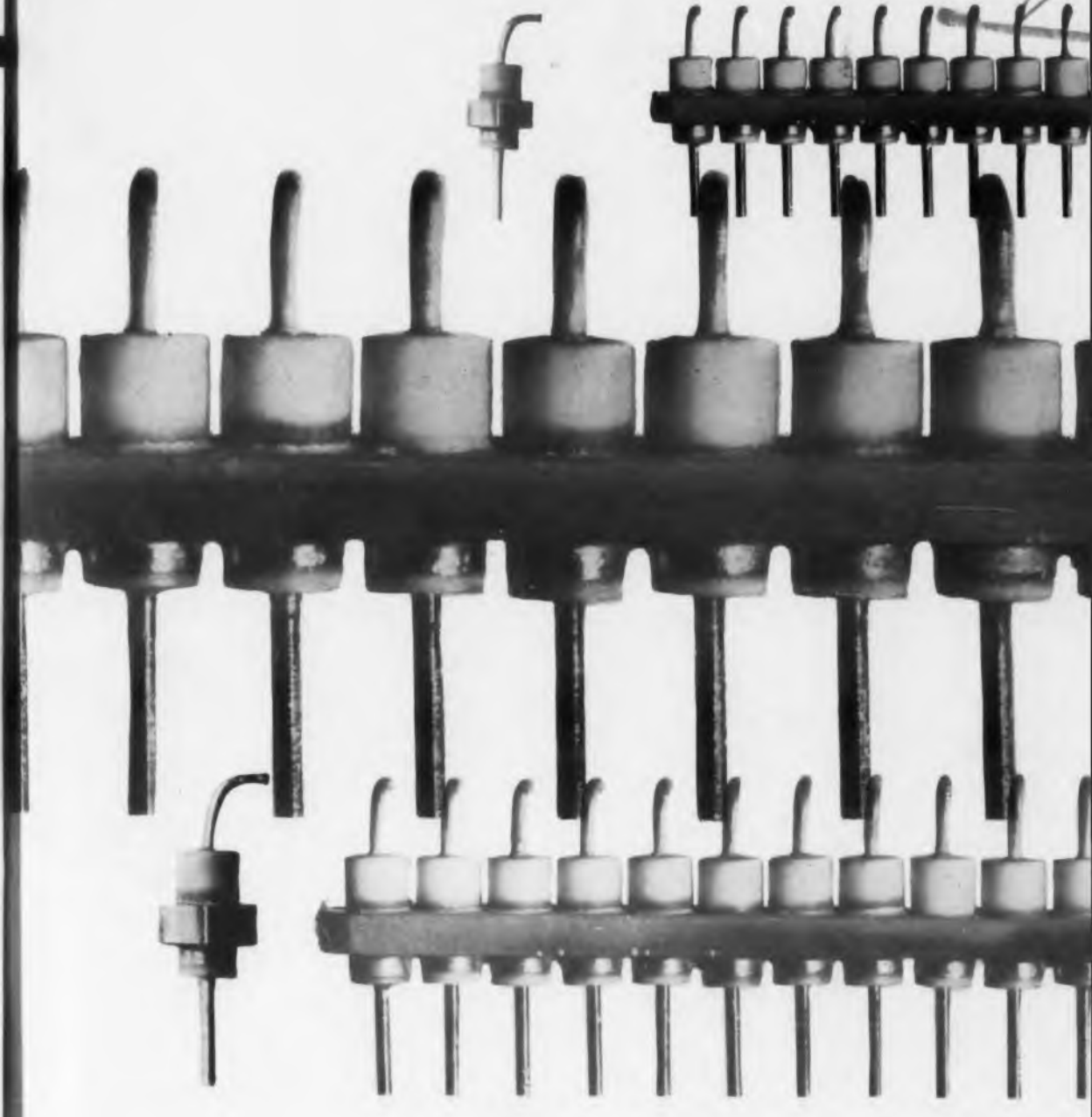

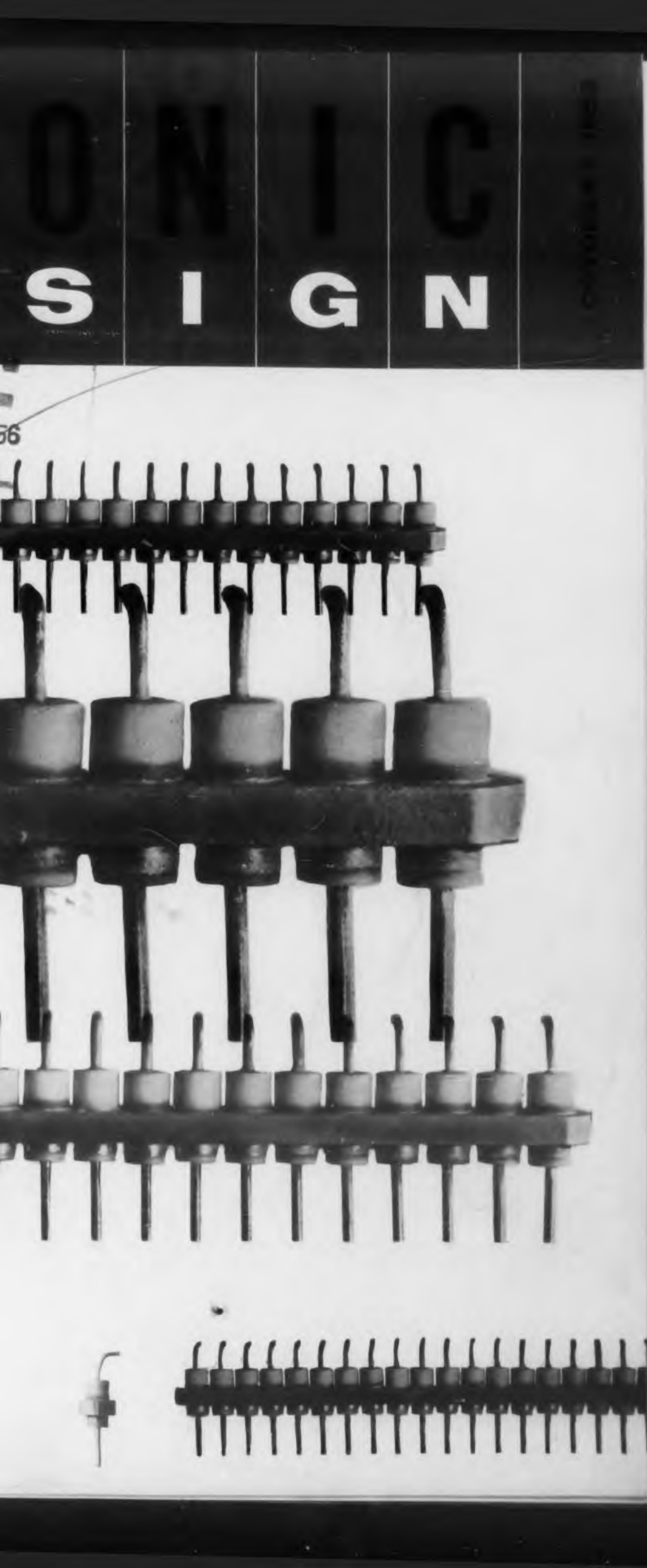
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Advertising Representatives

New York: Owen A. Kean
Lawrence Conover
Bryce Gray, Jr.
Robert W. Gascoigne
19 East 62nd St.
New York 21, N. Y.
TEmpleton 8-1940

Chicago: Thomas P. Kavooras
Berry Conner, Jr.
Nelson Joliffe
664 No. Michigan Ave.
Chicago 11, Ill.
SUperior 7-8054

Los Angeles: Robert E. Ahrensdorf
Earl W. Wilken
John Quillman
1140 Wilshire Blvd.
Los Angeles 17, Calif.
MAdison 9-2681

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Contents

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CIRCLE 2 ON READER-SERVICE CARD FOR MORE INFORMATION

Editorial

Science in Disrepute

The high prestige supposedly enjoyed by members of the engineering and scientific professions seems to be really a dangerous illusion. Science as a career is actually shunned by teenagers according to recent findings made by the Educational Reference Division of Purdue University. Of ten choices as an occupation, atomic scientist ranks at the bottom. The attitude of youth toward science is what is disconcerting. The report revealed that:

Twenty-eight per cent do not believe scientists have time to enjoy life.

Twenty-five per cent think scientists as a group are somewhat "queer."

Fourteen per cent think there is something evil about a scientist.

Nine per cent believe that you cannot be a scientist and be honest.

Twenty-seven per cent think that scientists are willing to sacrifice the welfare of others to further their own interests.

In the rating of occupations, chemists and engineers faired much better than scientists. Apparently this anomaly might be traced to students' opinions of intelligence or "brain-power." For example, the study showed that thirty-five per cent believe that it is necessary to be a genius to become a good scientist. Forty-five per cent feel that their own personal school background is too poor to permit them to choose science as a career.

It is obvious it is time for our profession to react to the melodramatist's type-casting of a scientist as mad or even as mildly eccentric. Evidence of psychologists show highly intelligent people to be far better adjusted than the average man. If the values of scientists and engineers differ from those held by less well trained majorities, they must not be sacrificed but vigorously advocated as worthy ideals. Enquiry and research must go on and the process and methods of science must be demonstrated as the most hopeful way for better life for more and more people.

Encouraging is the recent action of the Instrument Society of America. Fearful that lack of technically trained people would bring "automation to a halt" in the words of RCA vice-president Engstrom, members of the ISA are setting up a foundation for instrumentation educational research. One of the foundation's purposes is to attract more people into science.

One area that needs attention is the status of science in high school. Take one example—the startling number of general science teachers who cover electricity on the blackboard only because they are afraid of shock when working with apparatus. We might be losing as high as twenty-five per cent of our high school students to science because of the lack of a stimulating spark!

Electronic News

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

400 Mile Range Shipborne Radar

The most powerful shipborne radar set ever put into service has been installed on the US Navy cruiser Northampton.

Delivering over 10 million watts at peak power, the radar magnetron, "Big Maggie," was developed by Westinghouse Electric Corp., Pittsburgh. The tube, which weighs 60 pounds, has a permanent magnet which weighs 300 pounds. A new alloy cathode is employed which withstands temperatures up to 3100 F. Water and mild forced-air cooling is employed for the sealed magnetron oscillator. The magnetron power supply permits peak power pulses of 23 megawatts at 60 kv.

TV Helps Supervise Dam Construction

Massive dams being built by the Power Authority of the State of New York as part of the St. Lawrence Seaway development are enlisting TV as an aid in supervision. At both the 2350 ft Long Sault and 3230 Barnhart Island dams, two General Precision Lab. cameras are in use. At each dam, one camera is stationary and surveys the entire site; the other, telephoto lens equipped, scans a 120 degree arc. TV signals are transmitted by Raytheon microwave relays to the resident engineer's office where a few minutes observation of the TV monitors saves several hours travel to the work sites.

New Naval Airborne Search Radar

A Navy contract for approximately one million dollars for pilot production of new-type airborne early warning search radar systems has been awarded to GE, Light Military Electronic Equipment Dept., Utica, New York.

The radars, having increased range and improved performance, will be used in aircraft and blimps to extend early warning radar coverage for North America.

While using the same size antenna, the new radar is an improved replacement for the AN/APS-20E.

Electronics Industry Growth

Dr. W. R. G. Baker, president of RETMA and GE VP, Syracuse, predicts that a major portion of the electronics business 10 years hence will come from products not now in production. Electronics, 4th largest American industry, now employs 75 per cent of its more than 1-3/4 million employees on jobs which didn't even exist 10 years ago."

He indicates that to ". . . assume its responsibilities toward society . . . industry must: See that new products are not put on the market until the product is ready for market, and vice versa; Never fail to fulfill responsibilities for research, development, production and delivery of military products; Work unceasingly to provide a fair return on investments; Take a genuine interest in employee welfare by providing good pay, pleasant working conditions and steady jobs; Recognize that industry and the community have interrelated responsibilities which must be met if both are to prosper; Help provide for our increasing technology by assisting the field of education wherever possible; Assure efficient use of one of our great natural resources, the radio spectrum, by thoroughly studying the problem of whether uhf can be made reasonably comparable to vhf TV service."

Private Reactor Begins Operation

Nation's first private nuclear reactor for industrial research has gone into operation at Armour Research Foundation.

The instrument will enable industry for the first time to conduct studies without security restrictions and military competition.

Housed in a new $1,250,000 Physics and Electrical Engineering Research Building being constructed by Armour Research Foundation near 35th and State Sts. on Chicago's near south side, the reactor was built for ARF by Atomics International, a division of North American Aviation Inc.

B-52 H-Bomb Carrier Defense

A new era of aerial gunnery, where one gunner replaces six, has been ushered in by the Arma Division of American Bosch Arma Corp., Roosevelt Field, L.I., N.Y. Medium and long range bombers can be equipped with a automatic electronic system which automatically detects, tracks, leads and actuates a fire control system to destroy enemy fighters. The gunner assumes optical control of his weapons.

Observing TV Camera

Getting up close to watch gun tests is unnecessary for Navy Ordnance observers. Risks that accompany observing these tests are taken by a ruggedized small TV camera. Viewing screen can be located at a safe distance.

Previously, only one or two officers could watch the tests through an observation port. Now, only the camera need be near the gun. A projection TV system permits large groups to watch the tests.

Made by General Precision Laboratories, the camera is made to stand noise levels of over 120 db. Clear, detailed pictures are sent despite shock waves produced by the weapon.

Ruggedized TV camera observes a gun test and transmits pictures to a safe location for viewing by large groups.

New Epoxy-Base Enamel

A new enamel, developed for industrial use by Rexton Finishes, Irvington, N.J., is heat, chemical, corrosion and abrasion resistant.

Conventional glossy black or brown phenolic molded articles as well as metal, glass, wood and plastic can be covered with a single coat without a primer. Available in a variety of colors, the enamel air-dries in about 2 hours, and in less time if force dried or baked.

Chapel Bells For US Airmen

Forty-three electronic carillons are being built by the Special Products Division of Stromberg-Carlson, Rochester, N.Y. to sound the liturgical bells used in worship services of all faiths at USAF bases throughout the world.

In electronic carillons of this type, bell sounds are produced by striking small metal tone bars with tiny plastic hammers, electronically controlled, and amplifying the sounds through special magnetic pickup and loudspeaker systems.

The equipment also includes a clock-controlled record player for carillon recordings of hymns and other familiar music.

Versatile Man-Made Mineral

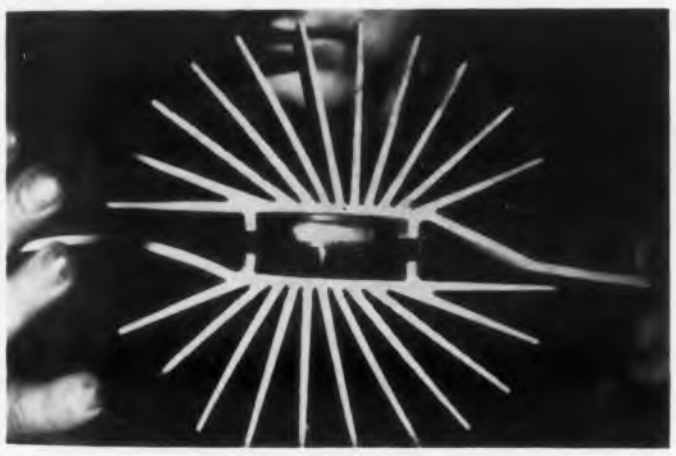
A cheap man-made mineral may free the U.S. from foreign sources of strategic and costly materials, such as tungsten. The new material, Sintox, may be used in applications in automobile and aircraft production, electronic and electrical fields, the machining of metal, wood, paper, and rubber, and in the manufacture of plastics and textiles.

Developmental batches of Sintox, made by Sintox Corp., Allentown, Pa., indicate a unique combination of properties for electronic applications. Its dielectric strength is twice that of porcelain and its high resistance is so little affected by temperature that at 300 C it is one million times that of porcelain.

Civilian Defense Radio Traffic Communication

In those localities where radio control of street intersection traffic signals is already in effect, it could be a relatively simple task to incorporate a system of motorist and pedestrian guidance for city evacuation or other safety directives.

Elmer W. Hassell, G.E. Supervisor, Syracuse, N.Y., indicated at the WESCON Show recently that voice messages could utilize traffic light equipment by using amplifiers mounted in the same cabinets containing intersection radio tone control units.



Heat Conducting Aluminum Fins

Silver-plated aluminum fins conduct heat away from dime-sized germanium cell. General Electric Co., Schenectady, N.Y.

Shielded Rooms Sport Rf-Free Lighting

Cold cathode fluorescent tubes, which deliver interference-free illumination at lower temperatures than conventional tubes, are now being employed in shielded enclosures.

The room incorporates the development by Cold Cathode Lighting Corp. to permit instant starting, long life and full lumen output in refrigerated or high temperature spaces.

The shielded rooms are built by Ace Engineering & Machine Co., Philadelphia.

Slow Scan TV Converter

A compatible system making it possible to combine slow and fast scan TV has been developed by the GE Electronics Laboratory. The system changes fast scan to slow scan TV by means of an electronic converter. Slow scan TV produces one picture every 4 or 5 secs, contrasted with fast scan which sends 30 pictures per second.

Still in the developmental stage, the conversion system promises to widen the combined use of fast and slow TV scan in commercial and industrial applications.

Slow scan has the greatest possibilities in uses not requiring transmission of motion. Picture distortion results from movement of the subject. Pictures without much action, such as signature comparisons, can be sent over lines that approach the telephone line bandwidth and can be received by slow TV monitors.

Since coaxial lines are not required for slow scan, the employment of telephone lines will reduce the cost of closed circuit TV. It is even possible to take a fast scan TV from an airplane, without a direct hookup to a fast camera, and convert it for slow scan TV.

Automatic Germanium Plating Rectifier

Incorporating automatic voltage stabilization and remote stepless reactor control at no extra cost, a new air cooled germanium plating rectifier has been announced by GE's Rectifier Dept., Lynn, Mass.

Output voltage is controlled by a reactor, eliminating moving parts, and reducing maintenance cost and down time. Voltage is maintained automatically, regardless of changes in tank load or variations in ac line voltage.

Heart of the reactor control system is a magnetic amplifier that signals the control reactor to make adjustments whenever the actual voltage is different from the desired voltage set at the remote control station. A cooling system, utilizing silver-plated aluminum fins that surround the germanium cell, conducts heat away from both sides. Germanium junctions, formerly, were cooled from only one side.

◀ CIRCLE 6 ON READER-SERVICE CARD

Forward Scatter Researchers Get Gold Medal

A research group consisting of Ross Bateman, Dana K. Bailey, and Richard C. Kirby, all one-time members of the Ionospheric Research Section, Boulder Laboratories, National Bureau of Standards, has been awarded the Department of Commerce Gold Medal for exceptional service . . . "For major contributions to the advancement of the science of radio wave propagation and long distance radio communications. . . ."

The research group took part in the discovery of ionospheric forward scatter and has studied the physics of the phenomena involved. In addition, they directed the application of scientific studies to construction of practical communication circuits, which has resulted in supervising Air Force contracts for installation of several such circuits in the Arctic.

Teflon and Rulon Bonded to Other Materials

Both Teflon and Rulon are being surface treated by Dixon Corp., Bristol, R.I., to enable these anti-adhesive substances to bond with almost any other material.

The new method is essentially a surface treatment but may penetrate the material to a depth of 0.001 to 0.003 in. Either part or all of any surface may be treated, so that only a portion can be bonded and the balance retains its non-adhesive properties. Flat shapes can be treated on either side or both, as required.

Solid Rulon bearings, with their high resistance to wear, have given excellent performance with no lubrication, and, within their load range, can be run indefinitely. Since solid bearings are expensive, however, use of a thin film of Rulon cemented to a metal bearing core is now practicable. It is particularly attractive as a method of reducing costs and increasing the range of loads and speeds for which the bearing may be used. Film thinness is said to speed heat transfer to the adjacent metal, permitting the bearing to run cooler.

CIRCLE 7 ON READER-SERVICE CARD ➤

Washington Report

Albert Warren

Spectrum Dissection . . . *Re-evaluation of entire radio* spectrum by Govt and industry, with eye to more efficient allocation among services, is being demanded in more and more quarters—and experts consider it inevitable. Move is being precipitated by plight of uhf TV stations, but their problems are so involved with the whole jigsaw of allocations that any move affecting them would affect vast number of military & industry users of the spectrum. Federal Communications Commission has proposed that all TV stations be moved to uhf, if further study proves it feasible technically & economically. At same time, FCC told other services to show they could best use the 72 mc of vhf space (scattered between 54 mc & 216 mc) if TV is moved out. This has produced a powerful drive by industrial radio users to get more vhf channels. One top FCC official puts it this way: "Technical developments have far outstripped the allocation scheme. The present setup isn't efficient. Of course, the economics of moving services around, of obsoleting equipment, must be considered. However, industry can afford to change equipment for the sake of efficiency—and the military are now pretty well capable of persuading Congress to allocate necessary funds for changes. Naturally, the most difficult problem is that of obsoleting broadcast receivers in the hands of the public, or of taking away service the public now gets." With industries of all kinds relying heavily on communications radio and closed-TV for speeding manufacturing operations, pressures on FCC to provide more channels for such services is illustrated by this comment from an FCC commissioner: "I thought the broadcast industry had good lobbyists. You should see the other industries move into this field. We're getting more and more insistent calls from Congressmen, and they're pressured by manufacturer constituents." Last complete evaluation of whole spectrum was during World War II, accomplished by Radio Technical Planning Board under aegis of FCC; it was made up of radio manufacturing and broadcasting representatives.

Washington Trends & Briefs . . . Faith in electronics industry was expressed recently by Edward P. Curtis, special asst. to President Eisenhower for aviation facilities planning, who said he expects industry to solve by March 1957 some of the **problems of preventing air collisions.** He said following were among companies working on problem: Ramo-Wooldridge, Sperry Rand, GE, Hoffman Electronics, Crosley div. of Avco. . . . Nine transistor development contracts, totaling $11,597,084, were let recently by Army Signal Supply Agency, Philadelphia—to RCA, Sylvania, Motorola, Western Electric, Philco, Hughes Aircraft, Texas Instrument, Transitron Electronics. . . . Revised booklet **"Functional Classification and Definition for Electronic Test & Measuring Equipment"** is available to all Govt and commercial contractors from Co. Melvin Abramovich, Office of Asst. Secy of Defense (R&D), Room 3D-132, Pentagon Bldg., Washington 25, D.C. . . . **"Electronic trail"** is being extended 100 mi over Greenland ice cap by Army engineers. System comprises 2 parallel wires fed ac, signal from which is picked up by receiver on "Weasel" vehicle. Indicators show driver position with relation to wires, give warning when he strays. System is designed to keep travelers from wandering into crevasses. Development continues at Ft. Belvoir, Va. labs and at General Mills, Minneapolis. . . . **Growth of transistor production** is emphasized by RETMA sales statistics: 4,758,603, valued at $13,728,111, produced in first half 1956, compared with total 1955 production of 3,646,802, valued at $12,252,741. . . . **Desperately short of engineers,** Federal Communications Commission now offers grade II jobs ($7035) to those who have 4 years of college engineering study or equivalent, plus 4 years experience. FCC officials point out that many engineers are more qualified for the jobs than they think, urge them to write to Personnel officer, FCC, Washington 25, D.C. . . . **Symposium on propagation of frequencies** under 100 kc will be held in Denver, Colo. Jan. 23-25, sponsored by Bureau of Standards and Denver-Boulder chapter of IRE. . . . **Multiple-antenna towers,** for TV, fm and other services, are getting more attention—under urging by FCC and aviation interests. Collection of all or most antennas in any area on one tower substantially reduces air hazards. Latest plans are for San Francisco, where KRON-TV plans 981 ft structure on San Bruno Mt., to support up to 15 antennas, candelabra fashion, and KGO-TV plans 980 ft tower on Mt. Sutro, to carry 5 vhf and 2 uhf antennas. Govt will have to make choice between them.

Letters to the Editor

Dear Sir:

On Page 102 of ELECTRONIC DESIGN, July 15, 1956, there is an announcement regarding a subscription to the REPORT OF NRL PROGRESS. Will you be good enough to print a correction of this. The REPORT OF NRL PROGRESS is available for purchase from the Office of Technical Services, Department of Commerce, Washington 25, D. C. for $1.25 per issue. At this time I understand no subscription price has been set and each issue must be ordered separately. Copies of this publication are not available from the Naval Research Laboratory, except for official use. One of the purposes of the Office of Technical Services is to make reports of the Government research available to the public.

Ruth H. Hooker, Librarian
U. S. Naval Research Laboratory

Dear Sir:

In your May 15 issue (page 141), you asked for comments on a definition of instruments proposed by Mr. Hausz.

Enclosed is the definition formulated by M. H. Aronson, Editor of the magazine *Instruments and Automation*, which is, in our opinion shorter, clearer, more specific, more useful, and more accurate in sense that it cannot be misinterpreted as easily as the one proposed by Mr. Hausz.

F. D. Marton
Managing Editor
Instruments Publishing Co.

Mr. Aronson's definition of Automation: "The use of devices—mechanical, pneumatic, hydraulic, electrical and electronic—for making automatic decisions and efforts." ***Ed.***

Gentlemen:

. . . about the importance of including derivations with equations . . . (they) are more important than the equations, for the following reasons:

They tell us *how* the author arrived at his results; therefore,

They inform us as to the validity of the results in a general case; and,

They inform us as to the validity of the results in special cases; and,

They give us information which will allow us to utilize the author's concepts in solving problems different than the one he presented.

The last item is most important . . . No two problems are exactly alike, and more design mistakes are made by blindly using the wrong cookbook recipe than all the others combined. If it is worth while to formulate a useful equation, it is certainly worth while to show the conditions under which the equation is valid.

A. Lange
Raytheon Manufacturing Company
Wayland Laboratory
Wayland, Massachusetts

Derivations, if published, would take up space in ELECTRONIC DESIGN that could be used for other timely material. Do you agree with Mr. Lange? We would like some more opinions. ***Ed.***

Sir:

I am in hearty agreement with your editorial (Meetings Are Not Job Marts) in the May 1, 1956 issue. In fact, I was once moved to drop a note to the editor of another magazine stating much the same ideas.

Your point about job dissatisfaction because of refusal of permission to attend conference is a particularly sore point with me. It was actually a factor in my decision to leave two different jobs.

I now find conferences much less interesting than I once did, but it is my feeling that there is a phase in an engineer's professional development in which attendance at conferences is very useful.

Melvin E. Frank
Los Angeles, Calif.

Meetings

Oct. 1-3: Twelfth Annual National Electronics Conference.

Hotel Sherman, Chicago, Ill. Sponsored by the AIEE, IRE, Illinois Institute of Technology, University of Illinois, and Northwestern University. More than 100 technical papers and 240 commercial exhibits will be featured. For information, write to Victor J. Danilov, Illinois Institute of Technology, Chicago 16, Ill.

Oct. 1-3: Canadian Institute of Radio Engineers Convention.

