unit at least 5½ inches shorter than 21-inch envelope types with 90° deflection.

Read these important facts about the new RCA-21CEP4: (1) "Straight" electron-gun design employing unique pre-focus electrostatic lens maintains image sharpness over the *entire* picture area (262 sq. in., minimum)—*and eliminates need for an ion-trap magnet.* (2) Smaller neck diameter permits use of a deflecting yoke having higher sensitivity—*and requiring only slightly more power than is needed for 90° deflection.* (3) Super-aluminizing produces bright, high-contrast pictures.

First of a new line of 110° wide-angle tubes for "black-and-white", RCA-21CEP4 is in production! For tube-delivery information, call your RCA Field Representative. For technical data on the RCA-21CEP4, write RCA, Commercial Engineering, Section K-18Q-1, Harrison, New Jersey.

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RCA-21CEP4

Associated Tubes and Components
Designed for use in 110° deflection-angle systems: For horizontal deflection, RCA-6DQ6-A; for vertical deflection, RCA-6CZ5. Both of these types are now commercially available. In addition, a developmental horizontal deflection transformer and a developmental deflecting yoke—both designed especially for use with 110° tubes—are available to TV equipment manufacturers on a sampling basis.

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