Automotive Building, Exhibition Park, Toronto, Canada. Technical papers are planned on medical electronics, scatter propagation, application of electronics to atomic energy projects, use of computers in automation and engineering problems, and transistors. An exposition will include many of the latest improvements in radio, radar, TV, control mechanisms, computers, and other electronic items. For information, write to Grant Smedmor, Convention Manager, 745 Mount Pleasant Rd., Toronto 12, Canada.

Oct. 1-5: AIEE Fall General Meeting.

Morrison Hotel, Chicago, Ill. Tentative schedule includes sessions on rotating machinery, protective devices, metallic rectifiers, insulated conductors, dielectrics, air transportation, land transportation, switchgear, feedback and control systems, electronics, computing devices, nucleonics, and management. For information, write to AIEE, 33 W. 39th St., New York 18, N. Y.

Oct. 3-5: Fifth Annual Meeting of the Standards Engineers Society.

Willard Hotel, Washington, D.C. Topics expected to be of particular interest to standards engineers in the electronic field are the session devoted to "Dynamic Standards for the Median Company" and the session devoted to "Drawing Practice Standardization." Additional information may be obtained from the Washington Section, Standards Engineers Society, 4042 N. 35th Street, Arlington 7, Va.

Oct. 8-9: Second Annual Symposium on Aeronautical Communications.

Hotel Utica, Utica, N. Y. Sponsored by the IRE Professional Group on Communications Systems.

The symposium will stress communication requirements in support of present and future aeronautical activities. For additional information, write to R. C. Benoit, Jr., 138 Riverview Parkway N., Rome, N.Y.

Oct. 8-12: Society of Motion Picture and Television Engineers Convention.

Los Angeles, Calif. A technical session will be devoted to a program of papers on transistors and their applications to motion pictures and television. For additional information, write John B. Olsson, Houston-Fearless, 11801 W. Olympic Blvd., Los Angeles 64, Calif.

Oct. 9-10: Computer Applications Symposium.

Morrison Hotel, Chicago, Ill. Sponsored by the Armour Research Foundation of Illinois Institute of Technology. For information, contact J. J. Kowal, Conference Secretary, Armour Research Foundation of Illinois Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

Oct. 16-18: Conference on Magnetism and Magnetic Materials.

Hotel Statler, Boston, Mass. Sponsored by the AIEE, IRE, American Physical Society, American Institute of Mining and Metallurgical Engineers. For further information, write to T. O. Paine, Measurements Laboratory, General Electric Co., W. Lynn, Mass.

Oct. 18-19: Third Annual International Meeting of the Institute of Management Sciences.

Statler Hotel, Los Angeles, Calif. Theme of the conference is "Management Sciences—A Progress Report." Program plans include the presentation of technical papers on the latest developments in the application of advanced sciences to business and industrial management. For further information, please contact Al N. Seares, Vice President Remington Rand, Sperry Rand Corp., 315 Fourth Ave., New York 10, N. Y.

Oct. 22-24: AIEE Machine Tool Conference.

Sheraton Gibson Hotel, Cincinnati, Ohio. For information, write to AIEE, 33 W. 39th St., New York 18, N. Y.

Oct. 29-30: Third Annual East Coast Conference on Aeronautical and Navigational Electronics.

Fifth Regiment Armory, Baltimore, Md. Sponsored by the Baltimore Section and Professional Group on Aeronautical and Navigational Electronics of the IRE. Theme of the conference is "Electronics in the Jet Air Age." For information, write to W. D. Crawford, Publicity Chairman, Westinghouse Electric Corp., Air Arm Div., Friendship International Airport, Baltimore 27, Md.

Oct. 29-Nov. 2: Convention on Ferrites.
London, England. Sponsored by the Institution of Electrical Engineers. Program will include sessions on theory, preparation, and properties of ferrites, microwave application, square loop applications, radio and TV applications, and carrier frequency applications. For further information, write to W. K. Brasher, Secretary, Institution of Electrical Engineers, Savoy Place, London W.C. 2, England.

Oct. 31-Nov. 3: Gaseous Electronics Conference.
Westinghouse Research Laboratories, Pittsburgh, Pa. Co-sponsored by the Division of Electron Physics of the American Physical Society and the Westinghouse Research Laboratories. For more information, contact A. V. Phelps, Westinghouse Research Laboratories, Beulah Rd., Pittsburgh, Pa.

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. For information, write to AIEE, 33 W. 39th St., New York, N. Y.

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: New England Radio-Electronics Meeting.
Hotel Bradford, Boston, Mass. Co-sponsored by the Boston and Connecticut Valley sections of the IRE. For additional information, contact NEREM, Room 1006, 73 Tremont St., Boston, Mass.

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. For information, write to Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 22, Pa.

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.

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. 23-25, 1957: *Very Low Frequency Symposium.*
NBS Boulder Laboratories, Boulder, Colo. Cosponsored 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.

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.*
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Meaning and Prediction of System Reliability*

Arthur Kohlenberg
Research Department
Melpar, Inc.

SYSTEM reliability can be defined in terms of the probable value of a system's performance of its intended function. Such an approach is important in system design. Unreliability, like noise, produces a reduction in system capacity.

The first stage towards building system reliability has been the improvement of component reliability. One might expect that if parts are perfect, nothing can go wrong with a system of such parts. However, *perfectly* reliable components are obviously not the complete answer to the reliability problem in the foreseeable future. Still, the work of improving components, and particularly learning everything possible about their expected failures, is fundamental.

The second stage of system reliability development has been in combining unreliable components in such a manner that the system has greater reliability than the individual elements. An example is the technique of paralleling functional elements so that if one fails, another still performs the job. The recent work of Claude Shannon on synthesizing reliable relay networks with unreliable elements is perhaps the most sophisticated example. Such efforts are extremely valuable because they accept the realistic limitations of the imperfect.

The third stage of developing system reliability is to examine what the system is supposed to be doing, the probabilities of error, and the *costs* of such errors. The costs of malfunction must be weighed in terms of the possible performance modes of an imperfect system. This third stage is of the greatest importance to the engineer who is generally concerned with the problems of system design, as opposed to the specialist in reliability.

Probability of Reliability

■ *Example 1.*

As an example, consider a teletype system with 26 keys—one for each letter of the alphabet. Assume that after a specified time, two keys stop working. What is the reliability of the system? Has it lost 2/26 or 1/13 of its operation, and therefore have a reliability of about 92 per cent? Probably not. Before being able to state the reliability in meaningful terms one must ask: "What is the teletype going to be used for, and what is the final effect of its failure to operate perfectly?" If the system is sending coded messages such that each letter is independent of the preceding letters, and all are equally probable, it will have lost about 8 per cent of the text.

Depending upon the code used this may mean 8 per cent of the content is lost, or it may mean 100 per cent is lost. On the other hand, if ordinary, clear English text is being transmitted over the system, practically nothing is lost of the content. If two letters are suppressed from a passage of English text, it is still possible to restore almost the complete meaning. In this application, then, the ultimate reliability of the system is perhaps 99.9 per cent. Therefore, one must measure the reliability of a system in terms of its functions based on the effect of the possible malfunctions of the system. The same system may have a reliability of 99 per cent or 1 per cent depending on its application.

■ *Example 2.*

Consider also a telemetering system for giving aircraft pilots a direction vector for flying towards some chosen point. As shown in Fig. 1, there are eight "registers" or "relays" in the aircraft which, on the basis of a data link, give the proper heading in eight-bit binary form. The first bit, in R_1, gives a 180 deg term, the second bit, R_2, gives a 90 deg term, and so on, the eighth bit giving the final accuracy of 1.4 deg. The problem is to find the necessary reliability of the individual relays for an overall system reliability of 95 per cent. For simplicity, the possibility of errors in the data link itself, can be ignored.

Of course, the first question to be asked is, "What is meant by the requirement of 95 per cent reliability?" It might mean that the probability all the relays will be operative, must be 0.95. This is Case I shown. If p is the individual probability of no failure for each relay, then it is required that $p^8=0.95$, giving $p=0.994$. Thus we need relays giving only 6 failures per 1000 operations.

However, in determining what is meant by requiring 95 per cent operation, it is found that the pilot must reach his target, or be able to follow the directional vector, with 95 per cent certainty. This is a realistic and very different form of requirement when one examines the cost of a system malfunction or loss of a piece of data. The aircraft pilot cannot realistically maintain a course direction to better than about 3 deg because of uncertainties in local winds and errors in his navigation system. To lose the contents of R_8, the 1.4 deg information, really effects the pilot only about 1 per cent of the time. Similarly, to lose R_7 is probably only to lose 5 per cent of the directional information. Furthermore, the pilot's bearing is being constantly corrected so that, even if he gets a little off course, he reaches the target after a small delay. On this basis, a realistic assignment of value can be made to the information in each register. Letting L_i be the factional cost of losing the data in the i-th register, it is estimated that $L_1=L_2=L_3=L_4=1$, $L_5=0.8$, $L_6=0.25$, $L_7=0.05$, and $L_8=0.01$.

In view of these estimates, and the requirement that the system perform its directing function with 95 per cent effectiveness, a computation of the necessary reliability of the individual register gives a probability of one and only one specific register failing of $p^7(1\text{-}p)$. Ignoring the probability that more than one register fails, the expected value of the system operation can be set equal to 0.95:

$p^8+p^7(1\text{-}p)\,[(1\text{-}L_1)+(1\text{-}L_2)+\ldots+(1\text{-}L_8)]=0.95$ from which $p=0.989$. That is, using an estimate of what each failure costs we can afford relays with 11 failures per 1000 operations.

A further consideration should be made regarding the effect of a relay failure. In most practical equipments, failure will cause the relay to remain permanently in either the 0 or the 1 position. If it sticks in

	180°	90°	45°	22.5°	11.25°	5.6°	2.8°	1.4°
INPUT →	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8

OVERALL RELIABILITY = 0.95 RELIABILITY PER RELAY = p

CASE I: ANY MALFUNCTION IS FAILURE;

$p^8 = 0.95$ $p = 0.994$ $(1-p) = 0.006$

CASE II: RELATIVE DATA VALUES, L_i = LOSS DUE TO FAILURE OF R_i

$L_1 = L_2 = L_3 = L_4 = 1$, $L_5 = 0.8$, $L_6 = 0.25$, $L_7 = 0.05$ $L_8 = 0.01$

$$p^8 + p^7(1-p)\left\{(1-L_1)+(1-L_2)+\cdots+(1-L_8)\right\} = 0.95, \quad p = 0.989, \ (1-p) = 0.011$$

CASE III: RECOGNITION OF BINARY NATURE OF FAILURE,

$p = 0.978$, $(1-p) = 0.022$

Fig. 1. Reliability calculations for aircraft telemetering system.

Let P = probability that alarm system works

Let σ = probability that pressure fails

Assign Risks
- 0 pressure and alarm operating
- 0 alarm fails, pressure operates
- 1 pressure fails, alarm operates
- 100 pressure fails, alarm fails

$$R = \sigma P + 100\sigma(1-P) = \sigma(100-99P)$$

$R \leq 1$ implies $\sigma = 0.1$, $P > 0.91$; $\sigma = 0.05$, $P > 0.81$; $\sigma = 0.01$, $P = 0$

$\sigma(\alpha) = e^{-\alpha}$; α = pressure system maintenance

$P(\beta) = 1 - e^{-\beta}$; β = alarm system maintenance

$$R = e^{-\alpha} + 99e^{-(\alpha+\beta)}$$

$\alpha + \beta = K$; $R(\alpha, K) = e^{-\alpha} + 99e^{-K}$

$R(\beta, K) = e^{-(K-\beta)} + 99e^{-K}$

Minimum for $\alpha = K$, $\beta = 0$

Fig. 2. Reliability preobability calculations for pilot's Oxygen pressure warning system.

λ = parameter labelling modes of system operation

$P(\lambda, t)$ = probability that system is in state λ at time t

$C(\lambda, t)$ = cost of state λ at time t

Reliability Risk $R(t) = \int C(\lambda, t)\, P(\lambda, t)\, d\lambda$

$$= \sum_{i=1}^{N} C(\lambda_i, t)\, P(\lambda_i, t)$$

If $P(\lambda, t)$ depends on design parameters $a_1, \ldots, a_r$

$$P(\lambda, t; a_1, \ldots, a_r)$$

set $\frac{\partial P}{\partial a_i} = 0$ for minimum-risk design criteria

Fig. 3. Reliability calculations for warning system taking time factor into account.

the 0 position, it will give an incorrect indication when a 1 is transmitted. When 0 is transmitted, on the other hand, it will give a correct indication. Thus, half of the time correct results occur even if the relay is not working. The final conclusion, then (Case III in Fig. 1) is that an individual relay error rate of 22 per 1000 can be tolerated, or about four times the original estimate.

Still further thought on the above example might well lead to the conclusion that where R_8 is worth only 1 per cent in information, only seven relays are required instead of eight. This would result in cost reduction and simplification of the system.

Example 3

Consider another example—a hypothetical system for supplying a pilot with oxygen at high altitudes. A warning device is included which operates an alarm when the partial pressure of the oxygen falls below a prescribed limit. When the alarm goes off, the pilot knows that his supply is endangered for one reason or another, and that he must take steps to restore it by increasing the flow from the storage cylinder attached to the system, switching in a reserve cylinder, or some other appropriate action. None of these actions for increasing the oxygen flow amounts to more than a minor annoyance to the pilot. If, however, the alarm system fails to operate, the pilot's reflexes may deteriorate to such an extent, before he realizes what has happened, that his safety is jeopardized.

To approach the question of system reliability assumptions must be made as to the risks involved in the various types of failure. As shown in Fig. 2, let P be the probability that the alarm system is in working order, and let σ be the probability of pressure failure. Also, assume that the two are statistically independent. A relative risk of zero can be assigned to the situation in which both pressure and alarm system are operating properly, a risk of unity to the case where pressure is not operating correctly but the alarm device is working, and a risk of 100 to the case where the pressure is incorrect and the alarm system does not operate. These are the risks, or values, of the possible malfunctions. Now, setting up the overall system risk, omitting the question of time variation of these probabilities, we get:

$$R = \sigma P + 100\,\sigma\,(1-P = \sigma\,(100-99P)$$

One might first assume that a risk of more than one unit is intolerable, the risk involved in low pressure when the alarm is working. One can then find the relationship between the two probabilities, σ and P. For example: for $\sigma = 0.1$, it is required that $P > 0.91$; while for $\sigma = 0.05$ it is only necessary that $P > 0.81$. In fact, it can easily be computed that if one keeps the likelihood of pressure failure below 0.01 there is no need for the warning device at all.

If one applies the formula to the design objective of minimum possible risk, which might well be the objective, values of σ and P that can be achieved

must be considered. It is not unreasonable to assume that these depend largely upon maintenance. Maintenance devoted to the pressure system itself may be assigned a parameter α; and let

$$\sigma(\alpha)=e^{-\alpha}$$

Similarly, maintenance on the warning system (β) may be written

$$P(\beta)=e^{-\alpha}$$

The expression for the reliability risk now becomes

$$R=e^{-\alpha}+99e^{-(\alpha+\beta)}$$

Thus, increasing the maintenance effort on either the supply system, α, or the warning system, β, decreases the risk, but the rate of decrease is greater with α than with β.

Adding a further condition that the total rate of maintenance effort is fixed $K=\alpha+\beta$, the risk expression can be written, in terms of either γ or β, as

$$R(\alpha, K)=e^{-\alpha}+99e^{-K}$$
$$R(\beta, K)=e^{-(K-\beta)}+99e^{-K}$$

The way to minimize the risk in this example, then, is to make $\alpha=K$ and set $\beta=O$. This means that all attention is given to the pressure system itself, letting the alarm system stop working completely. Certain assumptions have been made as to the relative values of failure and to the effect of maintenance efforts. Different assumptions would, of course, lead to different conclusions.

The last example contained the main elements of a system reliability calculation: probabilities of failure together with dependence on maintenance associated risks, and an overall measure of reliability risk. The time parameter has been omitted; yet, it should not be over-looked that failure probabilities and risks are time dependent. It is perhaps worth formulating a somewhat general expression containing these relationships. As shown in Fig. 3, let λ be a performance parameter which represents the possible modes of operation of the system. For an analog computer it might be a continuous variable giving the output accuracy, depending on partial system failures. For the oxygen supply system discussed above, it might have four discrete values: complete operation, failure of the pressure system, failure of the alarm system, and failure of both systems. In terms of these significant states of the system one can define the probability function $P(\lambda,t)$ giving the probability density that λ will have some particular value at time t. Associated with each state of the system is an operational risk, given by $C(\lambda,t)$. Note that this risk can also be time dependent since the importance of various modes of system operation can be a function of time. For example, in the oxygen system, failures are not important at the beginning and end of a flight, when the aircraft is at low altitudes, for which auxiliary oxygen is not necessary. In terms of these functions, the overall reliability risk of the system can be defined as

$$R(t)=\int C(\lambda,t\ P(\lambda,t)d\lambda$$

By explicitly writing out this expression for the system, including (where relevant) the effects of main-

tolerance and similar factors, one can study in a quantitative way the dependence of the overall system reliability on the many design parameters.

It is perhaps worth pointing out what determines the two functions $C(\lambda,t)$ and $P(\lambda,t)$. The risk function, $C(\lambda,t)$ is properly independent of the system design, It is purely determined by the operational purpose of the system, and by the cost of the partial failures of that purpose. The specific system design, maintenance, etc., enter in the function $P(\lambda,t)$ which describes the probability of actual performance using a given, specific design. Thus, the designer has the function $P(\lambda,t)$ to work with and should study which failures are costly and which are not before fixing a system concept.

It is a common misconception among system designers that simplicity means reliability, and that complexity means unreliability. This is only partially true since properly chosen complexity can provide increased reliability. Perhaps the best example of this is to be found in the system most commonly met in an engineering laboratory—namely, the engineers themselves. If one computes the number of cells in a human being and estimates the expected time-to-failure of the average cell, one has the data on the basis of which many pseudo-correct reliability calculations can be made. It is easy to show that a human being can only function for the first few days of life, and after that, everything has begun to go so seriously wrong that he ought to be tossed out. If not yet obsolete, he is, by his first birthday, at least obsolescent. In a sense, none of us satisfy JAN specs.

The ability of our bodies to readjust and maintain relatively steady output function while our detailed internal function is going rapidly and inexorably to pot, makes us act like the proverbial "One Horse Shay" in many ways. This "homeostasis" depends on our internal complexity. And our feeling that we do function satisfactorily during most of our lives is based on our assignment of function value: We measure our ability to function by our external actions, not by an examination of the relative hardness of our arteries or the detailed reaction times of our nervous systems.

It is an axiom of communication theory that one can swap bandwidth for signal-to-noise ratio to achieve a desired system reliability, and while it is perhaps not possible now to formulate these relationships as precisely for reliability as it is for communication capacity. The approach of defining reliability risk in terms of cost malfunction, and examining semi-quantitatively, the effects of differing system designs, maintenance procedures, and alternate modes of operation, in terms of their effect on the average risk, or operational success, is becoming of increasing importance as a basic design tool.

* Based on a talk given by Dr. Kohlenberg at the 1956 New England Radio-Electronics Meeting at the Sheraton-Plaza Hotel, Boston, Mass., April 23, 1956.

Table II - 1

Element Values (in ohms, henrys, farads) for a Normalized Tschebyscheff Filter with 1/2-db Ripple ($\epsilon = 0.3493$, $\epsilon^2 = 0.1220$)

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	.3493										∞
2	.7014	.9403									0
3	.7981	1.3001	1.3465								∞
4	.8352	1.3916	1.7279	1.3138							0
5	.8529	1.4291	1.8142	1.6426	1.5388						∞
6	.8627	1.4483	1.8494	1.7101	1.9018	1.4042					0
7	.8686	1.4596	1.8675	1.7371	1.9712	1.7254	1.5982				∞
8	.8725	1.4666	1.8750	1.7508	1.9980	1.7838	1.9571	1.4379			0
9	.8752	1.4714	1.8856	1.7591	2.0116	1.8055	2.0203	1.7571	1.6238		∞
10	.8771	1.4748	1.8905	1.7645	2.0197	1.8165	2.0432	1.8119	1.9816	1.4539	0
b) D = 1/2											
1	.5240										2.0000
2	1.0522	.8928									.42426
3	1.1972	1.2686	1.4940								1.6026
4	1.2527	1.3564	2.0409	1.0924							.43600
5	1.2793	1.3905	2.1601	1.4640	1.6242						1.5753
6	1.2940	1.4073	2.2060	1.5380	2.1663	1.1338					.43809
7	1.3029	1.4171	2.2287	1.5651	2.2716	1.5058	1.6619				1.5679
8	1.3088	1.4230	2.2422	1.5781	2.3099	1.5755	2.2046	1.1487			.43882
9	1.3128	1.4270	2.2507	1.5856	2.3284	1.5999	2.3055	1.5213	1.6779		1.5649
10	1.3157	1.4299	2.2564	1.5903	2.3389	1.6114	2.3406	1.5895	2.2214	1.1556	.43915
c) D = 1											
1	.6986										1.0000
2	1.4029	.7071									.50402
3	1.5963	1.0967	1.5963								1.0000
4	1.6703	1.1926	2.3661	.8419							.50402
5	1.7058	1.2296	2.5408	1.2296	1.7058						1.0000
6	1.7254	1.2479	2.6064	1.3137	2.4758	.8696					.50402
7	1.7372	1.2583	2.6381	1.3444	2.6381	1.2583	1.7372				1.0000
8	1.7451	1.2647	2.6564	1.3590	2.6964	1.3389	2.5093	.8796			.50402
9	1.7504	1.2690	2.6678	1.3673	2.7239	1.3673	2.6678	1.2690	1.7504		1.0000
10	1.7543	1.2721	2.6754	1.3725	2.7392	1.3806	2.7231	1.3485	2.5239	.8842	.50402
d) D = 2											
1	1.0479										.50000
2	2.1043	.4464									.42426
3	2.3944	.7916	1.9187								.62397
4	2.5055	.8899	3.1110	.5462							.43600
5	2.5587	.9293	3.4028	.8827	2.0153						.63480
6	2.5880	.9491	3.5106	.9664	3.2124	.5669					.43809
7	2.6057	.9604	3.5616	.9982	3.4944	.9038	2.0436				.63780
8	2.6176	.9674	3.5903	1.0136	3.5963	.9839	3.2428	.5743			.43882
9	2.6257	.9722	3.6078	1.0224	3.6436	1.0132	3.5220	.9119	2.0544		.63903
10	2.6314	.9755	3.6194	1.0279	3.6694	1.0271	3.6213	.9909	3.2560	.5778	.43915
e) D = 3											
1	1.3972										.33333
2	2.8058	.3140									.33571
3	3.1926	.5999	2.3205								.45860
4	3.3406	.6895	3.9223	.3958							.35545
5	3.4115	.7267	4.3318	.6735	2.4111						.47164
6	3.4507	.7455	4.4827	.7483	4.0228	.4131					.35918
7	3.4743	.7565	4.5532	.7776	4.4262	.6914	2.4366				.47530
8	3.4902	.7633	4.5925	.7919	4.5730	.7628	4.0521	.4194			.36048
9	3.5009	.7679	4.6162	.8002	4.6408	.7895	4.4537	.6984	2.4474		.47682
10	3.5086	.7711	4.6318	.8054	4.6774	.8023	4.5984	.7687	4.0646	.4223	.36109

Modern Network Design

Louis Weinberg

Research Laboratories, Hughes Aircraft Co., Culver City, Calif

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. In Part I, Butterworth characteristics were covered (*ED, Sept. 15, 1956, p. 22*). In this part II, several Tschebyscheff characteristics are covered. Parts III and IV will cover additional Tschebyscheff characteristics, Bessel Functions, and conversions and transformation data.

Tschebyscheff Characteristic

The Tschebyscheff[4] approximation to the magnitude characteristic of a low-pass filter is given by

$$\left| Z_{21}(j\omega) \right|^2 = \frac{1}{1 + [\epsilon\, T_n(\omega)]^2} \qquad (3)$$

Here the parameter ε is the ripple factor and $T_n(\omega)$ is the Tschebyscheff polynomial of order (and degree) n. The first ten orders of T_n are given in Table II-3. The role played by ε and the equal-ripple quality of the Tschebyscheff approximation are illustrated in Fig. II-1, where $n = 3$ and a 1 db ripple are used.

From the magnitude given by Eq. 3 the complete transfer function can be found. It is given by

$$Z_{21}(s) = \frac{H}{V_n(s)} \qquad (4)$$

where H again is a constant and V_n is formed from the left half-plane zeros of the denominator of Eq. 3; V_n is a polynomial of degree n with the coefficient of s^n equal to unity.

Synthesis From Tables—II

Each value of ε yields a different set of V_n polynomials. The zeros of these polynomials are given in Table II-4 and their coefficients are listed in Table II-5.

The element values of the ladder networks for values of ε corresponding to 1/2 and 1 db ripple (also 2 db, in part IV) and for decrement ratios of 0, 1/2, 1, 2, and 3 are presnted in Tables II-1 and II-2.

After the value of ε has been calculated from a specified ripple factor, it is necessary to determine the required value of *n*. Formulas useful for this purpose are

$$T_n(\omega) = \frac{(\omega + \sqrt{\omega^2 - 1})^n + (\omega + \sqrt{\omega^2 - 1})^{-n}}{2} \quad (5)$$

or

$$T_n(\omega) = \frac{(\omega - \sqrt{\omega^2 - 1})^n + (\omega - \sqrt{\omega^2 - 1})^{-n}}{2} \quad (6)$$

Table II - 3 **Tschebyscheff Polynomials $T_n(\omega) = \cos(n \arccos \omega)$ for n Running from 1 through 10**

n	$T_n(\omega)$
1	ω
2	$2\omega^2 - 1$
3	$4\omega^3 - 3\omega$
4	$8\omega^4 - 8\omega^2 + 1$
5	$16\omega^5 - 20\omega^3 + 5\omega$
6	$32\omega^6 - 48\omega^4 + 18\omega^2 - 1$
7	$64\omega^7 - 112\omega^5 + 56\omega^3 - 7\omega$
8	$128\omega^8 - 256\omega^6 + 160\omega^4 - 32\omega^2 + 1$
9	$256\omega^9 - 576\omega^7 + 432\omega^5 - 120\omega^3 + 9\omega$
10	$512\omega^{10} - 1280\omega^8 + 1120\omega^6 - 400\omega^4 + 500\omega^2 - 1$

Table II - 2
Element Values (in ohms, henrys, farads) for a Normalized Tschebyscheff Filter with 1-db Rippl ($\epsilon = 0.5088$, $\epsilon^2 = 0.2589$).

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	.5088										∞
2	.9110	.9957									0
3	1.0118	1.3332	1.5088								∞
4	1.0495	1.4126	1.9093	1.2817							0
5	1.0674	1.4441	1.9938	1.5908	1.6652						∞
6	1.0773	1.4601	2.0270	1.6507	2.0491	1.3457					0
7	1.0832	1.4694	2.0437	1.6736	2.1192	1.6489	1.7118				∞
8	1.0872	1.4751	2.0537	1.6850	2.1453	1.7021	2.0922	1.3691			0
9	1.0899	1.4790	2.0601	1.6918	2.1583	1.7213	2.1574	1.6707	1.7317		∞
10	1.0918	1.4817	2.0645	1.6961	2.1658	1.7306	2.1803	1.7215	2.1111	1.3801	0
b) D = 1/2											
1	.7633										2.0000
2	1.3665	.8767									.32080
3	1.5177	1.1950	1.7806								1.7047
4	1.5743	1.2645	2.3525	1.0275							.32635
5	1.6012	1.2909	2.4701	1.3364	1.9021						1.6836
6	1.6159	1.3038	2.5144	1.3948	2.4641	1.0580					.32735
7	1.6248	1.3112	2.5361	1.4159	2.5682	1.3658	1.9368				1.6778
8	1.6308	1.3157	2.5490	1.4258	2.6054	1.4209	2.4979	1.0688			.32770
9	1.6348	1.3188	2.5570	1.4315	2.6232	1.4399	2.5978	1.3766	1.9515		1.6755
10	1.6377	1.3209	2.5624	1.4350	2.6333	1.4488	2.6321	1.4306	2.5126	1.0738	.32786
c) D = 1											
1	1.0177										1.0000
2	1.8219	.6850									.37598
3	2.0236	.9941	2.0236								1.0000
4	2.0991	1.0644	2.8311	.7892							.37598
5	2.1349	1.0911	3.0009	1.0911	2.1349						1.0000
6	2.1546	1.1041	3.0634	1.1518	2.9367	.8101					.37598
7	2.1664	1.1116	3.0934	1.1736	3.0934	1.1116	2.1664				1.0000
8	2.1744	1.1161	3.1107	1.1839	3.1488	1.1696	2.9685	.8175			.37598
9	2.1797	1.1192	3.1215	1.1897	3.1747	1.1897	3.1215	1.1192	2.1797		1.0000
10	2.1836	1.1213	3.1286	1.1933	3.1890	1.1990	3.1738	1.1763	2.9824	.8210	.37598
d) D = 2											
1	1.5265										.50000
2	2.7329	.4384									.32080
3	3.0354	.7010	2.5873								.58660
4	3.1486	.7677	3.8748	.5138							.32635
5	3.2023	.7938	4.1585	.7668	2.6957						.59397
6	3.2319	.8066	4.2609	.8231	3.9829	.5290					.32735
7	3.2496	.8140	4.3334	.8439	4.2552	.7815	2.7261				.59601
8	3.2615	.8186	4.3361	.8538	4.3510	.8353	4.0151	.5344			.32770
9	3.2696	.8216	4.3526	.8594	4.3951	.8544	4.2841	.7871	2.7390		.59685
10	3.2754	.8238	4.3635	.8630	4.4190	.8633	4.377	.8401	4.0290	.5369	.32786
e) D = 3											
1	2.0354										.33333
2	3.6439	.3131									.25776
3	4.0472	.5296	3.2077								.42057
4	4.1981	.5887	4.9727	.3741							.26734
5	4.2698	.6124	5.3738	.5817	3.3182						.42893
6	4.3092	.6242	5.5175	.6309	5.0886	.3866					.26913
7	4.3328	.6310	5.5840	.6494	5.4805	.5939	3.3489				.43127
8	4.3487	.6352	5.6213	.6583	5.6187	.6407	5.1223	.3910			.26976
9	4.3594	.6381	5.6437	.6634	5.6818	.6576	5.5117	.5986	3.3620		.43223
10	4.3671	.6401	5.6584	.6666	5.7159	.6656	5.6472	.6447	5.1368	.3931	.27005

Table II-4 Zeros of Polynomials V_n derived from the Tschebyscheff Approximation

a) 1/2-db ripple ($\epsilon = 0.3493114$, $\epsilon^2 = 0.1220184$)

n = 1	n = 2	n = 3	n = 4	n = 5	n = 6	n = 7	n = 8	n = 9	n = 10
-2.8627752	-0.7128122 ±j1.0040425	-0.6264565	-0.1753531 ±j1.0162529	-0.3623196	-0.0776501 ±j1.0084608	-0.2561700	-0.0436201 ±j1.0050021	-0.1984053	-0.0278994 ±j1.0032732
		-0.3132282 ±j1.0219275	-0.4233398 ±j0.4209457	-0.1119629 ±j1.0115574	-0.2121440 ±j0.7382446	-0.0570032 ±j1.0064085	-0.1242195 ±j0.8519996	-0.0344527 ±j1.0040040	-0.0809672 ±j0.9050658
				-0.2931227 ±j0.6251768	-0.2897940 ±j0.2702162	-0.1597194 ±j0.8070770	-0.1859076 ±j0.5692879	-0.0992026 ±j0.8829063	-0.1261094 ±j0.7182643
						-0.2308012 ±j0.4478939	-0.2192929 ±j0.1999073	-0.1519873 ±j0.6553170	-0.1589072 ±j0.4611541
								-0.1864400 ±j0.3486869	-0.1761499 ±j0.1589029

b) 1-db ripple ($\epsilon = 0.5088471$, $\epsilon^2 = 0.2589254$)

n = 1	n = 2	n = 3	n = 4	n = 5	n = 6	n = 7	n = 8	n = 9	n = 10
-1.9652267	-0.5488672 ±j0.8951286	-0.4941706	-0.1395360 ±j0.9833792	-0.2894933	-0.0621810 ±j0.9934115	-0.2054141	-0.0350082 ±j0.9964513	-0.1593305	-0.0224144 ±j0.9977755
		-0.2470853 ±j0.9659987	-0.3368697 ±j0.4073290	-0.0894584 ±j0.9901071	-0.1698817 ±j0.7272275	-0.0457089 ±j0.9952839	-0.0996950 ±j0.8447506	-0.0276674 ±j0.9972297	-0.1013166 ±j0.7143284
				-0.2342050 ±j0.6119198	-0.2320627 ±j0.2661837	-0.1280736 ±j0.7981557	-0.1492041 ±j0.5644443	-0.0796652 ±j0.8769490	-0.0650493 ±j0.9001063
						-0.1850717 ±j0.4429430	-0.1759983 ±j0.1982065	-0.1220542 ±j0.6508954	-0.1276664 ±j0.4586271
								-0.1497217 ±j0.3463342	-0.1415193 ±j0.1580321

Table II-5 Polynomials V_n in Expanded Form $V_n = s^n + b_{n-1}\, s^{n-1} + \ldots + b_1 s + b_o$

a) 1/2-db ripple ($\epsilon = 0.3493114$, $\epsilon^2 = 0.1220184$)

n	b_o	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8	b_9
1	2.8627752									
2	1.5162026	1.4256245								
3	0.7156938	1.5348954	1.2529130							
4	0.3790506	1.0254553	1.7168662	1.1973856						
5	0.1789234	0.7525181	1.3095747	1.9373675	1.1724909					
6	0.0947626	0.4323669	1.1718613	1.5897635	2.1718446	1.1591761				
7	0.0447309	0.2820722	0.7556511	1.6479029	1.8694079	2.4126510	1.1512176			
8	0.0236907	0.1525444	0.5735604	1.1485894	2.1840154	2.1492173	2.6567498	1.1460801		
9	0.0111827	0.0941198	0.3408193	0.9836199	1.6113880	2.7814990	2.4293297	2.9027337	1.1425705	
10	0.0059227	0.0492855	0.2372688	0.6269689	1.5274307	2.1442372	3.4409268	2.7097415	3.1498757	1.1400664

b) 1-db ripple ($\epsilon = 0.5088471$, $\epsilon^2 = 0.2589254$)

n	b_o	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8	b_9
1	1.9652267									
2	1.1025103	1.0977343								
3	0.4913067	1.2384092	0.9883412							
4	0.2756276	0.7426194	1.4539248	0.9528114						
5	0.1228267	0.5805342	0.9743961	1.6888160	0.9368201					
6	0.0689069	0.3070808	0.9393461	1.2021409	1.9308256	0.9282510				
7	0.0307066	0.2136712	0.5486192	1.3575440	1.4287930	2.1760778	0.9231228			
8	0.0172267	0.1073447	0.4478257	0.8468243	1.8369024	1.6551557	2.4230264	0.9198113		
9	0.0076767	0.0706048	0.2441864	0.7863109	1.2016071	2.3781188	1.8814798	2.6709468	0.9175476	
10	0.0043067	0.0344971	0.1824512	0.4553892	1.2444914	1.6129856	2.9815094	2.1078524	2.9194657	.9159320

Example

The use of the tables is illustrated in the example below.

Determine a ladder network that has the following characteristics:

1. Low-pass filter with a peak-to-peak ripple in the squared magnitude characteristic not exceeding 15%.
2. A cutoff radian frequency $\omega_c = 5000$ (the bandwidth being measured at the minimum value of the ripple).
3. Resistance terminations at both ends with the load resistance equal to 1000 ohms.
4. The response is to be down at least 50 db at $\omega = 4\omega_c$.
5. The network is to be driven by a current source.

We first calculate the required value of ϵ^2. At a trough of the ripple we have

$$\frac{1}{1 + \epsilon^2 T_n^2(1)} = 1 - 0.15 = 0.85$$

$$1 + \epsilon^2 = \frac{20}{17}$$

$$\epsilon^2 = 0.176$$

Since this value lies between 1/2 db and 1 db ripple we must use Table II-1.

Now we calculate n. At $\omega = 4$.

$$\frac{1}{1 + \epsilon^2 T_n^2(4)} = 10^{-5}$$

$$1 + \epsilon^2 T_n^2(4) = 10^5$$

$$\epsilon^2 T_n^2(4) \cong 10^5$$

$$T_n(4) = 753$$

Now using Eq. 5, we have

$$\left.\frac{(\omega + \sqrt{\omega^2 - 1})^n + (\omega + \sqrt{\omega^2 - 1})^{-n}}{2}\right|_{\omega=4} = 753$$

$$\left.(\omega + \sqrt{\omega^2 - 1})^n\right|_{\omega=4} \cong 1506$$

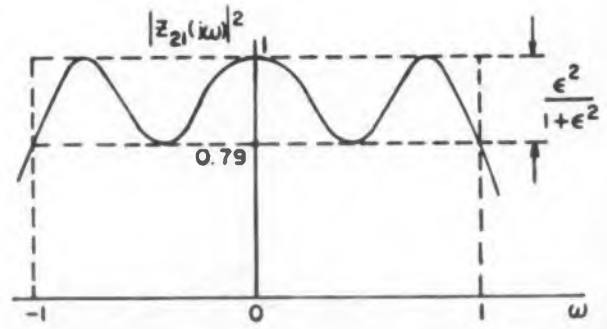

Fig. II-1 Low-pass filter obtained by using the Tschebyscheff approximation with n = 3 and a 1 db ripple.

$$(7.88)^n = 1506$$

$$n = 3.58$$

Therefore $n = 4$ will be more than satisfactory.

Since no ratio of decrements or resistances was called for in the specifications, we may use b, c, d or e of Table II-1. Suppose we use both c and d so that we can choose the more practical network for laboratory use. Consulting the Table II-1 c and d for $n = 4$ we find the normalized element values; we use the unprimed values since the input is a current source. Removing the normalization by multiplying all C's by $\frac{1}{Rw_c} = \frac{1}{5 \times 10^6}$, all L's by $\frac{R}{w_c} = \frac{1}{5}$, and the resistances by $R = 1000$, we obtain

$D = 1$	$D = 2$
$\frac{1}{5\times10^6} C_1 = 0.334 \times 10^{-6}$	$\frac{1}{5\times10^6} C_1 = 0.501 \times 10^{-6}$
$\frac{1}{5} L_2 = 0.238$	$\frac{1}{5} L_2 = 0.178$
$\frac{1}{5\times10^6} C_3 = 0.473 \times 10^{-6}$	$\frac{1}{5\times10^6} C_3 = 0.622 \times 10^{-6}$
$\frac{1}{5} L_4 = 0.168$	$\frac{1}{5} L_4 = 0.109$
$1000\ R_n = 504$	$1000\ R_n = 436$

The networks are shown in Fig. II-2.

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.

Reference

4. Amplitude-Frequency Characteristics of Ladder Networks, E. Green, Marconi's Wireless Telegraph Co., Essex, England; 1954.

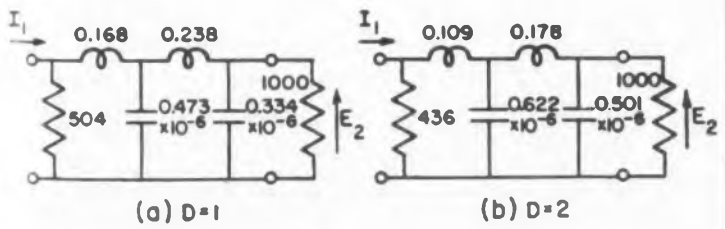

Fig. II-2 Networks obtained in example (values in ohms, henrys, and farads).

THREE new miniature ceramic connectors have just been made available for applications where space is at a premium, and where unusual operating conditions are encountered.

Developed and manufactured by Raytheon Manufacturing Company, Ceramic Division, Waltham 54, Mass., the three connectors are a ceramic feed-through terminal (not shown), a miniature coaxial ceramic connector, and a multi-pin ceramic connector.

Ceramic Feed-Through Terminal

This terminal, less than 1/4 in. in overall diameter, is of alumina ceramic construction. It is designed for extremely high voltage applications and where high temperature and high altitude operation is anticipated. The all-ceramic construction results in a rugged terminal with the elimination of glass which has the disadvantage of crazing. The terminal meets all military specifications and is available with or without a metal flange. Either type can be soft or hard soldered directly to the chassis or the electronic package. This ceramic terminal passes mass spectrometer leak tests and permits true hermetic sealing of electronic equipment.

Multiple-Pin Ceramic Connector

Raytheon's multi-pin ceramic connector has 22 pins, vacuum sealed. This multi-pin connector is designed for hermetic sealing of electronic packages and is particularly adapted to printed circuitry, allowing for plug-in unit construction. The multi-pin connector meets all military specifications, is of rugged construction, and has the same advantage as the ceramic construction of the feed-through terminal mentioned above in that it is particularly useful at high temperatures

Ceramic coaxial miniature connector (left) and multi-pin connector (right)

Miniature

Ceramic Connectors

and high altitudes. Constructed of a non-water absorption ceramic, with a dielectric breakdown of 300 v per mil, an extra long creepage path adds to its high voltage operating feature. Other forms than shown can be manufactured, such as circular or linear shapes with other numbers of pin connections.

Miniature Coaxial Connector

Believed to be the only ceramic coaxial connector of its size available, the coaxial connector shown is only 1/4 in. in diameter but is completely hermetically sealed. The high-shrink ceramic dielectric has a zero water absorption coefficient. Designed for use with subminiature cable, the outer metal conductor shell found on conventional designs has been completely eliminated. This allows further decrease in size. The connector can be soft or hard soldered directly to equipment chassis. It will withstand high shock and vibration and meet all military specifications. Not only is the connector the smallest in diameter but is also the shortest, measuring only 1 in. in length for the right-angle connector shown. The connectors can also be obtained straight if desired.

All of the connectors are good to 650 C or above as far as the connectors themselves are concerned. Temperature limitation may occur, however, because of the method of installation, such as soft soldering, hard soldering, brazing, etc. The connectors are especially adaptable to UHF frequencies and have very low losses in the microwave region, even to "K band."

For further information on these connectors fill out the Readers' Service card and circle No. 20.

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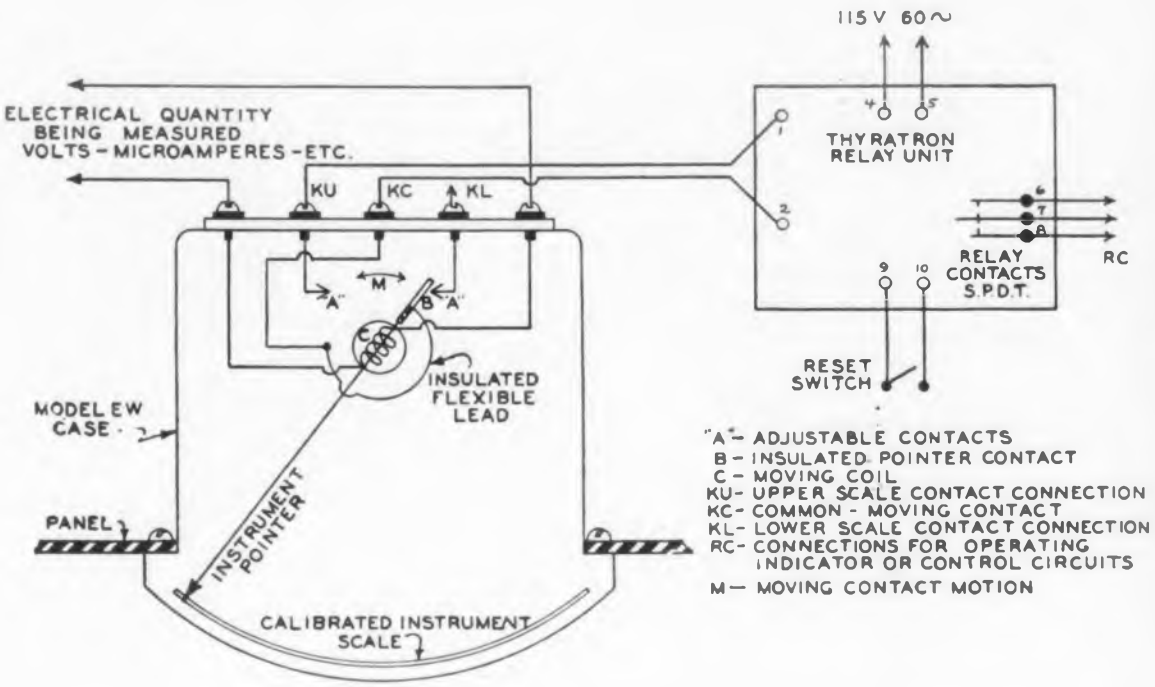
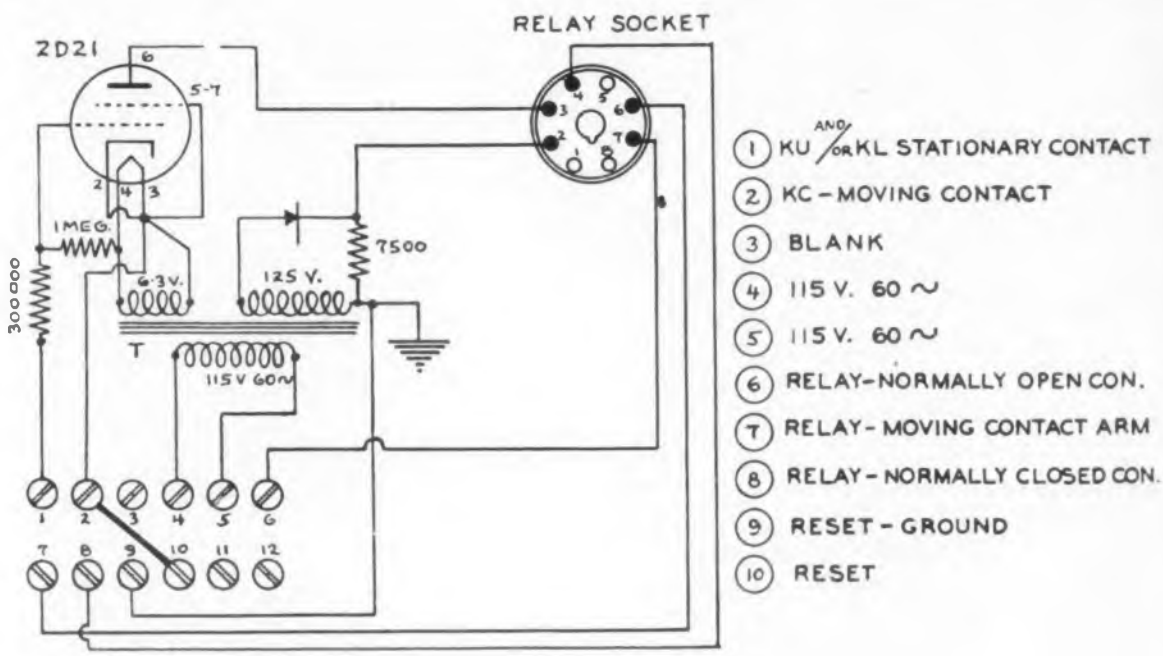
Precision Contact Making Deflection Meter



Instrument schematic, showing connection to typical relay unit.



Suggested companion contact relay unit schematic.

THIS precise deflection contact-making meter has a wide range of application in controlling other cricuits.

Manufactured by Sensitive Research Instrument Corp., New Rochelle, N. Y., the meter consists of three sections: On electrical direct reading deflection indication; a contact mechanism for sensing the indicator position; and a section to close and operate a thyratron relay unit, based upon a preset level of meter deflection.

Full scale deflection of 5-1/2 in. can be caused by an input of only 4μa in the low mvdc region, with an inherent accuracy of 0.5 per cent. Multipliers or shunts can be incorporated to increase the range of meter indications. Both ac or dc sensitive meter movement instruments are made. Required power is 60 cy, 115 v.

The suggested companion thyratron relay unit utilizes a simple circuit with a SPDT relay switch whose contacts are rated at 1 amp, 115 v (noninductive).

Electrical quantities to be measured, indicated, or controlled are connected to the appropriate binding posts. The connections for use in sensing the upper limit are shown on the instrument schematic. KC is connected to Terminal *2* of the Thyratron Relay Unit and KU is connected to Terminal *1*. Sensing the lower limit instead of the upper is accomplished by connecting Terminal *1* of the relay unit to KL instead of KU. If the same signal is desired for either upper or lower limit contacting, the KU and KL binding posts may be connected to Terminal *1* of a single thyratron relay unit. Separate sensing of upper and lower limits requires the use of two thyratron relay units. Sufficient ventilation must be provided to prevent overheating of the unit.

The meter can be readily applied to the field of automatic inspection (electrical go, no-go gaging) or control between maximum and minimum limits.

For additional information on this product, turn to the Reader's Service card and circle 23.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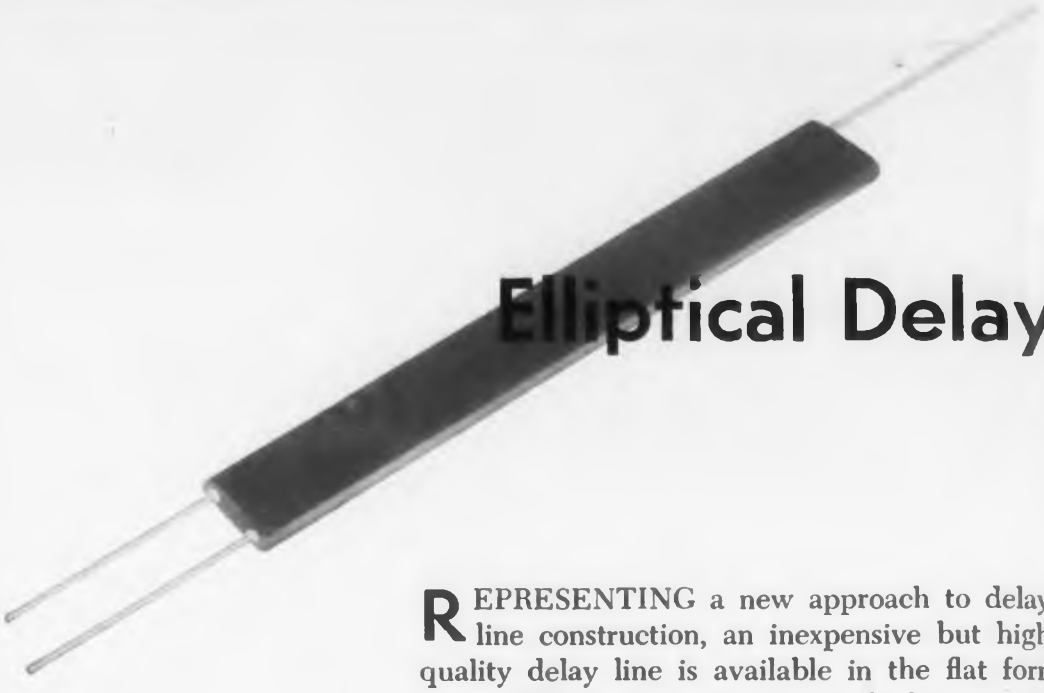
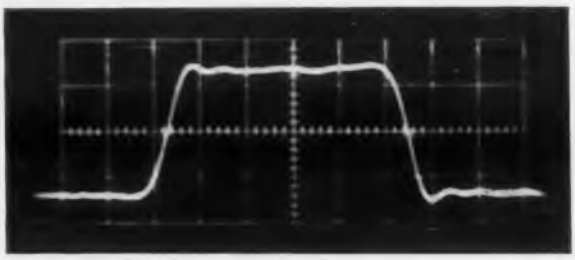
Elliptical Delay

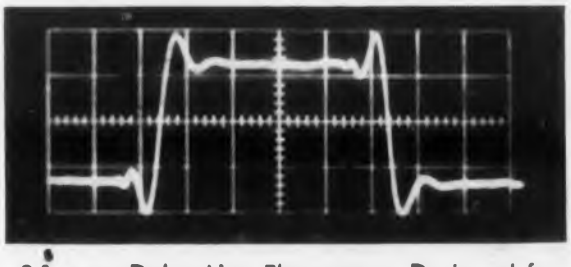


REPRESENTING a new approach to delay-line construction, an inexpensive but high-quality delay line is available in the flat form shown. Elliptical in cross section, the line appears similar to TV transmission cable. Its size is 5/8 by 3/16 by 5 in. long and is obtainable in an impedance range from 75 to 7500 ohms with delays ranging up to 2 μsec and beyond.

Known as a "Delay-Line Flat" and manufactured by Columbia Technical Corporation, of 61-02 31st Ave., Woodside 77, N.Y., this new-type delay line can be mounted in almost any position and location, even flat against a chassis. Because of its elliptical cross section, an advantage over the conventional distributed-parameter delay line of circular cross section results, in that it

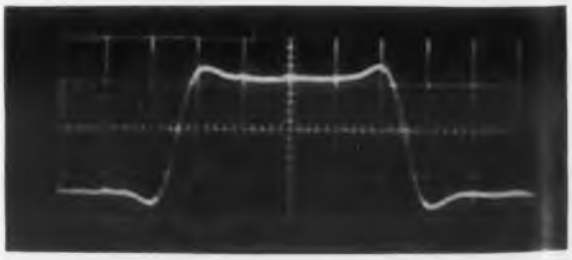


Pulse output from 0.7 μsec Delay-Line Flats. Impedance, 4000 ohms. Pulse width, 1 μsec.



2.1 μsec Delay-Line Flat output. Designed for computer application, rise time is only 0.17 μsec. A 5.0 μsec pulse is applied to the 2500 ohm Delay-Line.

Video amplifier pulse output from commercial TV receiver after passing through 0.7 μsec, 1700 ohm Delay-Line Flat.



Pulse output from 0.7 μsec Delay-Line. Impedance, 6800 ohms. Pulse width, 1 μsec.

Line

provides greatly increased capacitance per unit length. It also provides greater freedom in the choice of the L/C ratio, making it possible to cover a wider range of impedance and delay using the same core.

Standard low—impedance Flats are available with the following characteristics: 75 ohms at 0.05 μsec delay; 120 ohms at 0.10 μsec delay; 270 ohms at 0.30 μsec delay; and 470 ohms at 0.75 μsec delay. Beyond 500 ohms and up to about 1500 ohms, the maximum practical delay is 1.0 μsec. Up to 2 μsec or greater delay is possible on high-impedance lines varying from approximately 1500 to 7500 ohms. Longer delays can of course be obtained by connecting several Flats in series.

Maximum operating voltage for these lines is from 250 to 1000 v dc depending upon the line. Operating temperature ranges from —20 to +80 C for commercial applications, and through a choice of suitable materials can be widened to meet MIL-E-5400 Specification. Standard delay and impedance tolerances are ± 10% or ± 5%. Closer tolerances can be met if necessary.

The Delay-Line Flats are extremely rugged, and the leads of No. 20 AWG wire are molded into the core thus eliminating the danger of wire breakage. The conductor winding, ground plane, and insulation are covered with an impregnated jacket or are enclosed in a sealed plastic case.

Applications suggested for these delay lines are in the computer field, for tracking equipment, in oscilloscopes, and in the color TV field. A 2 μsec Delay-Line Flat having an impedance of 2500 ohms and having a rise time of better than 10% has been recently developed for a computer application. Typical pulses obtained after delay through Delay-Line Flats are shown. A Hewlett-Packard Model 212A Pulse Generator was used to supply the input pulse. Also shown is pulse output from a commercial video amplifier used in a popular color TV receiver after passing through a 0.7 μsec 1700 ohm Delay-Line Flat.

For further information about this product, fill out the Reader's Service Card and circle **26.**

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Design Techniques Using Conductance Curves

Pentode Degenerative Amplifier and Cathode Follower

Keats A. Pullen, Jr.

Ballistic Research Labs.
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THE pentode dengenerative amplifier differs from the triode degenerative amplifier in several respects. For example, the transconductance developed in the cathode circuit of a pentode is affected by the screen voltage reference. The transconductance available in the plate circuit is less than that available in the cathode circuit by a percentage dependent on the ratio of plate current to screen current. The effects of different pentode techniques are examined here. Use of conductance curves as a means of evaluating and predicting circuit behavior is demonstrated. Modified equations are included as required.

The Pentode Action Cathode Follower—Video Type

In order to obtain full pentode-type action from a pentode cathode follower, Fig. 1, the potential between screen and cathode should be kept fixed. Assume that a *12BY7* tube is to be used as a pentode-tpye cathode follower. (Curves in Fig. 2.) The maximum cathode resistance permitted by the video frequency response requirements is chosen as 1000 ohms. With a total of 50 μμfd loading capacitance, a rectangular pulse then should reach 90% of its rise or decay in about 20 millimicroseconds. If a minimum of 25 v peak-to-peak excursion is required, a screen voltage providing plate current somewhat greater than 25 ma for zero bias is indicated. From Fig. 2, 100 v for the screen to cathode voltage appears reasonable and 150 v as the static plate to cathode potential may be chosen. The zero bias cathode current is approximately $I_P([X_P + X_{C2}]$, for $E_p/E_i=1.5$, $I_p=32$ ma or 37 ma. Neglecting the variations of X_p and X_{C2}, the minimum cathode current is 12 ma. This corresponds to a nominal plate current of 12/1.16 or 10.4 ma. The tube grid to cathode bias required for this plate current is −1.75 v. [Author's note: X_p and X_{C2} vary little in area of minimum cathode current, approaching the values at $e_b/E_{c2}=2$ very closely.]

The nominal transconductance values at the two extremes of bias are 8800 and 15,000 micromhos. The actual values are 1.16 times these nominal values. They are 10,200 and 17,300. The cathode follower amplification for the pentode connected cathode follower is

$$VA = G_M\,(X_P)\,R_K/[1 + G_M\,(X_P)]R_K] \qquad (1)$$

For the two transconductance values given, the VA is 0.910 and 0.945. The resulting harmonic distortion is 0.60%. The average amplification is 0.927. The applied peak-to-peak signal voltage required is 25 + 1.75 or 26.75 v.

The effect of the high cathode follower gain on the input capacitance of the tube is worthy of note. The screen is maintained at cathode signal potential in the pentode cathode follower. A major portion of the input capacitance is affected by voltage degeneration. As a result, the input capacitance of the tube may be as small as a quarter of that listed in the tube data sheets. If the incoming signal has a rapid negative going front, however, the front may cut off the tube plate and screen currents.* If the tube is cut off by the incoming signal, then full tube input capacitance will be experienced momentarily. Cutoff of a capacitance loaded cathode follower under a negative voltage shift occurs more easily as the ratio of the input signal voltage to the zero to cutoff bias voltage becomes larger compared to unity *["Most of the input signal in a cathode follower is balanced by the output voltage from cathode to ground, leaving only a small voltage from grid to cathode. If, however, there is

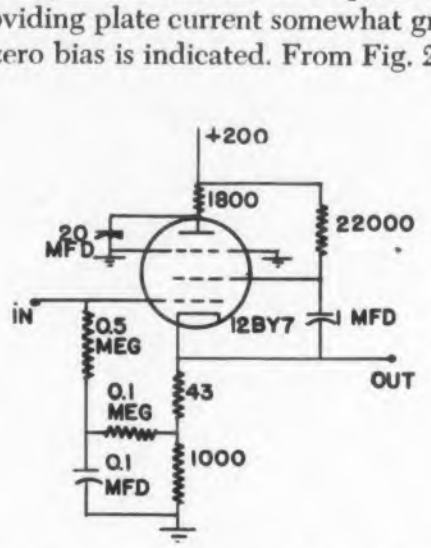


Fig. 1. Degenerative Amplifier

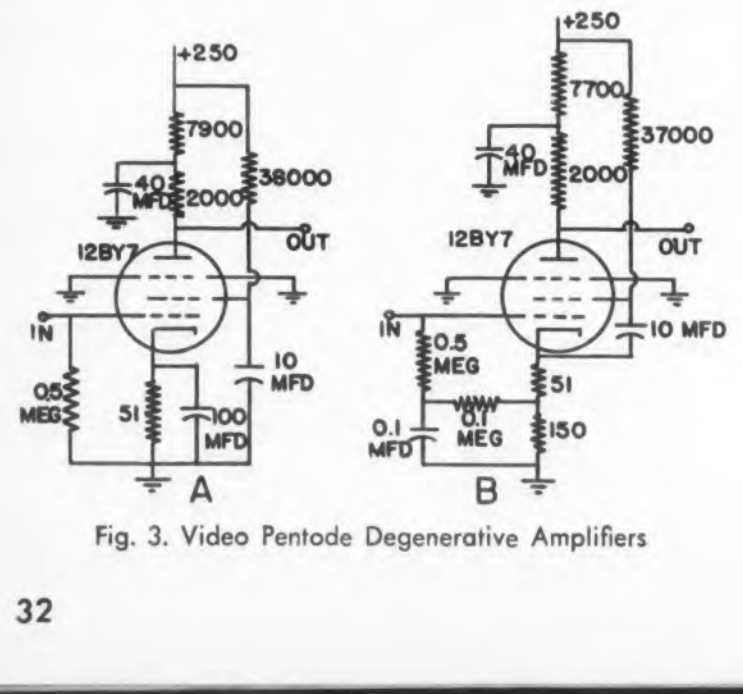


Fig. 3. Video Pentode Degenerative Amplifiers

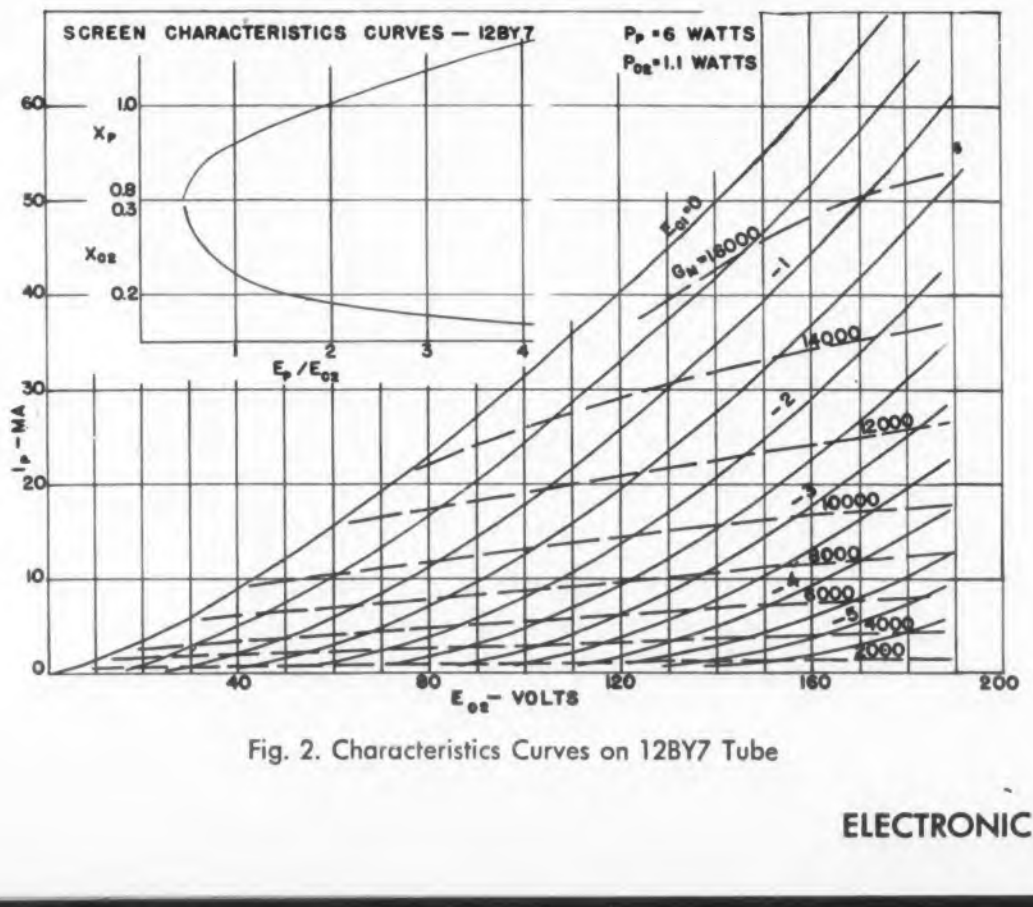


Fig. 2. Characteristics Curves on 12BY7 Tube

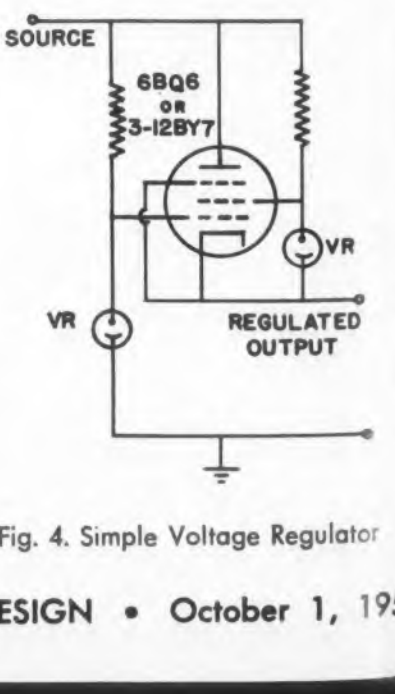


Fig. 4. Simple Voltage Regulator

appreciable capacitance from cathode to ground, then the capacitor may not discharge fast enough to permit the cathode voltage to follow the grid voltage. In this case, the portion of the input voltage applied from grid to cathode may become large enough to cut the tube off, making the output voltage in the cathode circuit that of the capacitor decay instead of the input signal. See sketch. Note that E_{cz}, the bias for tube cutoff, is approximately at the indicated location."]

Consequently, in video applications having stringent wave front requirements, the input voltage change applied to a cathode follower having an amplification near unity should be limited. The order of magnitude of the total grid to cathode voltage change should follow within the zero bias to tube cutoff range. For a supply voltage of 200 v, the screen voltage reducing resistor required to provide a voltage loss of 80 v at a grid bias of 0.875 v (screen current of 3.5 ma) is approximately 22,000 ohms. The screen is bypassed to cathode with a capacitance large enough to prevent the screen-to-cathode voltage change exceeding approximately 1 v at the lowest frequency to be passed. A voltage reducing resistor for providing the plate circuit voltage reduction of 30 v may be selected in a similar manner. The net plate current is 16.6 ma at the static bias of 0.875 v. The cathode resistors are found to be 1000 ohms and 43 ohms.

Screen Bypassed to Ground

The screen in the previous problem could have been bypassed to ground instead of to the cathode. Redesigning the previous problem assuming that the screen is bypassed to ground yields a cathode follower having two important differences. The first is that only part of the input capacitance effect can be controlled by degeneration. The grid-to-screen capacitance now is the same as that normally experienced, since the screen is at signal ground potential. The second is that a screen self-conductance type of term $G_{c2}\ R_K$ must be included in the denominator of Eq. 1. The new equation reads

$$VA = G_M\ (X_P + X_{C2})\ R_K / [1 + (X_P + X_{C2})\ (G_M + G_{C2})\ R_K] \quad (2)$$

where G_{c2} is the slope of the bias contour (ratio of nominal plate current change to screen voltage change). The value of G_{c2} at the nominal bias point, $E_{c1} = -0.875$ v and $E_{c2} = 100$ v is 0.0004. A small reduction in the voltage efficiency of the cathode follower results from bypassing of the screen to ground instead of to the cathode of the tube. The magnitude of the loss in voltage efficiency depends on the pentode tube concerned.

The provision of the suppressor and internal shield double connection arrangement for isolation of the input and the output in the *12BY7* tube is a very convenient aid to the application of degeneration to the tube. Where the screen and suppressor can not both be used to provide input-output isolation, the single electrode which is used to provide isolation must be designed effectively. Combining the shield and the suppressor, using tandem connections, should provide effective isolation.

Design procedures for the triode condition pentode cathode follower is similar in all other respects to the pentode condition design.

Table I Pentode Video Amplifier Design Data

Plate supply (net) volts	125 v	200. v
Mean plate current	15.9 ma	17.5 ma
Mean screen current	3.96 ma	3.43 ma
Series screen resistor	38000 ohms	44000 ohms
Bias resistor	51 ohms	49 ohms
Plate series decoupling resistor	7900 ohms	2900 ohms
Amplification; zero bias	26.0	28.5
Amplification, —2 v	14.1	15.6
Distortion	7.4%	7.3%

Table II Degenerative Video Amplifier

Plate series decoupling resistor	7700 ohms	2750 ohms
Screen series resistor	37000 ohms	43000 ohms
Amplification, zero bias	5.96	6.5
Amplification —2 v	5.16	5.56
Distortion	1.18%	1.95%

Table III Pentode Regulator-Filter

	6BQ6	3-12BY7
Screen voltage	75 v	105 v
Minimum plate voltage	60 v	84 v
Minimum plate dissipation	6. watts	2.8 watts per tube
Maximum screen dissipation	0.9 watts	0.67 watts per tube
Maximum Ep (at 100 ma.)	100 v	180 v
Source impedance	85.5 ohms	19.5 ohms
Regulation (Eq 4) [$E_p/E_{C_2} = 1.5$]	0.005	0.0013
Regulation (Eq 5)	0.947	0.986
Nominal plate current	91 ma	27.6 ma

The Pentode Degenerative Amplifier

In the analysis to follow the effect of degeneration on a video amplifier will be shown. A circuit using a *12BY7* tube is shown in Fig. 3a; modification for degeneration is shown in Fig. 3b. We will consider first the more-or-less conventional pentode video amplifier. Assume that the supply voltage is 250 v, and the maximum load impedance permitted by circuit capacitance and frequency requirements is 2000 ohms. The design of the video amplifier needed to handle a 2 v peak-to-peak signal, using a 100 v screen potential is given in Table I.

For best video results with small signals, voltage changes at the screen and plate supply points resulting from screen or plate current changes should not exceed 1% of the output at the lowest frequency to be used. For critical applications, the changes should not exceed one part in a thousand.

Introduction of 200 ohms degeneration in the cathode circuit as in Fig. 3b and bypassing the screen to

the cathode makes several changes in the operation of the circuit. The main changes are the reduction of the input capacity, the reduction of the amplification, and the reduction of the distortion. The changed values are given in Table II. The peak output voltage for these distortion values is still approximately 40 v, p-p. The input voltage required is approximately 6 v, p-p.

An increase in screen voltage to 150 v, with a bias of approximately —1.7 v, produces an amplifier capable of providing a peak-to-peak output of approximately 84 v. Without degeneration, and assuming a plate supply voltage of 200 v, its distortion is 7.5%. The zero bias amplification is 28.8, and the —3.4 v bias amplification is 15.52. With a 100 ohm degenerative cathode resistor, the amplifications are 10 and 8, the distortion 3%.

The effect of factors beyond the designer's control may, particularly with pentodes, prevent one from realizing the calculated distortion. Consequently, one should allow reasonable leeway in selecting the distortion limit. Since the X_p and X_{c2} factors represent an average of the values for several bias values and several screen voltages, one cannot obtain more than a general average corrected value of these factors.

The Low Impedance Vacuum Tube Filter

The pentode tube can be used directly as a filter and voltage regulator. The use of the pentode tube as a replacement for a filter network has been described by Tomer.[1] This circuit can be modified to take advantage of the degenerative regulation. The filtering action described is obtained as a result of the relative independence of the plate current and plate voltage in pentode tubes having constant applied screen voltage.

The pentode regulator filter circuit uses a pentode connected cathode follower having a regulated control grid voltage and a regulated screen voltage, Fig. 4. The selection of the proper regulator tube is based on the maximum required current and the regulator tube plate and screen power dissipations. The conventional amplifier-triode (or triode connected) regulator circuit regulates by virtue of the high effective transconductance of the regulator triode and its comparatively low plate conductance. The pentode regulator has a high ratio of transconductance to plate conductance. Since, however, its effective transconductance is limited in general to less than 20,000 micromhos, as compared to an effective transconductance of many mhos for the regulator tube in the amplifier type regulator, the unamplified pentode regulator will have an appreciable variation of output voltage with load current change. The effective source impedance of a pentode tube is approximately

$$Z = 1/[G_{M_1}(X_P)] \qquad (3)$$

The regulation as a function of source voltage is expressed in terms of the voltage amplification equations,

$$VA_{source} = G_P R_K/[1 + G_M (X_P) R_K] \qquad (4)$$

and for voltage changes in the load circuit,

$$VA_{load} = -G_M (X_P) R_K/[1 + G_M (X_P) R_K] \qquad (5)$$

Assume that a regulator capable of providing 100 ma at 150 v were required. One might either choose three *12BY7* tubes in parallel, or a single *6BQ6* tube (Curves in Fig. 5). The designs for the two approaches are summarized in Table III.

As can be seen, better regulation is obtained from the group of three *12BY7* tubes. However, the *6BQ6* tube is good enough for most routine applications. A 50 v supply voltage change will cause a load voltage change of approximately a 0.25 v. A load current change from 50 ma to 100 ma will produce an output voltage change of approximately 4.2 v.

Where pentode tubes are used as series tubes in amplifier type regulators, the use of the series tube with a fixed screen to cathode potential can prove

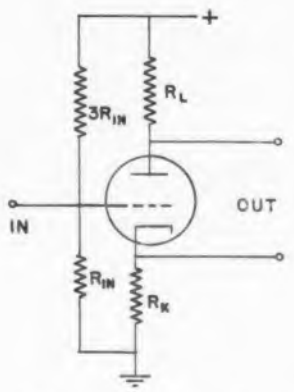


Fig. 6. Phase Splitting Amplifier

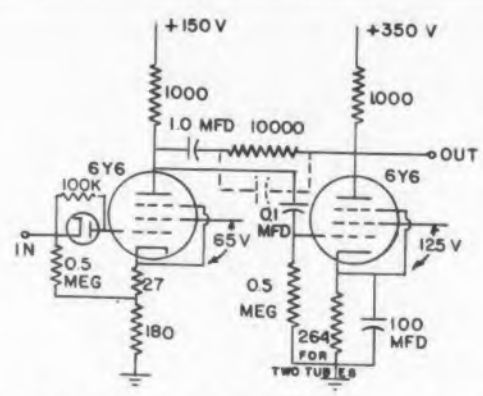


Fig. 7. Half of Push-Pull Video Power Amplifier

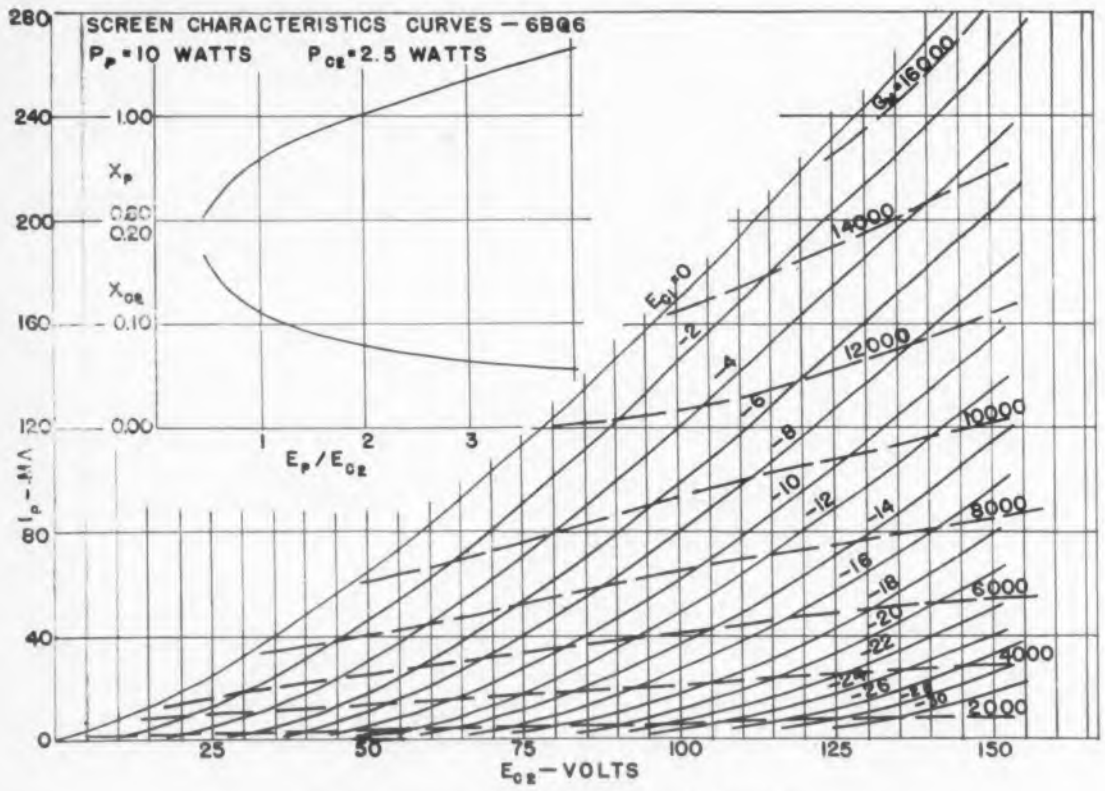


Fig. 5. Characteristics Curve on 6BQ6 Tube

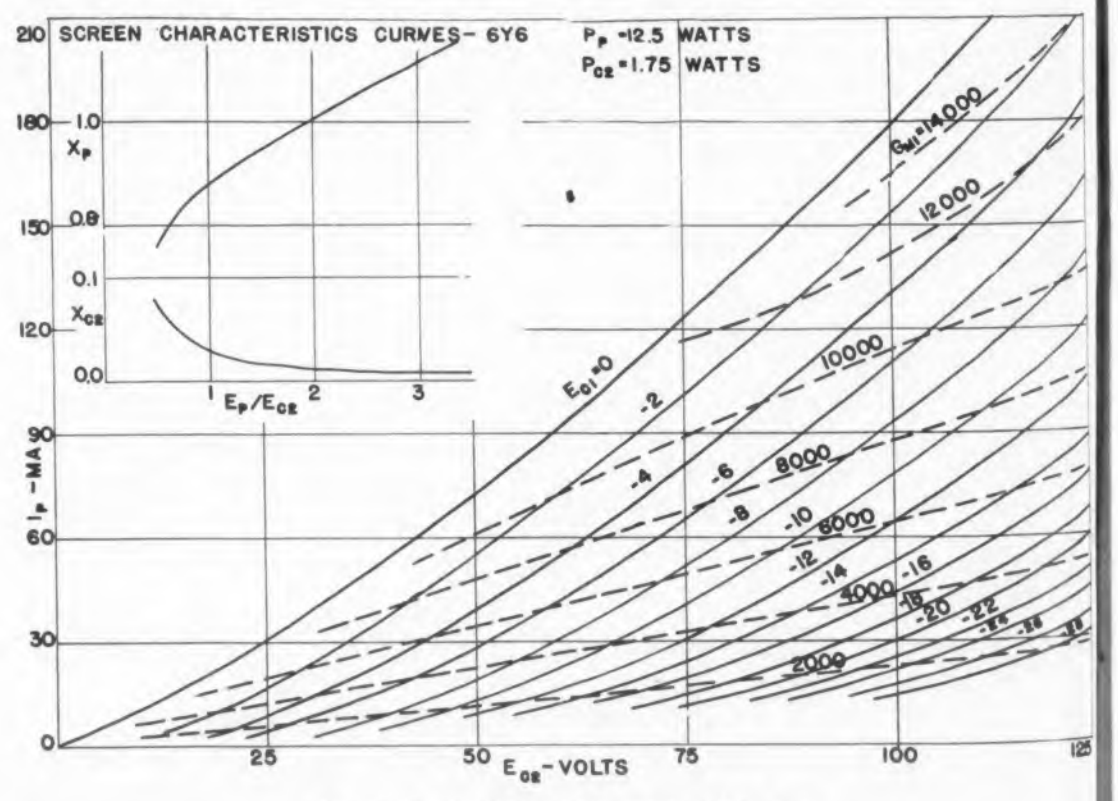


Fig. 8. Characteristics Curves on 6Y6 Tube

useful. The reduced plate conductance in particular improves the independence of the regulator operation with respect to its supply voltage source.

The Split Load Amplifier

The triode tube is commonly used as a split load amplifier, Fig. 6. As a source of equal out of phase voltages, it is unexcelled. It provides output voltages whose magnitudes are dependent solely on the size of the two load resistors. The cathode degeneration, even with only 1000 ohms in the cathode and plate circuits, may be high enough to provide cathode gain as high as 0.85 to 0.90 with a tube like the *12BZ7*. Distortion cannot exceed 4% for transconductance values in excess of 2000 micromhos. The amplification equations for the triode split load amplifier are

$$VA_P = -g_m R_L/[1 + (g_m + g_p) R_K + g_p R_L] \quad (6)$$

$$VA_K = g_m R_K/[1 + (g_m + g_p) R_K + g_p R_L] \quad (7)$$

Inspection shows that the variation of R_L may produce a much smaller effect on VA_K than R_K produces on VA_p. Consequently, although the output voltages may be the same if $R_K = R_L$, the variation of VA_K and VA_p with variation of R_K and R_L are different. The effective impedences are not balanced.

For the pentode split load amplifier, Eqs. 6 and 7 take the following forms

$$VA_P = -G_{M_1} X_P R_L/[1 + G_{M_1} (X_P) R_K] \quad (8)$$

$$VA_K = G_{M_1} (X_P) R_K/[1 + G_{M_1} (X_P) R_K] \quad (9)$$

From Eqs. 8 and 9 it is seen that the ratio of VA_p to VA_K is

$$VA_p/VA_K = -R_L/R_K \quad (10)$$

Since for large signal conditions X_p cannot be constant, distortion is introduced into the plate circuit of a heavily degenerated pentode. This distortion might be called partition distortion in recognition of its existence as a result of current partitioning between the screen and plate. For small amounts of degeneration where $G_M(V_P)R_K$ does not exceed about five to ten, the partitioning actually reduces distortion.

Degeneration in Power Amplifiers

Often power dissipation limits on tubes prevents one from utilizing the full capabilities of a push-pull amplifier. Design to prevent exceeding the power dissipation limitation may introduce serious distortion. This distortion may be reduced by the proper use of degeneration.

One way of obtaining linearization by degeneration is by use of plate-by-plate feedback resistors coupling the driver stage plates to the final stage plates, Fig. 7. When checking the need for degeneration in a push-pull amplifier, it is helpful to plot the transconductance as a function of bias, summing for the two tubes at each bias point. The transconductance sum should be constant throughout the range of bias. Without degeneration the sum is usually roughly parabolic (See Table IV). The voltage amplification for the stages in Fig. 7 is given by

$$VA = \frac{G_{ML} X_{P1} R_{L1}}{1 + G_{M1} (X_{P1}) R_{K1}} \left[\frac{R_F - 1/G_{M2} X_{P2}}{R_{L1} (1 + 1/G_{M2} X_{P2} R_{L2}) + \frac{1}{G_{M2} X_{P2}} \left(1 + \frac{R_F}{R_{L2}}\right)} \right] \quad (11)$$

Based on the data in Table IV and Figs. 7 and 8, the amplifier, without feedback, would have about 12% distortion for a plate-to-plate output of 180 v.

The design of the driver amplifier now must be considered. The voltage developed in R_{L1} is a function of both the current produced by the driver and the current fed back from the final stage. The total voltage developed by the driver is the sum of the bias applied to the final grid and the voltage fed back to the driver.

Table V lists several typical points in the operation of this feedback amplifier. In calculating each point, use the output tube bias as the starting point. The output tube amplification is determined from the bias, and the plate voltage excursion is determined. When the feedback voltage is found, the driver output is determined. The required driver plate current is then established. This current poses a significant design problem. The negative bias swing of the driver tube is the one which provides proper operation of the final stage. The effect of the positive swing, on the other hand, is unimportant, since the output *6Y6* tube is cut off on the negative swing. Because the design has to develop good transconductances on the negative portion of the signal, use of a tube capable of efficient operation with low plate and screen voltages is required. The driver tube should be biased near zero bias and the effect of the positive grid voltage swing may be minimized by the use of a blocking diode in the grid lead. Use of 65 v on the screen of a *6Y6* driver amplifier, a negative 2 v static bias, and an E_p/E_{c2} ratio of 1.0 at zero signal, the static plate dissipation of the driver tube is 4.5 w, the static screen dissipation is 0.25 w.

The next step is to determine the overall amplification at each of the indicated points. These data are tabulated in Table VI, taking $R_{K1} = 200$ ohms. Overall distortion with feedback is 3%. Consequently, the distortion over the two stages in cascade is a quarter of that of the final without feedback.

The grid-to-cathode voltage change on the input *6Y6* is 10 v. The cathode-to-ground change is 7.5 v. The total signal required is therefore ±17.5 v peak. The *12BY7* tube can provide this amount of signal drive with little difficulty. The peak output deflection voltage is 180 v for the operating conditions chosen.

Table IV Video Amplifier Transconductance Sums

Bias excursion	0	4	8	122	1616	2020	2424
Rough transconductance	6400	6700	7700	9200	11000	12300	16000
Corrected transconductance	6400	6750	7650	8950	10300	11100	12150

Table V Driver Current Calculation

Output tube Bias change	— 8	8.	16	24
Output plate current change	—18.0 ma	30.9 ma	86 ma	140 ma
Output voltage change	16.4 v	—28.1 v	—78.2 v	—127.3 v
Feedback voltage	1.49 v	— 2.56 v	— 7.1 v	— 11.6 v
Total driver output voltage	9.5 v	10.56 v	25.1 v	35.6 v
Driver plate current change	10.4 ma	—11.6 ma	—27.6 ma	— 39.2 ma

Table VI Overall Amplification of Video Loop

Final bias	—8	0	8	16	24
$G_{M1} X_{P1}$	9300	8800	7740	5890	3990
$G_{M2} X_{P2}$	1720	3400	5880	9500	12150
VA	2.87	2.84	2.72	2.43	2.00
VA	1.18	2.15	3.23	4.37	5.00
Eq. 11	3.39	6.10	8.24	10.6	10.0
Sum for PP stage	11.63	12.2	11.63	10.6	10.0

Conclusion

The development of difficulties in designing a circuit to accomplish a given purpose within tube dissipation ratings should be considered as a warning that the wrong tube is being used. For example, a *12BY7* tube as a driver amplifier, would prove to be overloaded for any satisfactory design. Redesign with a different tube is indicated.

The designs discussed indicate to some extent the value of the conductance design method as applied to low frequency electron tube circuits.

1. "Electronic Filter Choke," R. B. Tomer, Engineering Edition, *Radio and Television News*, December, 1952, p. 11.

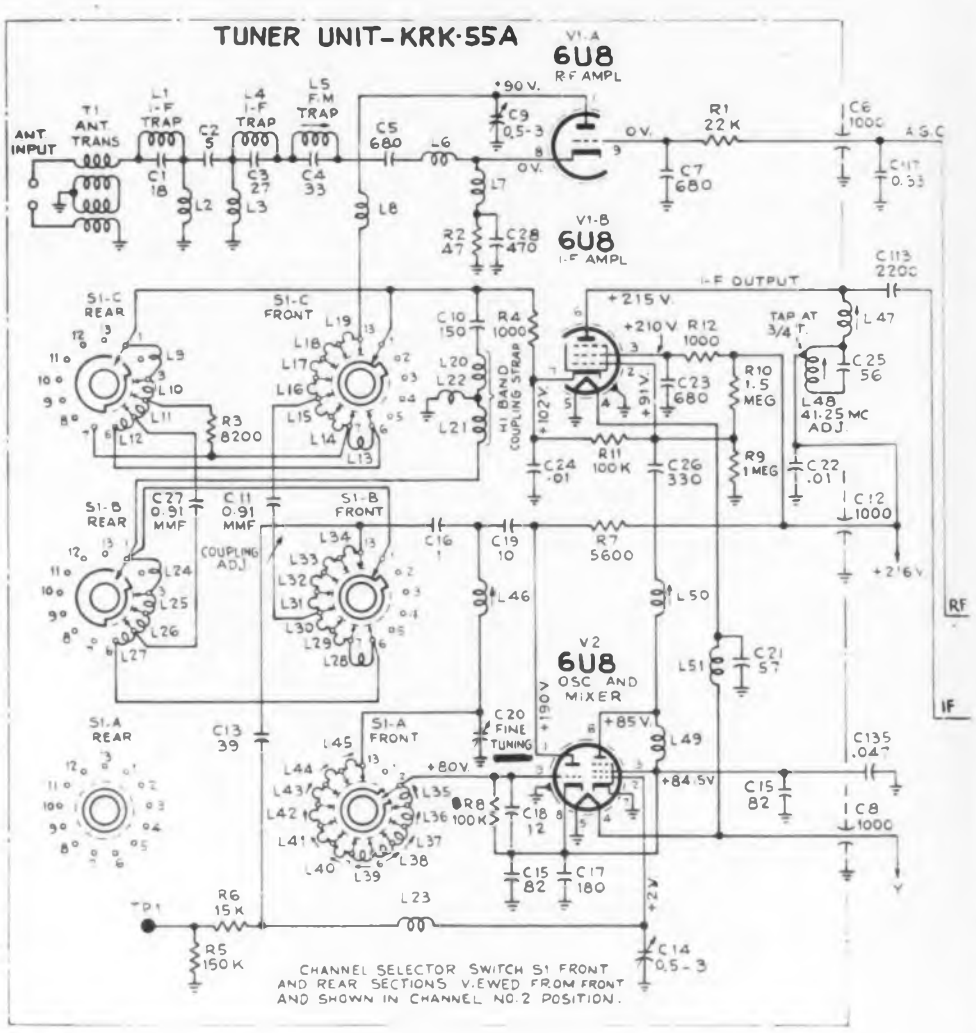
Pentode Does Two Jobs

Leslie M. Balter
Consulting Engineer

INTENSE merchandising competition in the television industry brought forth almost overnight the portable television receiver. The resulting technical developments striving for an overall small physical size and weight reduction so that the receiver will be easy to handle offer much of interest to designers.

One of the most significant developments of todays modern portable receiver design may be seen from a study of the RCA KCS 100 chassis, Model 8PT series (*8DP4* picture tube).

A study of the set schematic reveals the development of a circuit which permits one tube to do the work of two. This is not the use of two separate tubes within one envelope, but truly is a circuit design which permits one pentode to be used to perform two individual functions. The same pentode tube is used as a sound intermediate frequency amplifier and also the first audio voltage amplifier.

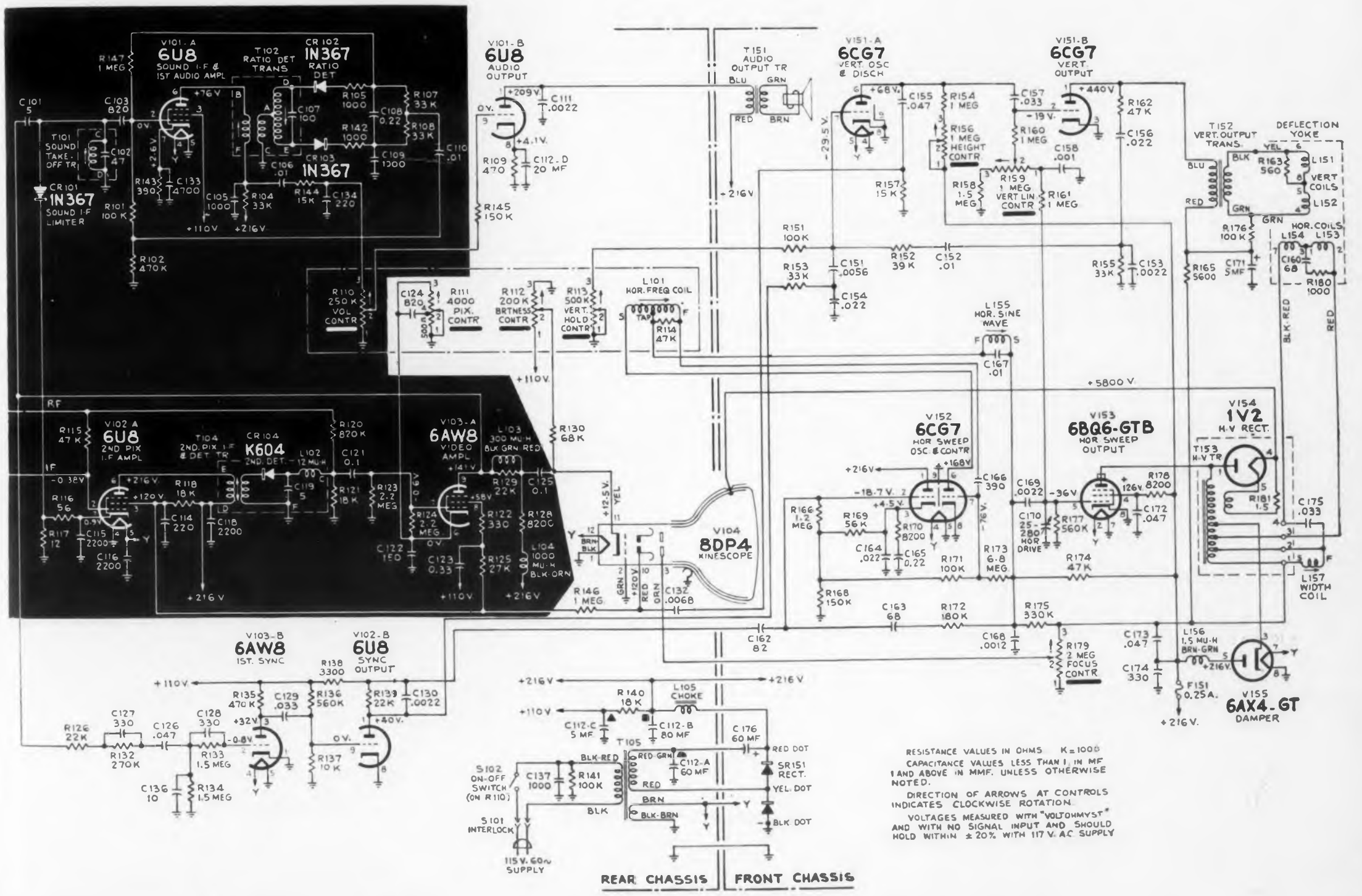


Black portion shows *6U8* which acts as both sound if and first audio amplifier in RCA chasis KCS 100B.

Referring to the blocked out portion, the 4.5-mc intercarrier fm sound is taken from the plate of the *6AW8 (V103A)* video amplifier. This is the normal sound take off point in an intercarrier chassis. The 4.5-mc signal is then coupled through *C101*, a 5-μμf capacitor, which serves as a high pass filter to aid the separation of the fm signal from the video. The *1N367* diode acts as a limiter to hold the signal input to the *6U8 (V101A)* at constant amplitude. The signal is then fed to T101 which is a parallel resonant circuit tuned to 4.5 mc across which the sound signal is developed. This 4.5-mc signal is then fed through *C103* to the control grid, pin 2 of the *6U8*. The series resistors, *R101* and *R102* act as Q dropping resistors to broaden the response and load down the grid circuit slightly. The 4.5-mc signal is then transformer coupled from the plate circuit of the *6U8* through the ratio detector transformer and is detected in a conventional type of ratio detector circuit using two *1N367* diodes. The detected fm sound signal is then taken from the junction of *R107* and *R108* and coupled through *C110 back* into the control grid circuit, again pin 2, of the same *6U8*. *C103* presents a high impedence to the now audio signal and does not permit *T101* to bypass the audio to ground. The audio signal through *R101* is then applied into the grid of the *6U8*. The primary of the ratio transformer has a low impedance to the audio frequency and the audio signal is developed across *R104* which acts as a conventional plate load resistor. *C105*, 1000 μμf while acting as a bypass around *R104* to the sound as if, is so small as not to cause much shunting of the sound as audio to ground. The audio voltage developed across *R104* is then coupled through *C106* and the de-emphasis network *R144* and *C134* to the volume control *R110*, and on into the other half of the *6U8* which acts as a conventional audio output circuit. Note that the tuner section uses *6U8*s also.

It is important to note that in a dual application such as this, the point at which the tube operates is extremely critical and must be closely held constant. It is for this reason that the diode limiter is used, even though theory indicates that when using a ratio detector, a limiter is not normally necessary. In order to hold the operating point of the control grid of the *6U8* constant, the if is limited. In addition, *R147* serves to feed back a negative bias on strong signals to the same grid. These measures are necessary to insure proper operation and avoid rectification in the tube.

It thus can be seen that this is an application where one tube is made to serve as a high frequency tuned amplifier and an audio frequency voltage amplifier simultaneously through a clever utilization of high and low pass filters.



Design Tips For

- *Simplicity*
- *Cost Savings*
- *Reliability*
- *Usability*

These design suggestions are excerpted from a new 1956 edition of the booklet, "Suggestions For Designers of Electronic Equipment," prepared by the Reliability and Standards Branch, Engineering Division, of the U. S. Navy Electronics Laboratory. The booklet was prepared to help electronic manufacturers "produce simpler, more economical, and more reliable electronic equipment" for Bu Ships. All designers should find these suggestions valuable.

Suggestions given here should result in Electronic equipment which is simpler, more reliable and more usable and at the same time will save costs in manufacture. Although these tips are based on the premise that designers are developing equipment under Bu Ships contract, practically every suggestion is well worth considering for design of commercial and other military gear.

General Design Tips

1. The use of assembly type construction is encouraged, where possible, coordinated with Bureau of Ships. (3.4)*
2. Giving due consideration to maximum equipment reliability the use of miniature parts is encouraged. (3.3.8)
3. Use tubes from the list of Standard Electron Tubes, MIL-STD-200 (latest issue). Do NOT, under any circumstances, use tubes selected within a type. (3.3.45)
4. Do not use tubes in applications that require the use of parameters not controlled by authorized procurement specifications (example: do not use as a noise source a tube generally intended as a thyratron).
5. For Navy electronics equipment select electronic parts from MIL-STD-242 (latest issue). (3.3.1)
6. Provide 10 per cent spare terminals (at least 2) on terminal strips and connectors. (3.3.14)
7. All terminal strips and parts boards shall be adequately marked in a permanent manner. (3.3.14.4) (3.13.4.1)
8. Keep use of relays to a minimum. (3.9.6.3) (3.3.36)
9. Do not use acid or corrosive soldering fluxes or pastes. Rosin is the only noncorrosive flux. (3.11.3)
10. Conductors should be color-coded in accordance with Standard MIL-STD-122. (3.9.11)
11. Noninsulated leads should be color-coded by means of color spots near all terminals. (3.9.11.1)
12. Make provision to lock chassis both in the closed and maintenance positions. (3.11.9.1)
13. All controls should be clearly labeled with standard nomenclature, and marked, indexed, or metered such that each position can be readily identified. (3.12)
14. Part reference designations shall be located adjacent to each part. Type designations of each tube and other plug-in part and the reference designation shall be marked on both sides of the chassis adjacent to the socket. (MIL-STD-16). (3.13.4)
15. No cable entrances on front panels. (3.9.8.2)
16. Keep "parts peculiar" to an absolute minimum. (3.3)
17. Transformers, chokes, and other potted networks shall have circuit diagrams with current, voltage, and impedance ratings stenciled on the outside. (MIL-T-27). (3.3.44)
18. Maximum size restrictions:
    a. surface vessel installation (3.11.12.2)
        (1) Height 72 inches;
        (2) capable of passing through a 30-inch-by-30-inch hatch with round corners on 7 1/2-inch radius; or
        (3) capable of passing through a 26-inch-by-45-inch door with round corners on 8-inch radius.
    b. Submarine installation (3.11.12.3)
        (1) Height 72 inches;
        (2) capable of passing through a 25-inch diameter circular hatch; and
        (3) capable of passing through a 20-inch-by-38-inch door with rounded corners on 10-inch radius.
19. Mount terminal strips or connectors so as to be accessible from the front of equipment when opened. (3.11.9). (3.3.14.3)

Environmental Requirements

1. MIL-E-16400 extreme environmental conditions (may be modified by equipment specification) (4.4.4):
    a. —62 to +75C (nonoperating) (4.5.7.1)
    b. —54 to +65C (operating) (4.5.7.2)
    c. 95 per cent relative humidity. (4.5.8)
    d. Equipment exposed to weather is expected to withstand winds of 100 knots and to operate in winds of 75 knots. (3.8.3)
    e. Equipment exposed to the elements shall operate with an ice load of 4.5 pounds per square foot. (3.8.4)
    f. Shock and vibration (MIL-S-901B, MIL-T-17113, MIL-STD-167, etc.) (4.5.14)
    g. Line voltage and frequency (excursions per equipment specification)
    h. Salt spray (for external finishes and materials) (4.5.15)
2. Equipment shall be dripproof, splashproof, or waterproof, as required by the equipment specification. See Standard MIL-STD-108. (3.11.8)

Electrical Suggestions

1. Adequate derating in parts application must be used in order to increase reliability of equipment in service. (3.3.5)
2. Undesired radiation and radio interference must be within the limits specified by MIL-I-16910. (3.9.1) and (3.9.2)
3. Provide protection from damage due to overload, excessive heating, etc. (3.9.6)
4. Fuse or otherwise protect both sides of the line and provide spare fuses in a convenient location. (3.9.5) (3.9.6) (3.9.6.1)
5. Avoid use of friction or pressure contacts where possible. (3.11.6)
6. Provide dimmer control for all dial and indicating lights. (3.12.12)
7. Transmission line terminals shall be marked with the characteristic impedance of the line. (3.13.4.5)
8. Use of cable plugs and connectors should be kept to absolute minimum.
9. Lamp holders should be of the lock type and replaceable from the front. (3.3.32)
10. Do not series-connect pilot lights. (3.12.12)

* Numbers in parentheses indicate applicable paragraphs in Specification MIL-E-16400A.

11. Provide running-time meters where required by the specifications. (3.12.13)
12. In mounting parts by pigtails, the clearance between the soldered connection and the body of the part shall not be less than 3/16 inch and should not exceed 1/2 inch in length. (3.3.51)
13. All external metal parts shall be at ground potential. Antenna and transmission line terminals shall be at ground potential except with regard to the energy to be transmitted. (3.7.2.1)
14. Provide simple performance evaluation and equipment checking devices where possible. (3.10.3.2)
15. Regulate heater voltage for electron tubes (within ratings) to enhance reliability.
16. Apply electron tubes in conservative operation; derate for improved reliability.
17. In design, allow for change in tolerance of electronic parts for such factors as aging, temperature and humidity.

Mechanical Suggestions

1. Electron tubes, large fuses, and other plug-in items must be secured by easily released positive holding clamps. (3.3.13)
2. Pigtail connected electronic parts which are large in comparison with the standard 2-watt composition resistor should be clamped down to the chassis or parts board to preclude lead breakage from fatigue under vibration. (3.3.51.1)
3. Self-tapping screws should not ordinarily be used. If used, approval must be obtained from the bureau or agency concerned. (3.3.42.10)
4. Devices for retaining panels and cover plates shall be of captive types with slotted or knurled and slotted heads. (3.3.42.14)
5. Use external-tooth type lock washers. (3.3.43.3)
6. Conductors shall be wound into a cable and held by means of lacing twine or other acceptable means. Wire harnesses and cables should be clamped down to the chassis at reasonable intervals to reduce conductor breakage under vibrations. (3.9.8)
7. Wires and cables running through holes in metal partitions must be protected from mechanical damage by grommets or other acceptable means. (3.9.8.3)
8. Stranded copper wire that has been soldered to a terminal should be secured so that vibration does not allow the conductor to flex near the area where the individual strands have been tinned together.
9. Do not joint leads without a support at their junction.
10. Equipment shall be of the lightest weight consistent with sturdiness, safety, and reliability. (3.11.13)
11. Make provision to lock chassis in both the closed and maintenance positions. (3.11.9.1)
12. Provide suitably labeled lifting-eyes on equipment weighing more than 150 pounds. (3.11.14)
13. Electronic equipment should use as few lubricants as practicable. (3.11.17)
14. Minimize need for special tools. Special tools must be securely mounted in a convenient place in the equipment. (3.11.18)
15. Control knobs should be kept to a minimum and have standard shape and color. Control knobs should be secured by means of two setscrews. (3.12.1)
16. Controls and indicators which are only occasionally required should be mounted behind access doors. (3.12.2.2)
17. Controls infrequently required shall be accessible when the equipment is open for maintenance purposes. Maintenance controls shall be screwdriver adjusted. (3.12.2.3)
18. Controls shall be arranged to facilitate smooth and rapid manipulation. Adequate end stops shall be provided on all controls with limited degree of motion. (3.12.4) (3.12.7)
19. Provide control locks where specified. (3.12.6)
20. Glass windows shall be secured to the panel by means of clips, snap rings, or other devices. Do NOT use cement alone. (3.12.1)
21. Light leakage shall be prevented. (3.11.8)
22. Do not use rivets to mount parts which may be subject to replacement, nor for electrical continuity.
23. Identification markings shall be permanent and legible. (3.13.4.4)
24. Positive identification of scales in use shall be provided.
25. Side and back plates for terminal tube mounting or clamps shall be removable. (3.9.8.2)
26. All setscrews shall have one type of head. (3.3.42.12)
27. Do not use flathead screws on thin panels. (3.3.42.13)
28. All moving parts shall operate smoothly and quietly without introducing objectionable electrical noise. (3.11.5)
29. Backlash and torque-lash shall be kept to a minimum. (3.11.5)
30. Lubrication points shall be accessible and clearly marked. (3.11.17)
31. Drawers or other removable chassis should have at least two guide pins on the front panel and two guide pins on the rear of the chassis. The guide pins on the front panel can be made part of the captive screw assembly, if desired. (3.3.42.14) (3.11.9.2)
32. Locate heavy parts (transformers, etc.) as low as possible in order to keep the center of gravity of the equipment low.
33. Electron tubes often break by striking against adjacent transformers during shock. Clamp tubes to prevent relative motion or maintain wide tube clearance to eliminate damage.
34. Avoid the use of cantilever brackets for mounting of parts.
35. Alignment pins or similar devices should be used to bear shock and vibrational loads between chassis, assemblies, and enclosures. Electrical connectors must not be depended upon to bear such loads.
36. Provide adequate ventilation facilities. Do not provide openings in top of equipment. (3.11.16)
37. Use of liquid cooling requires approval of the bureau or agency concerned. (3.11.16.3)
38. When forced-air cooling is used, provide suitable dust filters, mounting and size to be coordinated with bureau or agency concerned. (3.11.16.2)
39. Provide equipment heaters where necessary.
40. Locate parts for best heat dissipation and isolate critical parts from excessive heat sources. (3.11.15) (3.3.5)
41. Use conduction heat-transfer techniques to lower surface temperature of tubes, resistors, transformers, and small motors.

Selection of Materials

1. Screws, studs, nuts, etc., shall be of nonferrous material. Corrosion-resistant steel or nickel-copper alloy may be used where required for reasons of strength. (3.3.42.4)
2. Avoid threading aluminum alloy into aluminum alloy parts. (3.3.42.7)
3. Do not use toxic or hygroscopic materials, nor materials which will support combustion or fungus. (3.5)
4. The use of magnesium requires approval of the bureau or agency concerned. (3.5.11.2)
5. Do not use dissimilar metals in contact where an increase in corrosion can be expected. (3.5.14)
6. Use glareproof and shatterproof glass. (3.5.10)
7. Iron and steel shall not be used except where required for electromagnetic or strength reasons. (3.5.11.3)
8. Plate or otherwise treat metals to protect them from corrosion. (3.5.13)
9. Materials for embedding electronic parts in assemblies shall be in accordance with Specification MIL-C-16923. (3.5.17)
10. Finish enamel shall conform with Specification MIL-E-15090 or TT-E-485, as indicated. (3.6.5.2)

Design for Installation

1. Side and back plates for terminal tube mounting or clamps shall be removable. (3.9.8.2)
2. Mounting bolts should be accessible so equipment can be

Some Common Faults

The following faults are often experienced with electronic equipment and should be avoided.

1. Bend radii too small in sheet-metal items.
2. Inadequate welds, rivets, or bolts in enclosure fabrication.
3. Poor finishing due to improper preparation of base metal.
4. Inadequate locking devices for hinges and drawers.
5. Assembly and installation work not properly inspected. All nuts, bolts, and screws should be tightened with a torque wrench.
6. Drawer guide pins of insufficient strength; or failure to provide steel inserts in mating parts.
7. No guide pins provided on front panel and rear of chassis drawers. Guide pins are especially important on shock-mounted equipment.
8. Inadequate gasketing on watertight and dripproof enclosures.
9. Inadequate ventilation.
10. Improper design and location of louvres on dripproof enclosures.
11. Shock mounts used in equipment which might better be designed for direct mounting.
12. Incorrect selection and location of shock mounts.
13. Shock mounts difficult to install and remove.
14. Inadequate protection of cables in drawer-type and hinged construction.
15. Inadequate protection of wires and cables passing through metal partitions.
16. Lack of adequate clearance between parts to prevent damage during shock conditions.
17. Inaccessibility of parts for maintenance.
18. Failure to secure larger resistors and capacitors which have pigtail leads.
19. Poor support of terminal boards and similar vulnerable assemblies and parts.
20. Use of inadequate or incorrect type of lock washers.
21. Patent fasteners (Dzus and other types) too small for application.
22. Gears secured with setscrews instead of being properly pinned.
23. Relays chatter under shock or vibration. See Specification MIL-R-5757 for relay requirements.
24. Inadequate stiffness in structures, resulting in resonances within the vibration test frequencies.
25. Use of screws of insufficient size in mounting heavy parts.
26. Inadequate power-line filters.
27. Operation of tubes and parts at levels above ratings.
28. Inadequate electrical design. Examples: sensitivity selectivity, hum, regeneration, spurious responses.
29. Excessive radiation and radio interference.
30. Excessive complexity in circuitry.
31. Poor design of controls.
32. Enclosures, structures, and chassis poorly designed with the result that the equipment is excessively heavy.
33. Many existing tube clamps are ineffective.
34. Excessive play in chassis drawer slides.

installed without the necessity for removing parts and assemblies.

3. Usual shipboard installations make access to the rear and sides of equipment difficult. Avoid the need for such access.

Operational Considerations

1. Counter-type indicators should be of the large type.
2. Tuning instructions and calibration charts shall be mounted on the equipment when such instructions and charts are required. (3.13.3)
3. Minimize "nontamper" factory adjustments. When such adjustments are required, they should be marked as such. (3.12.10)
4. Provide indicators of equipment malfunctioning where possible. (3.10.3.2)
5. Prevent extraneous light escape. (3.11.8)

Design for Maintenance

1. Insure complete interchangeability of all like removable units, maintenance parts, etc. (3.3.7)
2. Parts mounted on terminals and parts boards must be accessible for servicing. (3.11.9)
3. All terminal strips and parts boards shall be adequately marked in a permanent manner. (3.3.14.4)
4. Part reference designations shall be located adjacent to each part. Type designation of each tube and plug-in part and the referenced designation shall be marked on both sides of the chassis adjacent to the socket. (MIL-STD-16) (3.13.4)
5. Transformers, chokes, and other potted networks shall have circuit diagrams with current, voltage, and impedance ratings stenciled on the outside. (MIL-T-27) (3.3.44)
6. Conductors should be color-coded in accordance with standard MIL-STD-122. (3.9.11)
7. Noninsulated leads should be color-coded by means of color spots near all terminals. (3.9.11.1)
8. Fuse or otherwise protect both sides of the line, and provide spare fuses in a convenient location. (3.9.6.1)
9. Built-in test equipment (meters, etc.) should be used where possible to determine whether the equipment performance is normal. (3.10.3.2)
10. Provide test points for checking essential wave forms and voltages where terminals are not otherwise accessible. (3.10.3.1)
11. Provide voltage dividers with test points for measurement of voltages in excess of 1000 volts. (3.10.5)
12. All parts must be readily accessible for complete visual inspection and replacement without removal of parts and fixed assemblies to get to other parts. (3.11.9)
13. Provide rotating assemblies with means for hand training for maintenance and provide markings of normal direction of rotation.
14. Mechanical assemblies subject to maintenance disassembly should be indexed to insure proper relative position of parts on reassembly.
15. Minimize need for special tools. Special tools must be securely mounted in a convenient place in the equipment. (3.11.18)
16. Controls infrequently required shall be accessible when the equipment is open for maintenance purposes. Maintenance controls shall be screwdriver adjusted. (3.12.2.3)
17. Doors or hinged covers should be provided with slip hinges and stops to hold them open. (3.11.10)
18. Rear of plug connectors must be accessible for test and service.
19. When parts MUST be replaced at specified intervals, they should be clearly marked as such.
20. Leave about 1/16 inch pigtail on leads beyond terminals and do not mount more than three wires on one terminal. (3.3.51.2)
21. When devices protecting against overload conditions are used, it is preferred that they be accessible from the front panel.

Built-in Safety

1. Provisions shall be made to prevent personnel from coming into contact with voltages in excess of 70 volts while installing, operating, or interchanging assemblies or plug-in parts. (3.7)
2. All external metal parts shall be at ground potential. Antenna or transmission line terminals shall be at ground potential except with regard to the energy to be radiated. (3.7.2.1)
3. Interlocks must be provided where potentials exceed 70 volts. (3.7.1)
4. Provide personnel protection from moving machinery. (3.7.6)
5. Provide protection to personnel from imploding cathode ray tubes. (3.7.3)
6. All control shafts and control shaft bushings shall be grounded. (3.7.3)
7. Plugs and connectors when disconnected should not expose "hot" leads.
8. Provide means for bypassing interlocks for servicing and have warning indicator. (3.7.1.1)
9. Doors or hinged covers should be rounded at corners and have slip hinges and stops to hold them open. (3.7.6) (3.11.10)
10. Provide rotating antenna assemblies with local power saftey switch at the antenna. (3.7.1.2)
11. Provide guards, safety covers, and warning plates for potentials in excess of 350 volts rms on contacts, terminals, and like devices. (3.7.2.2)

Human Engineering Design Tips

The following design suggestions are presented as background for good human engineering design.

Visual Displays

1. Visual indicators should be mounted as nearly perpendicular to the line of sight as possible.
2. Numerals on fixed displays should be mounted so that they do not have to be read upside down.
3. Numerals and letters should be simple in design, similar to Leroy lettering guides. Avoid extra flourishes.
4. Use capital letters for labels but use standard capitalized and lower case type for extended copy.
5. Scale graduation should not be finer than necessary within the accuracy of the instrument itself.
6. Separation between indices and numerals on a dial should be sufficient for accurate reading.
7. Instrument pointers should be designed to reduce parallax. They should not overlap numerals or indices.
8. Irregular scale breakdowns should be avoided.
9. When several instruments must be read at once as in check-reading, orient the instruments so that the "normal" operating positions of all pointers are aligned (preferably at the 9- or 12-o'clock position).
10. Utilize similar numbering and scale progressions for dials which may appear on the same panel.
11. Utilize color code techniques to define operating and danger ranges, to simplify check-reading.
12. Use scale breakdowns of units, fives, or tens when possible.
13. Orient scales to make critical ranges appear in the left or upper quadrants so that an increase in reading will progress in the expected direction.
14. For multirevolution dials, orient the zero position at 12 o'clock.
15. Numbering systems should increase from left to right or bottom to top whenever possible.
16. Provide suitable coding or labeling on both the display and control to tell which control affects which display.
17. Controls marked to indicate direction of operation.
18. For dials which have a finite scale, provide a definite scale break between the end of the scale and the zero position.
19. Utilize maximum contrast between the color of dial and scale markings and the background of the dial.
20. Dial pointers should be the same color as indices and numbers on the dial.
21. Select counter types in which the numbers "snap" into place.
22. An upward movement of a counter should indicate a numerical increase.
23. Avoid counter designs which have too much space between numerals when the numerals must be read as a whole number.
24. Avoid fractions or decimals on dial scales when possible.
25. Select counters which read from left to right.
26. When selecting warning lights, make sure they are compatible with the ambient illumination levels expected. A dim light will not be seen in bright sunlight, and a bright light may be detrimental to dark adaptation. Utilize dimmer controls if necessary.
27. When dark-adaptation is necessary, use red light only (wave-lengths longer than 620 millimicrons).
28. Flash rates for flashing warning lights may vary from 3 to 10 per second, but "duration on" should be at least .05 second.
29. Warning signals should not be obtrusive longer than necessary to attract attention. A device meant to provide a specific warning for a given purpose should never be designed also to actuate during any part of normal operations.
30. Critical warning lights should be isolated from other lights to be most effective.
31. Ambient illumination surrounding a cathode ray display for detection tasks should be controlled at about 0.1 millilambert.
32. Vibration of visual displays should be held to a minimum. Any display movement requires simpler design, higher illumination levels, and longer reading time.
33. Counters should be mounted close to the panel so that numbers are not obscured by bezel openings.
34. Don't combine unrelated information.
35. Avoid the use of more than two pointers on a single dial shaft.
36. Provide even illumination of all parts of a dial including the pointer.
37. In dial scale design, the fixed scale with moving pointer is preferred over the fixed-index moving-scale design.
38. Numeral and scale index designs are dependent upon the reading distance. Use optimum numeral/letter height-width and stroke ratios.
39. Provide a display to show that an instrument is not operating properly.
40. Up-to-date information is necessary for adequate visual display.
41. Instrument design should minimize mental translations of units and symbols.
42. Changes in visual indications should be easy to detect.
43. When reciprocal readings are necessary from a single pointer, make sure the two ends of the pointer are identifiable.
44. The opening for open-window dial display should permit viewing at least two numbers.
45. Keep visual displays as simple as possible within the informational requirement of (1) quantitative, (2) qualitative, or (3) check-type readings.

Control

46. Controls which must be located without having to be seen should be positioned in forward areas rather than to the side or behind the operator.
47. Often-used controls should be placed somewhere between elbow and shoulder height.
48. Control movement should be in the "Expected" direction: that is, increases should be caused by movement to the right or upward.
49. Control movements and location should be parallel to the axis of the display motion which they affect.
50. Cranks should be designed and positioned with respect to the speed or load which they administer; that is, small cranks,

at elbow height for fast wrist action, light loads; large cranks oriented for full arm motion.
51. Adjustment-type knobs for electronic equipments should be no more than 2 inches in diameter and should be used only for very light torques.
52. Round knobs should be used for controls requiring smooth continuous movement. Bar- or pointer-type knobs should be used for detent-type switching.
53. Toggle or bat-handle switches should provide at least 30° throw each side of center to give good visual indication of displacement.
54. Brake pedals should be mounted so that the knee angle (between the upper and lower leg) of the operator is somewhere between 105° and 135°.
55. Pedals should be pivoted so that control action is similar to the limb or foot motion (near the heel of the foot for ankle action on an accelerator pedal, or above the foot for leg motion as in the case of the brake).
56. Control actions shoud be positive without being sticky or stiff.
57. Joystick movement should be equally free in all directions. Small joysticks on table or desk-top installations should be mounted so that the hand has a resting place for steadying the control movement.

Panel Layout

58. Panel layout should be as functionally simple as possible. Compromises of primary position for controls and displays should be considered as a whole in order to see all interactive tasks.
59. Cover those displays and controls which are not absolutely necessary to actual operation.
60. Orient displays at proper eye height and arrange often-used controls near elbow height when possible. Make sure the operator cannot cover a display while manipulating a control.
61. Provide clear, legible labels. Use standard abbreviations. Provide illumination where necessary and be consistent in placing labels either above or below controls or displays.
62. Avoid glossy surfaces or highly polished metals. Use antiglare coating on transparent instrument covers when possible.

Console Design

63. Cabinets, racks, and consoles should be designed with the dimensional statistics of the human operator in mind. Static dimensions are available to the designer, but he must exercise common sense in adjusting these figures to the dynamic situation.
64. Vertically mounted visual displays should be 50 to 70 inches above the floor when they are to be viewed from a standing position.
65. Use a 30-inch seat-to-eye height reference to locate visual displays used by a seated operator and specify the chair height along with the console dimensions.
66. For a comfortable display mounting angle, use the following rule of thumb: 60° from horizontal for seated operators; 45° for a combination sit or stand and 30° for a straight stand position. These angles provide a good compromise for mounting displays such as CRT's.
67. Use a 28-inch arm reach, measured from the operator's shoulder, as a limiting figure for the placement of controls which are to be used often.
68. Controls should be located near the display which they affect when this does not conflict with other manipulatory requirements.
69. When possible, controls should be arranged sequentially with respect to the expected or required order of operation. Activity for both hands should be evenly distributed.
70. Generally, control-display organization should be such that visual displays occupy central areas, and controls occupy peripheral areas, to avoid hand and arm interference with visual tasks.
71. Functional organization of displays and controls should be emphasized by using such techniques as color coding, marked outline, symmetry of grouping, and/or differential plane of mounting.
72. Where consoles are designed for seated operators, utilize good seating principles such as optimum dimensions with regard to the expected population of users, backrests, armrests, footrests, cushioning, and adjustability.
73. When desk positions are required, consider height of writing surface, working width and depth, knee and foot room, and elbow room if more than one operator is involved.
74. Storage space should be designed with man's physical dimensions in mind; consideration should be given to reach distance, eye height when stored items must be seen, and depth of bin for articles pushed to the rear).

Multiple Layout

75. When men and machines are grouped for system or team operations, consider not only the individual needs but also the equitable flow of human traffic and aural and visual communication links.
76. When multiple man-machine combinations are grouped together, make sure that operators primary control manipulations are not restricted.
77. When group activity demands use of a central visual display make sure that lines of sight to the display are not blocked by poor arrangement of people or equipments.
78. Corridor and passageway design should provide enough space for people to pass each other and for doors opening into passageways without hindering the flow of traffic.
79. Special consideration should be given to passageways and doorways used by personnel who are encumbered by special clothing or equipment.

Environment

80. Good illumination should include the following considerations: (a) suitable brightness for the task at hand, (b) uniform lighting on the task, (c) suitable contrast between task and background, (d) freedom from glare from either the light source or the work surfaces, and (e) suitable quality and color for the illuminants and surfaces.
81. For aircraft cockpits or other specialized military applications, consult recommended lighting-level tables for both the ambient and specialized lighting.
82. Do not assume that general ambient illumination will be adequate for individual tasks. A careful analysis of the entire lighting system will prevent later makeshift remedies.
83. Consider the environmental conditions under which the man-machine combination must work. If these conditions cannot be controlled directly, it is necessary to provide other safeguards. Temperature, ventilation, and noise are the major considerations, and modern protective measures should be used by the designer.

Maintenance

84. Design and use of displays that will indicate marginal or substandard performance to the maintenance technician. Although it is obvious when most equipments are inoperable, it is often difficult to determine when they are functioning poorly or below effective levels.
85. Consider the matter of maintenance simplification as well as operational simplification. Utilize unitization techniques, go-no-go indicators, and disposable packages where feasible.
86. Follow good display and control design practices when providing a display or control for the maintenance technician. Poor meter displays, screwdriver controls which are too sensitive, or poor use of color coding hinder maintenance.
87. Avoid large cumbersome back-access doors on cabinets or racks. These create a nuisance and a hazard. Utilize quickly-removable or small double-hinged doors which do not complicate the space problem.
88. Avoid cable entrances on the front of cabinets.
89. Screwdriver calibration adjustments are unsatisfactory from the standpoint of human manipulation. Use knobs whenever possible, and if these shouldn't be disturbed except in special cases, cover them or provide a special seal or danger code.
90. Provide an index for adjustment controls. It is difficult to remember settings without some marking, and this indexing in turn may reveal gradual deterioration in performance as settings need changing.
91. Keyways for tubes and tube sockets should be suitably marked so that the technician does not rely on "feel" to find the proper position. Tube labels should also be oriented so they can be seen from the maintenance position.
92. Use care in counting miniaturized parts. Their size often influences the designer to mount them too closely together. The hand remains the same size.
93. In mounting parts on chassis and chassis in racks, keep in mind the problem of maintenance. Provide access to both sides of a chassis. Leave sufficient hand room for the technician to remove and replace parts without danger. Provide hand grips for lifting.
94. Avoid mounting parts and assemblies so that several intermediate pieces have to be removed to get to one that requires frequent servicing.
95. When drawer slides are used, make sure they will not stick and will hold the unit firmly in the open position, and that the technician does not need three hands to manipulate fasteners or guide flexible cables.
96. Reduce the number of types of parts required. Utilize common parts where possible to simplify maintenance and storage.
97. Utilize legible and permanent tuning instructions, calibration graphs, labeling, and dial markings. Separate instructions that get lost hinder good maintenance.
98. Provide adequate illumination for maintenance. Ambient room illumination is seldom satisfactory. Dark colors for cabinet interiors are not recommended since they create shadows.
99. Provide routine check points which are available without removing the chassis from the cabinet.
100. Avoid using adjustable parts when part values need not change during the life of the equipment.

Selecting Proper Parts

1. Keep in mind the environments the equipment must meet eventually in the field (shock, vibration, temperature, humidity, salt spray, etc.).
2. Know electronic parts and their limitations. Know circuit conditions under which parts operate best.
3. Use military preferred reliable parts in all applications possible.
4. Compensate in equipment design for known limitations in parts.
5. Apply suitable margins of derating factors (safety factors) to compensate for variations encountered in use.
6. Use prescribed derating factors for temperature effects, especially of resistors, capacitors, and tubes.
7. Guard against voltage overload and excessive current.
8. Position parts in the equipment so that the heat radiated by surrounding parts and the temperature rise in individual parts and circuits do not exceed maximum safe operating temperatures.
9. Arrange parts so that they are easily accessible for testing and maintenance.
10. Provide adequate ventilation. If necessary, even add blowers to keep parts within safe operating temperatures.
11. Protect equipment with fuses, meters, etc., to prevent damage from unexpected operating conditions.
12. Check circuit function with random selections of tubes. Determine if shifts in tube characteristics or normal aging of other items are likely to affect operation seriously during the desired life of the equipment.

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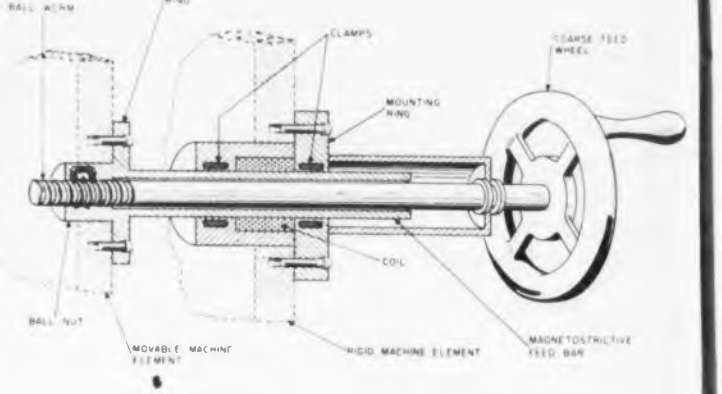

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Linear motion in millionth of an inch increment

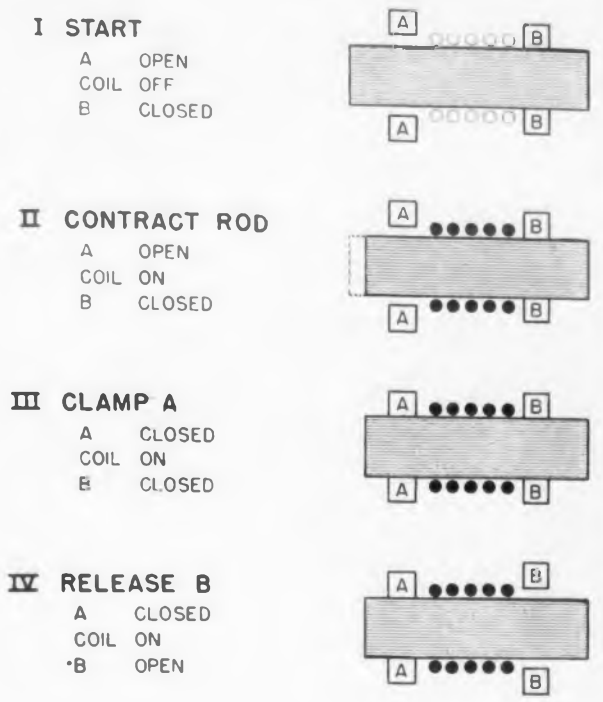
Design Forum

THIS linear actuator is a logical successor to the lead screw in all feed mechanisms requiring micronich (0.000,005 in. to 0.0001 in.) dimensional control. Its first large-scale application in the machine tool field has been to replace the lead screws in centerless grinders. The device employs the magnetostriction effect. Expansion and contraction of the armature, when subjected to an electromagnetic field, is converted to forward or backward motion, reversing on demand without backlash.

Machine cutting tools are generally mounted on a heavy member which slides on accurate ways which are formed as part of the machine bed. Stick-slip, the characteristic of a larger force being required to start two members sliding than that required to maintain the motion once started, must be overcome or reduced to controllable limits before positioning in the millionths-of-an-inch region can be accomplished. The Inchworm actuator, developed by Airborne Instruments Laboratory, Inc. has brought the stick-slip problem under control to the extent that the minimum increment of slide motion in typical installations has been reduced by a factor of 15 through Inchworm replacement of conventional feed mechanisms. These installations have consistently repeated to an accuracy ±5 millionths of an inch under machine load conditions requiring a break-loose force of 300 pounds and a sliding force of about 220 pounds (Cincinnati Milling Machine Co. flat bed No. 2).

The Inchworm lends itself well to the automation trend in the machine tool field in that it will, through a simple converter, respond directly to gage signals. In this manner, machines may be made continuously responsive to tool variations as well as material hardness variations and the many other variables that enter into precise machine finishing.

It is refreshing to see the magnetostriction principle put to use in this new way. Its another example of design engineer's ingenuity in making his knowledge play an important expanding role in industry.

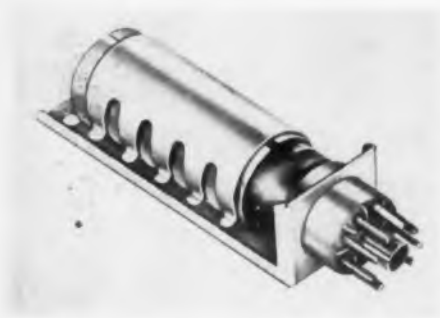


Step cycle of magnetistriction action.

New Products

Subminiature Tube Mounting

Shield Button Base Tubes



This right angle subminiature tube clamping shield with integral socket with round button base subminiature tubes permits placing complex electronic components in confined places while retaining ready access to them for service and replacement. Increased tube life and reliability by reduction of bulb temperature, maximum tube retention under severe shock and vibration, and effective electrostatic shielding is afforded.

International Electronic Research Corp., Dept. ED, 145 W. Magnolia Blvd., Burbank, Calif.

CIRCLE 31 ON READER-SERVICE CARD FOR MORE INFORMATION

Pulse Transformer

For Low Power Applications

The "Stat-Tran" is designed to replace miniature broadband pulse transformers in most applications with improved waveform, better impedance match, lower losses, higher output, and higher voltage rating. It is produced semi-automatically at reduced cost. Values of leakage inductance and distributed capacitance make it a valuable for the power levels encountered in missile and computer circuitry. It is particularly useful in pulse coupling and differentiation where high efficiency is desired.

Pulse Engineering, Dept. ED, 2431 Spring St., Redwood City, Calif.

CIRCLE 32 ON READER-SERVICE CARD FOR MORE INFORMATION

Forced-Air Cooled Triode

Has Thoriated-Tungsten Filament

The ML-5530-H is a thoriated-tungsten filament, forced-air cooled triode designed for industrial heating equipments in the 3 kw to 6 kw power level. A modification of the ML-5530, the ML-5530-H incorporates a new terminal structure and has been given increased plate voltage and power ratings for the usual dielectric heating frequency band.

The tube is rated for a maximum plate input of 10 kw at frequencies to 30 mc. It offers a broad load imepdance range varying from 8.5 k, to 1.18 amp to 5.7 kv, 7.75 amp. Anode dissipation of 4 kw requires only 250 cfm at 1.7 in. of water static pressure.

Machlett Laboratories, Inc., Dept. ED, Springdale, Conn.

CIRCLE 33 ON READER-SERVICE CARD FOR MORE INFORMATION

5000 V DC Power Supply

Weighs Only 2 Pounds

Model PS503, a 5000 v dc power supply, measures 4 x 2-5/8 x 5-1/2 in. Input of 275 v dc provides 5000 v dc at 300 μa. Lower output voltage at correspondingly higher currents are obtainable too. The transformer hermetically sealed in an epoxy resin casting, operates on 30 kc.

Servo Corp. of America, Dept. ED, 20-20 Jericho Turnpike, New Hyde Park, L.I., N.Y.

CIRCLE 34 ON READER-SERVICE CARD FOR MORE INFORMATION

Speed Reducers

For Control Shafts

Designed for adjustment and control of indicator or circuit functions of electronic and mechanical apparatus, speed reduction in these units is obtained from the differential-planetary rotation of precision ball bearings, providing efficient and smooth rotary motion.

The units are completely enclosed and factory lubricated for life. All materials used comply with Govt specifications. Known as the RD series, these reducers are available with 6 different input-output ratios from approx 2.5-1 to 20-1.

Jan Hardware Mfg. Co., Dept. ED, 75 N. 11th St., Brooklyn 11, N.Y.

CIRCLE 35 ON READER-SERVICE CARD FOR MORE INFORMATION

Low-Level DC Amplifier

Eliminates Gain Variations

Unprecedented gain stability is provided by the Micromag MMO-422 low-level magnetic dc signal amplifier for telemtering and instrumentation applications.

Incorporation of a transistor oscillator permits the Model MMO-422 to operate directly from a dc power source.

The MMO-422 finds particular application in the amplification of thermocouple and strain gage output. It serves equally well as a very stable dc voltage amplifier for radio telemeter systems or as a high-gain dc power amplifier for relay-type temperature and servo control systems.

Magnetic Research Corp., Dept. ED, 200-202 Center St., El Segundo, Calif.

CIRCLE 36 ON READER-SERVICE CARD FOR MORE INFORMATION

New 5-Inch Oscilloscope

For Color TV Testing

Model 632, in the medium price range, is a new 5-inch oscilloscope for testing voltage and wave forms in color as well as black and white TV receivers. The unit is designed to complement the Model 616 Color Bar Dot Generator.

Hycon Mfg. Co., Dept. ED, 2961 E. Colorado St., Pasadena, Calif.

CIRCLE 37 ON READER-SERVICE CARD

Thermostats Cut Heating

"Peaks" and "Values"

Two new line voltage thermostats have been developed to take hot "peaks" and cold "valleys" out of electric heating. One does it by fast cycling (up to 20 times per hour), and the other by cycling only 3 to 6 times an hour.

The fast cycling T-40 is responsive to as little as 0.4 deg of temperature change, and is designed to cycle up to 15 to 20 times per hour under a normal 50 per cent heating load requirement.

The T-41 thermostat uses slow cycling periods when used with large-mass heating elements of the type normally mounted in ceilings, floors and similar installations. Its differential is 1 deg.

Minneapolis - Honeywell Regular Co., Dept. ED, Wayne & Windrum Aves, Philadelphia, Pa.

CIRCLE 38 ON READER-SERVICE CARD

New Cable Identification Sleeve

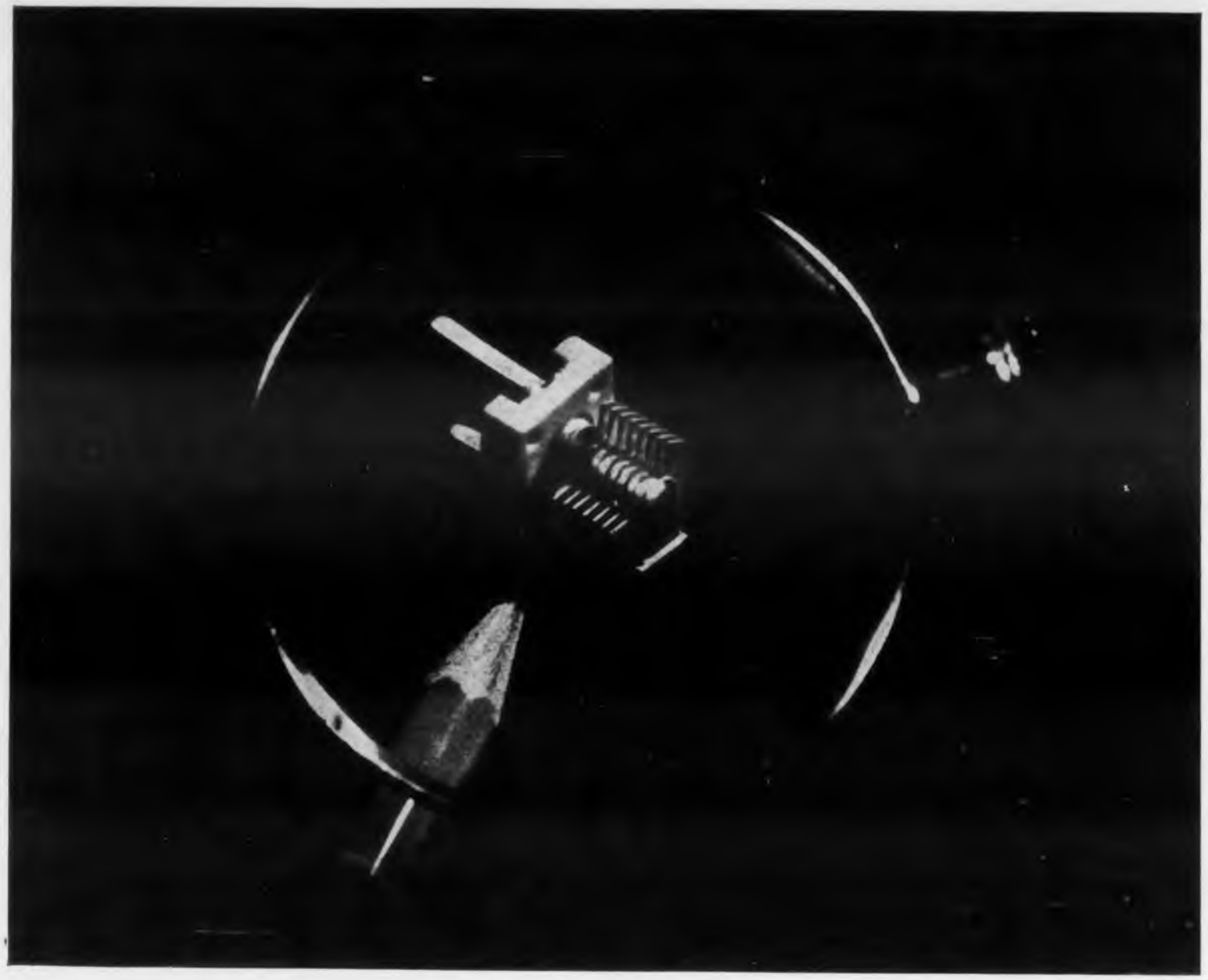
Resists High Temperatures

A printable material, IDENTA-SLEEVE, which resists temperatures up to 700 F, still retains cable or harness identification marks. IDENTA-SLEEVE is a semi-rigid, finely woven fibre-glass sleeve, coated and impregnated with GENCOTE 125C, a specially formulated polymer. Numerals and letters are printed on the sleeve using systems such as the Kingsley Marking Machine. Unaffected by corrosive chemicals, gasoline and oils, the sleeve is also non-burnable.

General Plastics Corp., Dept. ED, 165 Third Ave., Paterson, N. J.

CIRCLE 39 ON READER-SERVICE CARD

CIRCLE 40 ON READER-SERVICE CARD ➤



More than 4½ times actual size.

NOW! even smaller air trimmer capacitors

For every type of electronic equipment—printed wiring board or conventional chassis—Radio Condenser's new Series 75 trimmers mean more circuit in less space. Measuring just 25/64" x 7/16" x 17/32" behind mounting surface, they're the tiniest trimmers ever made in the United States.

Three capacitance ranges are available, as tabulated below. Each is equipped with plug-in tabs for printed wiring board insertion, as well as two holes for conventional screw mounting. The sturdy low loss ceramic body, brass plates soldered and silver plated, assure a rugged unit, able to take extreme shock, vibration and temperature change. Capacitance is easily varied by means of a screwdriver slot in the rotor shaft.

Insulation resistance, "Q" and thermal stability characteristics are excellent.

Complete Engineering data and specifications for the new Series 75 Subminiature Trimmer capacitors are provided in Bulletin TR-123, available free on request. Write Radio Condenser now for your copy.

RADIO CONDENSER
MINIATURE AIR TRIMMER CAPACITORS

Type No.	Min. Cap. μμF	Effective Max. Cap. μμF	Air Gap	No. Plates
875001	1.2	5	.014	9
875002	1.2	10	.008	11
875003	1.5	15	.008	15

RADIO CONDENSER CO.

Davis & Copewood Streets • Camden 3, New Jersey
EXPORT: Radio Condenser Co., International Div., 15 Moore St., N.Y. 4, N.Y.. CABLE: MINTHORNE
CANADA: Radio Condenser Co. Ltd., 6 Bermondsey Rd., Toronto, Ontario

CIRCLE 41 ON READER-SERVICE CARD FOR MORE INFORMATION

Coaxial Connectors

For Hi-Voltage Uses

The Teflon Hi-Volt 259 and 239 UHF Coaxial Connectors are designed expressly for high voltage application where RG Cable is used in conjunction with power supplies. These connectors are rated for 5000 v dc.

The assembly of the cable to the connector employs the same techniques as the conventional UG, uhf type connectors. These connectors are not impedance matches but may be used in the same circuitry where the SO239 and PL259 are employed.

Coaxial Connector Co., Inc., Dept. ED, 37 N. 2nd Ave., Mount Vernon, N. Y.

CIRCLE 42 ON READER-SERVICE CARD FOR MORE INFORMATION

Dynamotors

In Powers up to 110 w

A line of dynamotors, the 3000 Frame Series, includes units with power output up to 110 w, depending on duty cycle and ventilation. All units operate in the temperature range from −55 to +105 C. Specific input and output voltages are available to meet engineering requirements. The unit illustrated is the BD3011 D, with input of 27.5 w at 3 amp, output of 160 v at 250 ma, and speed of 9000 rpm.

Induction Motors Corp., Dept. ED, 570 Main St., Westbury, L.I., N.Y.

CIRCLE 43 ON READER-SERVICE CARD FOR MORE INFORMATION

Datables

Self-Adhesive Labels

Engineering handbook and standard data, in concise tabular form for easy, quick reference, are washable, transferable, heat and moisture resistant, and can be mounted on any smooth surface.

Timber Top Products, Dept. ED, P.O. Box 14, Freeport, N. Y.

CIRCLE 44 ON READER-SERVICE CARD FOR MORE INFORMATION

Tube Pin Straightener

Is Also Cut-Off Tool

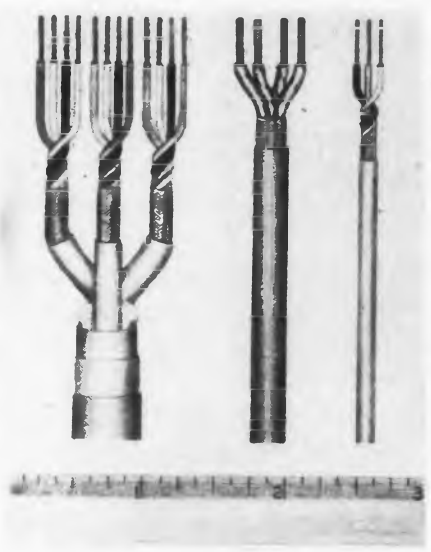
The JE 20 Combination Subminiature Tube Pin Straightener and Cut-Off Tool speeds up the alignment and trimming of leads of both inline and round base subminiature tubes. It features stainless steel 303 inserts set in a black anodized aluminum base. Holes of the stainless steel inserts are precision drilled and counter-sunk to exacting specifications.

Star Expansion Products Co., Dept. ED, 142 Liberty St., New York 6. N. Y.

CIRCLE 45 ON READER-SERVICE CARD FOR MORE INFORMATION

New Multi-Conductor Cable

Teflon Insulated



Teflon insulated cables, designed in constructions from single through thirty-seven conductor assemblies, are available.

The primary insulation suggested for these constructions, is parallel wrapped Teflon, featuring high cut-through resistance and ease of stripping combined with maximum flexibility. The insulated conductors conform to the requirements of MIL-W-16878B, Types E and EE.

Any of the insulated wires may be individually shielded, but usually an overall silver-plated copper shield is supplied with various outer jackets. For high temperature applications a Teflon outer jacket is recommended, or a glass braid can be provided lacquered with silicone or Teflon. For lower temperatures, extruded vinyl or nylon jackets and lacquered nylon braids are supplied.

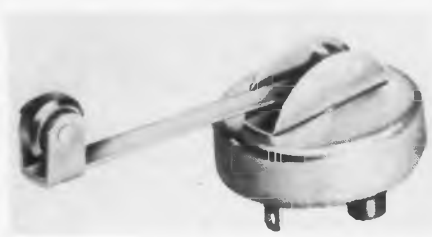
Teflon insulation offers a broad working temperature range of −90 to +250 C, high dielectric strength, low capacitance, and complete resistance to all chemicals.

Tensolite Insulated Wire Co., Dept. ED, 198 Main St., Tarrytown, N. Y.

CIRCLE 46 ON READER-SERVICE CARD FOR MORE INFORMATION

Sealed Switch

Offered With Roller Actuator



This snap-action, W-Blade sealed switch is now available with a versatile roller-actuator that features: low cost; complete protection against water, dust, dirt, and chemicals; long life (up to 1 million cycles under rated load); precise calibration; and high capacity compared to size.

The actuator is available without the roller where a simple leaf actuator is desired. Also, it may be ordered without the roller or the arm to which it is mounted, but with a pin which the arm normally actuates. This enables the customer to select the actuator type. The W-Blade switch also is available either as a limit or as a toggle switch.

Electra Manufacturing Co., Dept. ED, 4051 Broadway, Kansas City, Mo.

CIRCLE 50 ON READER-SERVICE CARD FOR MORE INFORMATION

Non-Destructive Hipot Tester

5 μa Circuit Breaker

Sensitive Hipot Testers, which automatically de-energize high voltage when leakage current in samples reach 5 μa, are available from 2 kv up to 120 kv, and special units can be custom built. The smaller units are adjustable up to 1000 μa and larger units up to 5000 μa.

The tester avoids the brute force method of burning up fine equipment and components when testing for leakage. Hipot testing allows convenient and accurate dielectric testing of equipment, components and materials. With the new Series "H" tester, leakage currents in insulation show up which may appear to be perfect on less sensitive instruments.

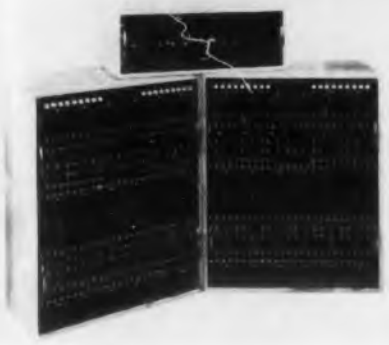
Standard features include both ac and dc outputs and continuously adjustable output voltage. Accurate, hand calibrated dual scale metering, which is directly across the HV output, can be recalibrated at any time by a simple screw driver adjustment. A selfholding primary contactor prevents the accidental reapplication of high voltage after a line failure.

Peschel Electronics Inc., Dept. ED, New Rochelle, N. Y.

CIRCLE 51 ON READER-SERVICE CARD FOR MORE INFORMATION

Analog Computing Systems

Compact, Wide Range Instruments



Complete analog computing facilities capable of operating at speeds 3000 times faster than real time are now available in the form of General Purpose Simulators, Models GPS-6 and GPS-12. A wide variety of linear and nonlinear computing elements and special function generators are available for use with these basic systems, allowing a wide class of design problems to be handled.

GPS General Purpose Simulators can perform complete problem solutions up to 50 times per second, allowing the research operator to change problem parameters, and observe instantaneously and continuously the resulting changes in problem solutions. They are particularly useful for the rapid study of alternative system configurations, for optimizing the parameters of a defined system, for the solution of boundary-value problems, and for the trial-and-error design of any given physical system.

The GPS-6 system consists of a Master Generator and a Basic Computing Unit capable of solving problems up to sixth order. The GPS-12 system consists of a Master Generator and two Basic Computing Units, and is capable of simulating linear physical systems up to twelfth order. Basic Computing Units are 29 x 13 x 36 in. high and weigh 60 lb each.

The Master Generator used measures 26 x 10 x 13 in. and weighs 35 lb.

GPS Instrument Co., Dept. ED, 811 Boylston St., Boston, Mass.

CIRCLE 53 ON READER-SERVICE CARD FOR MORE INFORMATION

VU Level Indicator

Conforms to ASA and JAN Specs

VU Meters are now built into Beede styled cases, Model #23 in clear plastic, Model #16 in satin black. Zero power level is 1 mw, in 600 ohm line. Instrument impedance is 3900 ohms; 3600 ohms external resistance is supplied on special request giving a total of 7500 ohms.

Beede Electrical Instrument Co., Dept. ED, Penacook, N.H.

CIRCLE 54 ON READER-SERVICE CARD FOR MORE INFORMATION

Black India Ink

Ball Point Pen

Black India ink has been gelatin-:ed so that it can be used in a ball oint pen with a stencil-like point 'hich permits writing directly on all 'pes of technical Diazo sensitized ıcsimile papers. Perfect opacity ıakes possible clear, legible copy.

The ink is indelible, waterproof, in-:ant drying, it won't smear, won't run nd won't corrode.

Samuel Taubman & Co., Dept. ED, 76 Madison Ave., New York, N. Y.

CIRCLE 56 ON READER-SERVICE CARD

New Miniature Dc Relay

Compact Design

Type S, a new miniature dc relay, ıeasuring only 7/8 in. wide, 1-3/16 ı. long, and 1 in. high overall, is suit-ble for use in low cost electronic quipment, radiosonde, expendable evices, printed circuits, automotive pplications, electrical toys, etc. Addi-ional specifications are: sensitivity ated at 40 mw; coil resistance up to 500 ohms, standard; contact rating -1/2 amp at 115 v ac, for SPDT; ross-bar contacts available; choice of wo mounting styles, single stud 6-32 5/16 in. or insulated base.

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

CIRCLE 57 ON READER-SERVICE CARD

Enjoy Electrical Appliances

In Your Car

"Powercons", designed specifically or the automotive market to convert he normal 6 or 12 v dc battery power upply to 60 cps 110 v ac, has been ntroduced.

These small, box-like units with arious power ratings can be installed n convenient spaces, such as under he dashboard or in a car's trunk com-partment.

The line of "Powercons" for mobile ervice range in size, weight and ca-pacity from 20 w to 150 w or 200 w nits. Several models have output oltage control built in.

Cornell-Dubilier Electric Corp., 'Powercon" Div., Dept. ED, South Plainfield, N. J.

CIRCLE 58 ON READER-SERVICE CARD

CIRCLE 59 ON READER-SERVICE CARD ➤

"Dust Control" Hoods

Use Filtered Air

This blower system is a combinatio housing through which air is passe and filtered to a 1/2 micron efficiency The filter can be changed externally to prevent internal contamination o the working area. The aerodynami shape and contour of the housin eliminates internal turbulence of th pressurized air. The "Dust Control hoods are cast in a single piece o transparent shatter-proof plastic.

P. M. Leonard Co., Dept. ED, 19 De Graw St., Brooklyn, N. Y.

CIRCLE 60 ON READER-SERVICE CARD

Small Oscillograph

Withstands Shock, Acceleration

Model 560 Oscillograph records un der extreme acceleration and shoc conditions, even in excess of 3000 g. I is packaged in a cast aluminum cas measuring only 6-5/8 x 7 in.

Facilities for mounting damping re sistors on each of the 14 channels ar included inside the unit. All operatin controls and the viewing screen ar accessible from one end, allowing th instrument to be more easily operated A wide range of galvanometers i available with natural frequencies u to 3500 cps.

Midwestern Instruments, Dept. ED 41 St. and Sheridan Rd., Tulsa, Okla

CIRCLE 61 ON READER-SERVICE CARD

Synthetic Mica

In Powder and Sheet Form

"Synthamica" synthetic mica is nov available in quantity for industrial ap plication. Four forms are currentl offered: 202, a high quality, syntheti fluor-pholgopite mica in flake or pow der form; 707, a bonded, inorgani punching material, 0.005 to 0.100 in thickness; 727, a flexible, inorgani bonded material for creating formed parts or insulation wrapping to b heat cured; and 807, reconstituted mica paper sheets with no binder.

"Synthamica" is capable of with standing sustained temperatures a high as 2000 F without physical o electrical failure.

Synthetic Mica Corp., Dept. ED Caldwell Township, N.J.

CIRCLE 62 ON READER-SERVICE CARD

◀ CIRCLE 59 ON READER-SERVICE CARD

Microwave Antenna

Rear Feeds

Microwave antenna rear feeds used with parabolic reflectors produce pencil shaped rf beams. Each unit consists of a section of rectangular waveguide, terminated by a weather-proof teflon sealed cup feed. Input connectors are standard choke flanges. Available standard models and center frequencies are: MA-625 (9.375 Kmc/s), MA-624 (16.5 Kmc/s) and MA-1046 (34.86 Kmc/s).

The MA-1046 rear feed and a 1 foot diameter parabolic reflector of 3 in. focal length produces a pencil beam of approximately 2 deg width over the frequency range 34.5-35.225 Kmc/s.

Feeds designed for specific applications are available on special order.

Microwave Associates, Dept. ED, 22 Cummington St., Boston 15, Mass.

CIRCLE 64 ON READER-SERVICE CARD FOR MORE INFORMATION

Video Distribution Amplifier

Extremely Compact

Video distribution amplifier, Model PA-1002, is designed especially for use in the distribution and transmission of video signals, both color and monochrome. This unit is capable of any number of outputs from a common input signal source, all isolated from the input to prevent disturbances from being reflected back into the signal source.

The frame can accommodate a total of eight amplifiers. The frame also contains a pair of compensating inductors for each amplifier input which effectively neutralized input capacity, thus maintaining resistive line termination.

The new amplifier features an exceptionally flat amplitude frequency response of ±1% to 6 mc, and it is down less than 3 db at 10 mc. Differential gain characteristics are indicated by a variation of less than 1% for ±3% B + voltage variation of 5% filament voltage variation. Similarly, differential phase is less than 0.5° at 3.6 mc.

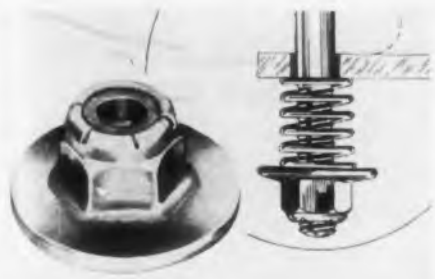
The amplifier has high impedance input, and output is 75 ohm internally terminated. Power consumption is low.

General Precision Lab., Inc., Dept. ED, Pleasantville, N. Y.

CIRCLE 65 ON READER-SERVICE CARD FOR MORE INFORMATION

Flanged Base Self-Locking Nut

For Spring Mounting Applications



A new flanged hexagon self-locking nut with a large washer type seat for fastening applications involving spring tension, such as compressor motor mountings in refrigerators, has been developed. The large built-in bearing area of the ESNA Type 1994, eliminates the need of individual nuts and special washers in such applications.

During shipment of a spring mounted unit, the nut can be turned down compressing the spring and making a solid mounting which cannot shift. Upon delivery of the ESNA self-locking nut is backed off to the proper spring tension to float the unit. As a self-locking fastener the 1994 will remain locked at any desired position on the bolt permitting exact spring tension adjustment.

The base flange against which the spring seats is 1 in. in diam. ESNA's red fiber insert provides the locking feature of the nut and retains it in any position on the bolt despite pressure of the spring or severe vibration. The new flanged self-locking nut is made of steel with a plain or plated finish.

Elastic Stop Nut Corp. of America, Dept ED, Union, N. J.

CIRCLE 67 ON READER-SERVICE CARD FOR MORE INFORMATION

Beacon Cavity Oscillator

Applicable to Missiles

Model 193 Rocket Tube Cavity Oscillator has small size and light weight, making it especially suitable for aircraft, guided missile, and beacon applications. It is a coaxial line cavity oscillator, employing the Sylvania UHF Planar Triode tube, and it provides a highly stable rf pulse signal source.

The unit features a single control for tuning, and it utilizes fixed feedback. It is available for frequencies from 2500 to 4000 Mc, with a tuning range of 200 Mc/sec. Its overall length is only 5-1/2 x 1-5/16 in. diam. and it weighs only 14 oz. Peak plate voltage is 1200-1500 v with a peak output of 200 w. Output connection is a BNC jack. The cavity may be furnished with a regulated power supply.

Amerac, Inc., Dept. ED, 116 Topsfield Rd., Wenham, Mass.

CIRCLE 68 ON READER-SERVICE CARD FOR MORE INFORMATION

LAPP ANTENNA TOWER INSULATORS

We at Lapp are mighty proud of our record in the field of tower insulators. Over 30 years ago, the first insulated broadcasting tower was erected—on Lapp insulators. Since then, most of the large radio towers in the world have been insulated and supported by Lapp insulators. Single base insulator units for structures of this type have been design-tested to over 3,500,000 pounds.

A thorough knowledge of the properties of porcelain, of insulator mechanics and electrical qualities has been responsible for Lapp's success in becoming such an important source of radio insulators. Write for description and specification data on units for any antenna structure insulating requirement. Lapp Insulator Co., Inc., Radio Specialties Division, 941 Sumner Street, LeRoy, N. Y.

Lapp

CIRCLE 71 ON READER-SERVICE CARD FOR MORE INFORMATION

All Metal Mount

Isolates Helicopter Vibrations

Low speed rotating components and rapid changes in flying attitude, for example, set up severe vibrations which are characterized by low forcing frequencies and unusually high excursions. These two factors, unlike those in conventional craft which have high frequencies and low excursions, rule out the use of ordinary vibration controls for isolating electronic equipment.

The new mount with a low natural frequency, ranging from 4 to 4.5 cps and a large deflection which also provides some degree of shock control, takes an extremely high excursion, 1/4 in. peak-to-peak load, with a magnification factor of 1.8 or less at resonance.

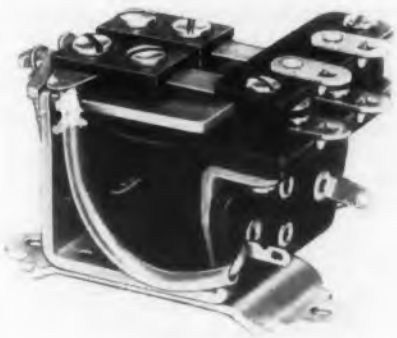
Known as Series 600, the Belleville spring type design consists of two load-carrying convex springs, a circular coil spring and wire mesh pads. The new Finn mount is an all-metal captivated mount, lightweight, and is available with both short or long studs in load ranges from 3-1/2 to 28 lb.

T. R. Finn & Co., Electronic Div., Dept. ED, 200 Central Ave., Hawthorne, N. J.

CIRCLE 72 ON READER-SERVICE CARD FOR MORE INFORMATION

Medium Duty Power Relays

AC or DC



These rugged relays can be applied to lighting systems, signal devices, motor starting, heater loads, photographic applications, or any load circuit requiring fast positive switching of ac or dc power.

All coils are formvar wound, baked varnish impregnated for protection against mechanical and moisture damage.

Properties are: pure silver contacts, 1/4 in. diam, rated at 10 amps, 115 v 50-60 cps, non-inductive load; contact pressure, factory adjusted, minimum of 25 grams; dimensions: 2-3/8 x 1/12 x 1-11/16 in. high; mounting: Two, 6-32 tapped holes on 2 in. centers.

Line Electric Co., Dept. ED, 1407 McCarter H'way, Newark 4, N. J.

CIRCLE 73 ON READER-SERVICE CARD FOR MORE INFORMATION

Teflon Terminals

Takes Press Fit

The "Press-Fit" line of Teflon press-fitted terminals has been expanded until it now includes hundreds of standard types of stand-offs, feed-thrus, breakaway connectors, and contact receptacles. All numbers are available in RETMA standard color codings: yellow, orange, red, blue, green, brown, gray, and white. This firm also offers test points which, mounted externally, accept standard 0.080 in. test probes for quick checkups and measurements of housed radio-electronic or electrical equipment.

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

CIRCLE 76 ON READER-SERVICE CARD

Germanium Transistors

Diffused Base Type

These transistors feature unusually good high frequency performance. They are particularly suited to vhf oscillator, medium power if, and broad band video amplifier applications. Representative units have provided 50 mw output as oscillators at 200 Mc. Other units of this type as video amplifiers have given about 19 db gain per stage with an 8 Mc bandwidth.

Although subject to change with state-of-the-art diffusion techniques employed, typical units produced at present have an alpha frequency-cutoff median value of approx 400 Mc, with some units showing alpha frequency-cutoff in excess of 600 Mc. Power dissipation is 150 mw max at 25 C with an appropriate heat sink. Common emitter short circuit current gain at 50 Mc is 12 db min.

The emitter layer and base contact are made from films of aluminum and gold-antimony by using techniques of vacuum evaporation and alloying. Electrical connections to the base and emitter areas are made through spring point contacts. The completed assembly is mounted in a hermetically sealed metal case of approx 5/16 in. diam x 3/8 in. high.

Radio Div., Western Electric Co., Dept. ED, 120 Broadway, New York 5, N.Y.

CIRCLE 77 ON READER-SERVICE CARD

Voltage Divider Networks

In Variety of Configurations

A variety of sizes and configurations of precision voltage divider networks is offered by this firm. The same method of construction is used on all networks, involving internal cushioning and the application of synthetic resins during winding.

A typical network has 11 precision wire wound resistors of values ranging from approximately 7 K to 171 K and matched to 0.005% at both dc and 400 cps over a temperature range of 50 C. The network is mounted on an anodized engraved aluminum faceplate containing Teflon feed-throughs to minimize leakage. Four studs are provided for mounting. The network is encapsulated in thermosetting resin with zero percent shrinkage characteristics to avoid external pressure effects on the resistors and to meet MIL-R-93.

Eastern Precision Resistor Corp., Dept. ED, 675 Barbey St., Brooklyn 7, N.Y.

CIRCLE 81 ON READER-SERVICE CARD FOR MORE INFORMATION

X-Band Circulator

Has High Front-to-Back Ratio

Model 601 X-Band Ferrite Circulator, with a front-to-back ratio approaching 300:1, is a medium power mircrowave component developed around the non-reciprocal differential phase shift principle as outlined by Kales, Chait, and Sakiotis. Power entering the circulator is transmitted in sequence from one terminal to another: power entering at "A" leaves at "B", while power entering at "B" leaves at "C". Power entering at "C" leaves at "D", while that entering at "D" returns to "A". The 601 is a high performance component for such uses as a low-loss, broad band isolator, or in passive duplexing applications.

Frequency range is 8500-9600 Mc; isolation is 30 db min; insertion loss is less than 0.2 db; return loss is 30 db min; input vswr is 1.2 max; waveguide is RG-52/U-RG67U; flanges are UG-39/U, 135/U at B, C, and D; input terminals are UG-40A/U, UG-136A/U.

Microwave Development Laboratories, Inc., Dept. ED, 92 Broad St., Wellesley 57, Mass.

CIRCLE 82 ON READER-SERVICE CARD FOR MORE INFORMATION

Ultrasonic Transducer

In Water Jacket or Open Frame

This is a new ultrasonic transducer of the stack-tool type. The unit has been designed so that tools can be mounted on it for soldering, cutting or other ultrasonic applications. Water cooled jackets may be supplied. The unit is available as a separate item for application to already existing generators manufactured for ultrasonic or other uses.

The transducer operates at a standard frequency of 19.2 ±5%, input power 250 to 500 w at 75 ohms, tool end tapped 1/2 - 28.

Alcar Instruments, Inc., Dept. ED, 17 Industrial Ave., Little Ferry, N. J.

CIRCLE 86 ON READER-SERVICE CARD FOR MORE INFORMATION

Phase Generator

Accurate Simple Measurements

When excited with a fixed voltage at a fixed frequency, the phase generator, Model PG-1, produces a constant output voltage of the same frequency whose time phase varies in linear response to a dial rotation. Two such outputs are provided which instantaneously differ from each other by 90 degrees time phase. The engraved dial graduations represent the output phase. Each unit is operative at one frequency only. Though the output attenuates with loading, the operation remains unaffected.

Specifications: Excitation: 115 v, 400 cps; Output: 10 v, 400 cps, two phases; Phase Shift Range: 360 degrees, continuous rotation; Phase Shift Accuracy: Dial reading within one degree. Variations to customer requirements: Excitation: 1 v to 500 v, 20 cps to 10 kc; Phase Shift Accuracy: Dial reading within 5 minutes of arc.

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

CIRCLE 87 ON READER-SERVICE CARD FOR MORE INFORMATION

Printed Circuit Solder Pot

Has Mechanical Dial Thermometers

This new line of 25 sizes of printed circuit solder pots, in the temperature range of 300 to 600 F, has mechanical type dial thermometers to indicate solder temperature. All components except the elements may be serviced easily without taking the pot apart.

High-low heat switch controls approximately 35 per cent of the total wattage so that the pot may be used for either hand dipping or fast machine dipping without excessive cycling time.

Standard equipment includes 2 pilot lights, a magnetic contactor on units of more than 3000 w, and a power switch on standard units of 2500 w or more. Models are available in 110, 220 and 440 v.

Dee Electric Co., Dept. ED, 1101 N. Paulina St., Chicago 22, Ill.

CIRCLE 91 ON READER-SERVICE CARD FOR MORE INFORMATION

Electronic System Housing

Units Individually Accessible

Modu-Rak line of miniature desk racks, designed for modular construction of test equipment, makes possible any number of separate units in one rack.

Easily accessible for assembly or repair, Modu-Raks are designed for standard 19, 9, and 4-3/4 in. rack panels. They are available 21-3/4 wide x 12 in. deep and 12-1/4 wide x 12 in. deep, in a variety of heights with removable rear panels or doors. Panel mounting holes are tapped for 10-32 machine screws on universal spacings and panels fit into a recess so edges are not exposed.

Modu-Raks are sturdily constructed of 16 gauge cold rolled steel and are attractively finished in gray hammertone with rounded front corners and red striped chrome trim top and bottom. A complete selection of vertical strips, angle brackets, horizontal dividers and panels are available.

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

CIRCLE 92 ON READER-SERVICE CARD FOR MORE INFORMATION

Flow Rate Indicator

Direct Reading Digital Unit

Designed primarily for use with the company's turbine flowmeters, this flow rate indicator features a complete digital system, operating from the frequency output of the turbine meter, taking full advantage of the linearity and repeatability inherent in the turbine meter primary. In-line, illuminated, truly digital indication is provided in 1 in. high edge-illuminated numbers. Only the relevant number appears; there is no distracting mechanical movement in going from one digit to another.

Direct reading of flow is provided with manual correction for specific gravity as an optional feature. Conversion into the desired flow units and correction for the calibration factor of the primary are accomplished electrically. In addition to straight indication, the digital information stored in the indicator can be fed directly to complete data handling and automation systems.

Fischer & Porter Co., Dept. ED, 758 Jacksonville Rd., Hatboro, Pa.

CIRCLE 94 ON READER-SERVICE CARD FOR MORE INFORMATION

Spring Tension Gage

Tests Springs in Electronics

To meet the need for a method of testing springs in delicate electronic applications, this company has introduced a Spring Tension Gage for accurately determining settings or for checking the tensions of relay or other springs. Tensions are registered in grams.

It is made with a nickel silver frame on which are assembled an indicating spring, a folding handle, and an adjustable tension attachment. The folding handle, when closed, serves as a protector for the indicating spring. The adjustable tension attachment provides for setting the indicating spring at an initial tension. The scale is calibrated front and back so the gage can be used for indicating left to right or right to left.

Size is 4-1/2 in. x 1-1/2 in. overall. Four models with different scale ranges are available.

K. Neuses, Inc., Dept. ED, W. Euclid and Dwyer Sts., Arlington Heights, Ill.

CIRCLE 95 ON READER-SERVICE CARD FOR MORE INFORMATION

cut assembly costs ■ ■ ■ with U.S.G.-fabricated precision parts of

TEFLON*
KEL-F†
BAKELITE
Fluorothene
NYLON

■ U.S.G. precision-molded or machined parts from the fluorocarbons and other plastics meet exacting specifications, assure uniform density and dimensional stability, uniform electrical, chemical and physical characteristics of the highest quality.

Strict quality control "from powder to part" and many years of experience in the particular technique of fabricating these unique plastic materials, assure cost-cutting results in your production line.

Write for 20-page brochure "Inside U.S.G." which suggests how this organization can serve you. Or send us your blue prints for quotations.

UNITED STATES GASKET COMPANY
CAMDEN 1, NEW JERSEY

U S G BELMONT

* du Pont's trademark for its tetrafluoroethylene resin.
† Kellogg's trademark for its trifluorochloroethylene resin.

CIRCLE 98 ON READER-SERVICE CARD FOR MORE INFORMATION

New Weighing Counter

Records Up To 200 Per Minute

A new remote electric counter permits the user to tabulate and record up to 200 weighings per minute from any point in his plant. It can be used to keep production records, as well as tabulate customers' orders.

The counter's high recording rate is attributed to the speed and accuracy of the clutch arrangement, which prevents "double count" even when the counter is actuated by chattering contact or a washing mercury switch.

Model 31-41 has two row digits, one for an accumulative total and one for individual weighings. Model 31-42 records only individual weighings.

Richardson Scale Co., Dept. ED, Van Houten Ave., Clifton, N. J.

CIRCLE 99 ON READER-SERVICE CARD FOR MORE INFORMATION

Paper Base Laminate

Resists Arcing and Flame

Phenolite Y-2500 is bonded with a modified phenolic resin that gives fire resistant qualities for service in electrical and electronic applications. General properties correspond to NEMA Grade XX, but this paper base laminate also provides arc resistance up to 100 sec. It is designed to punch and shave better than melamine paper base laminates presently used for arc-resistant applications. As a self-extinguishing laminate, it passes the standard Underwriters Laboratory flame test.

The laminate is particularly suited for such applications as arc deflectors, circuit breaker components, electrical switches, and other interrupting devices. It is available in sheet sizes of 39 x 47 in. and 39 x 39 in., and in thickness of 0.015-1.0 in. It comes in a standard semi-gloss and a special dull finish in either natural (light brown) or red.

National Vulcanized Fibre Co., Dept. ED, 1056 Beech St., Wilmington, Del.

CIRCLE 100 ON READER-SERVICE CARD FOR MORE INFORMATION

High Current DC Power Supply

Close Regulation, Fast Response

Balanced design in a new thyratron dc power supply controlled by fast acting circuits results in performance that has been exceeded only by series-tube supplies. Ripple, peak-to-peak is 0.1 per cent; load regulation, no load to full is 0.15 per cent; line regulation, ±10 per cent variation is 0.15 per cent; 20 per cent of load is 0.15 per cent; 5 per cent step of line voltage is 0.15 per cent; response time is 10 ms.

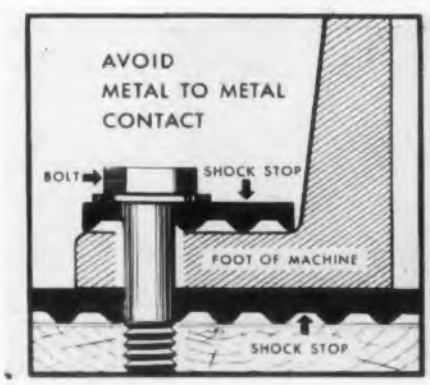
These compact supplies operate from 60 cps power and are available for output voltages up to 500 v and for currents larger than 3 amp. Several voltage units can be packaged in one frame. Covers are optional.

Dynamic Controls Co., Dept., ED, 31 Davis Ave., Arlington 74, Mass.

CIRCLE 104 ON READER-SERVICE CARD FOR MORE INFORMATION

Shock Stops

Vibration Pads



Inexpensive rubber vibration dampening pads effectively isolate noisy, irritating or destructive vibration. Known as Cohrlastic "Shock Stops," the pads are installed between the base or feet of equipment and the floor or foundation.

Shock stops come in 18 x 18 in. molded sheets which are easily cut and installed to a weight/size formula. Their effectiveness is due to a waffle design which gives sure support, yet soaks up vibration to a remarkable degree. Laid on a smooth surface, additional dampening effect is provided by the air trapped within the waffle cups. When equipment must be bolted to the foundation or floor, the bolts may also be isolated with shock stops. Made of Neoprene rubber, shock stops are not affected by fuels and oils.

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

CIRCLE 105 ON READER-SERVICE CARD FOR MORE INFORMATION

When network discharge service needs

HIGH RESISTANCE to SHOCK and VIBRATION—

Specify THE NEW

Kuthe 3C45W

Product of the world's largest manufacturer of HYDROGEN THYRATRONS

Ruggedized, smaller size—for more dependable performance in missiles, aircraft, vehicles and other heavy-duty applications . . .

Kuthe's new 3C45W is a unipotential cathode, 3-element hydrogen-filled thyratron designed for network discharge service . . . producing pulse outputs of 50 KW at an average power level of approximately 65 watts.

Smaller in size and featuring ruggedized construction to a remarkable degree, the 3C45W is outstandingly reliable under the most severe conditions of shock and vibration. It is equipped with a reservoir for longer, more stable life.

Kuthe's new 3C45W incorporates the broadest engineering experience, highest quality and finest craftsmanship in the industry.

Principal Electrical-Mechanical Data and Ratings:

Heater voltage	6.3 ±5.0%
Heater current	2.6 amps.
Minimum heating time	3 min.
Mounting position	Any
Overall length	3.75" (max.)
Greatest diameter	1.56" (max.)
Base	Med., 4-pin, A4-9
Anode connector	Small metal, C1-1
Reservoir	Connected internally across cathode heater
Anode supply voltage	800 v. (min.)
Peak anode voltage, forward	3000 v. (max.)
Peak anode voltage, inverse	3000 v. (max.)*
Peak anode current	35 amps. (max.)
Anode current rate of rise	750 amps/-usec. (max.)
Average anode current	45 ma.
Grid drive voltage	175 v. (min.)
tad	0.6 μs.
Δ tad	0.15 μs.
tj	0.02 μs.
Pb	0.3 x 10⁹

** 25 μs. after end of pulse.*

Typical operation as Pulse Modulator, DC Resonance Charging

Anode supply voltage	1.5 KV DC
Pulse repetition rate	2500 PPS
Pulse duration	0.5 microseconds
Pulse forming network impedance	50 ohms
Trigger voltage	200 volts
Peak power output	45 KW
Average power output	56 watts
Anode current	40 ma. DC

For complete information, write to Dept. W-235

Kuthe Laboratories, Inc.

An Associate of
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION
730 South 13th Street • Newark, N. J. • Bigelow 2-6000

AN IT&T ASSOCIATE

CIRCLE 106 ON READER-SERVICE CARD FOR MORE INFORMATION

High-Precision Impedance Comparator

Direct Indication

Type 1605-A impedance comparator indicates not only the difference in magnitude between the two components being compared, but also indicates simultaneously the phase-angle difference.

The impedance comparator is completely self-contained, including a calibrating voltage. The internal oscillator provides frequencies from 100 cy to 100 kc in decade steps. Meter voltages are available externally to operate recorders, remote indicators, or selecting devices.

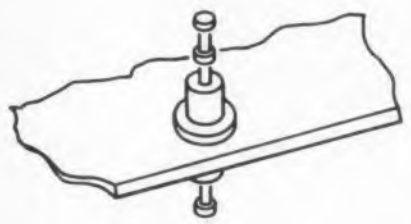
The range of impedances which can be compared is nominally from 2 ohms to 20 megohms. Four independent ranges are provided for the impedance-difference (±0.3%, ±1%, ±3%, ±10%) and the phase-angle-difference (±0.003, ±0.01, ±0.03, ±0.1 radian full scale).

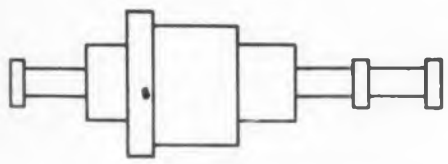
General Radio Co., Dept. ED, 275 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 109 ON READER-SERVICE CARD FOR MORE INFORMATION

Feed-Through Terminals

For Chassis Mounting





These insulated feed-through terminals may be mounted directly on a metal chassis where no room is available for a terminal board. The units use a high electrical grade of melamine for insulation. Terminals mounted on metal chassis have withstood breakdown tests in excess of 1500 v.

The terminals may be swaged directly onto the metal part, without warpage. Because they are completely rigid when mounted, they will withstand heavy shock without causing noise problems. Two models are offered: 6065 and 6066; they use MME insulation material, and are available for board thicknesses of 1/32 to 3/32 in. Model 6065 has a double tie on one end, and Model 6066 has a double tie on both ends.

Lerco Electronics, Inc., Dept. ED, 501 S. Varney St., Burbank, Calif.

CIRCLE 110 ON READER-SERVICE CARD FOR MORE INFORMATION

Junction Transistor Checker
Is Battery Operated

The Junction Transistor Checker measures the significant characteristic of p-n-p or n-p-n transistors: collector leakage with base grounded, collector current at zero base current (base open), and base to collector current gain at 4.5 v on the collector. Self-contained, with batteries lasting over a year in normal use, the checker is quick and easy to use (no warm-up time).

The meter reads gain directly, showing up defective units and indicating relative gain. A useful feature is the provision of pin jacks connected to base emitter and collector circuits for plugging in clip leads; this makes easy the checking of transistors not readily plugged in (those with long leads, in circuits, etc.).

Instant Circuits Div., Alfred W. Barber Laboratories, Dept. ED, 32-44 Francis Lewis Blvd., Flushing 58, N. Y.

CIRCLE 112 ON READER-SERVICE CARD FOR MORE INFORMATION

Cooling-Effect Detector
Protects Electronic Equipment

Series 18801 Thermoswitch is a cooling-effect detector designed to detect inadequate cooling of air-cooled electronic components. This detector senses the combined cooling effect contributed by both ambient temperature and mass rate of air flow. Since the detector has its own source of heat, it can be set to simulate the temperature condition of the equipment it protects. It can be connected to an alarm device or, by suitable relay, control solenoid or motor-actuated valves to produce the additional cooling action required for an over-temperature condition.

The adjustment range of the detector allows it to be used at air flow rates of 500 to 20,000 lb/hr/sq ft (or higher with modification) in ambient temperatures of −65 to +160 F, and at any heater voltage between 0 and 32 v ac or dc. The detector is normally flange mounted with the sensing leg extending into the duct at right angles to the airstream.

Fenwal, Inc., Dept. ED, Ashland, Mass.

CIRCLE 113 ON READER-SERVICE CARD FOR MORE INFORMATION

RADIO INTERFERENCE AND FIELD INTENSITY *measuring equipment*

Stoddart equipments are suitable for making interference measurements to one or more of the following specifications:

AIR FORCE—MIL-I-6181B
150 kc to 1000 mc

BuAer—MIL-I-6181B
150 kc to 1000 mc

BuShips—MIL-I-16910A (Ships)
14 kc to 1000 mc

SIGNAL CORPS—MIL-I-11683A
150 kc to 1000 mc

SIGNAL CORPS—MIL-S-10379A
150 kc to 1000 mc

The equipments shown cover the frequency range of 14 kilocycles to 1000 megacycles.

Measurements may be made with peak, quasi-peak and average (field intensity) detector functions.

F.C.C. PART 15—Now in effect, the revised F.C.C. Part 15 places stringent requirements upon radiation from incidental and restricted radiation devices. Stoddart equipment is suitable for measuring the radiation from any device capable of generating interference or c-w signal within the frequency range of 14 kc to 1000 mc.

Write Stoddart Aircraft Radio Co., Inc., for your free copy of the new revised F.C.C. Part 15.

NM-10A (AN/URM-6B)
14 kcs to 250 kcs

NM-20B (AN/PRM-1A)
150 kcs to 25 mcs

NM-30A (AN/URM-47)
20 mcs to 400 mcs

NM-50A (AN/URM-17)
375 mcs to 1000 mcs

The **Stoddart NM-40A** is an entirely new radio interference-field intensity measuring equipment. It is the commercial equivalent of the Navy type AN/URM-41 and is tunable over the audio and radio frequency range of **30 CPS to 15 kc.** It performs vital functions never before available in a tunable equipment covering this frequency range. Electric and magnetic fields may be measured independently over this range using newly developed pick-up devices. Measurements can be made with a 3 db bandwidth variable from 10 CPS to 60 CPS and with a 15 kc wide broadband characteristic.

STODDART *Aircraft Radio Co., Inc.*

6644-J SANTA MONICA BLVD., HOLLYWOOD 38, CALIFORNIA · Hollywood 4-9294

CIRCLE 116 ON READER-SERVICE CARD FOR MORE INFORMATION

Clamp

For Tubes, Relays, Capacitors

This clamp is designed to hold radio and transmitting tubes, as well as relays and capacitors, to chassis. Opened and closed from the top, it allows tubes to be placed close together, saving space and weight. Diameter tolerance is ±1/8 in., which reduces the number of sizes required in the stock room.

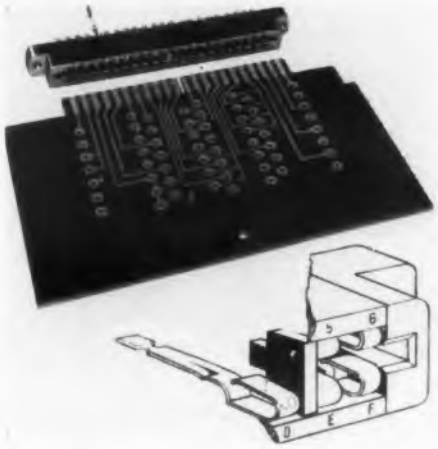
Sizes range from 9/16 to 3 in. diam. All material used is stainless steel, and attaching parts are silver soldered. Over 65 types or sizes are available. In addition to the standard clamps, both wire and hat type clamps are available.

Electronics Div., Peerless Machine Co., Dept. ED, 5338 Alhambra Ave., Los Angeles 32, Calif.

CIRCLE 117 ON READER-SERVICE CARD FOR MORE INFORMATION

Printed-Circuit Varicon Connectors

Series 6,000 Polarized



For use with printed circuit boards, these connectors have contacts designed to make good connection with printed circuitry regardless of normal warpage or variation in thickness inherent in the boards. This is accomplished by the double spring action incorporated in the contact form.

Contact terminals are designed for use with either taper tab or conventional soldered connections. All contacts are securely locked in position and cannot be pushed out by taper tab tools.

Polarizing tabs may be snapped in between contacts with finger pressure. They will not come out under vibration, but may be removed with long nose pliers if a change in polarity is desired.

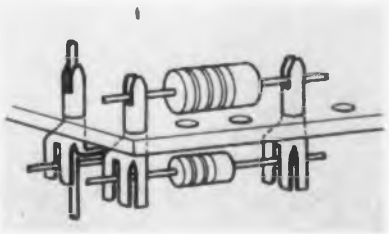
The ease with which polarization is accomplished makes it unnecessary to stock more than one type of connector.

ELCO Corp., Dept. ED, "M" St. below Erie Ave., Phila. 24, Pa.

CIRCLE 118 ON READER-SERVICE CARD FOR MORE INFORMATION

Quick Push-In ZIP Terminals

No Staking Required



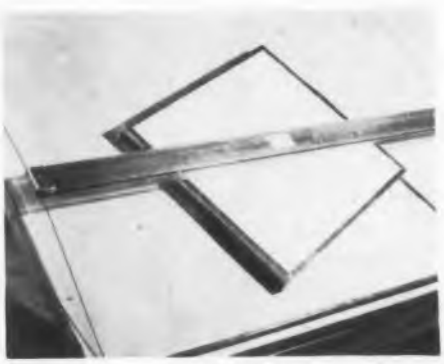
Vector Push-in Zip Terminal needs only to be pushed into the 0.093 in. wall or deck hole and it holds itself securely without staking. The serrated slots grip inserted wires tightly for testing or dip soldering. The Push-in Zip Terminal is a formed strip brass terminal having a partially tubular end which fits into the holes in the board and is held by spring tension. The upper portion of the terminal has a narrow tapered slot with serrated edges, which firmly grip the wire lead of any size between 0.030 and 0.045 in. The slot is offset from the axis of the tubular hole by approximately 0.040 in. so that a riser wire coming up through the hole does not interfere with the cross-wire. The portion of the tubular member which protrudes from the opposite side of the board also has a slot which grips wires on that side of the panel. In addition, there is a thumb on the terminal, used for small wires such as are found on transistors, diodes, and miniature tubes; or the thumb may be bent outwardly to form a junction with an adjacent terminal, thus making a cross-section.

Vector Electronics Co., Dept. ED, 3352 San Fernando Rd., Los Angeles 65, Calif.

CIRCLE 122 ON READER-SERVICE CARD FOR MORE INFORMATION

Portable Tracing Table

Low Cost



This modern, extra-thin tracing table is lightweight, portable, easy to store and yet strong enough to permit tracing on Bristol board. Called Porta-Trace, it is 1-7/16 in. thick. Because of its low height and flush top, drawings which are actually larger than the unit, can be traced, and Porta-Trace can be used easily under a string straight edge. The flush plexiglas top provides for light diffusion with minimum glare; fluorescent lighting gives high light output with minimum heat. In addition, rubber feet on the bottom of the unit keep it stationary even on tilted drawing or drafting boards. Tables are made in four sizes: from 11 x 18 in. to 24 x 36 in.

Porta-Trace Inc., Dept. ED, 342 Clinton St., Binghamton, N. Y.

CIRCLE 123 ON READER-SERVICE CARD FOR MORE INFORMATION

an important new drafting technique

possible only with MARS-LUMOCHROM

All colors blueprint perfectly, making color-drafting possible.

MARS-LUMOCHROM does not fade . . . does not smear . . . is waterproof . . erases perfectly . . . keeps finest point

Send for free sample

STAEDTLER also proudly introduces the Mars-Pocket-Technico for field use, the Mars "Draftsman's" Pencil Sharpener with the adjustable point length feature, and the efficient, clean Mars lead sharpener. All available—along with the established standards: Mars-Lumograph black graphite drafting pencils, Mars-Technico lead holder and leads, and Tradition-Aquarell painting pencils—at all leading art material and drafting supply dealers.

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

CIRCLE 124 ON READER-SERVICE CARD FOR MORE INFORMATION

Rotary Joints

X, S, and C-Bands

A rotary joint employing one or two in-line transitions is offered at the X, S, and C-bands. The in-line transitions make possible improved packaging of rf components and drive mechanisms in many applications.

The L-type unit illustrated operates over the frequency range of 5400-5900 mc and has a vswr under 1.20. Special attention has been given to designing both the in-line and right-angle transitions to handle high power. This C-band unit withstands in excess of 500 kw at atmospheric pressure and mates with a standard 1 x 2 in. waveguide. It may be rotated at 20 rpm and is pressurized to 30 psig. Other pressurized rotating joints are available operating up to 3600 rpm.

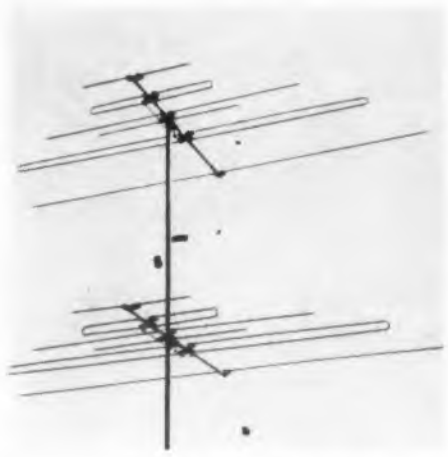
This firm offers a complete line of standard L-shaped and in-line rotary joints, as well as the more conventional rotary joints employing two right-angle transitions.

Canoga Corp., Dept. ED, 5955 Sepulveda Blvd., Van Nuys, Calif.

CIRCLE 127 ON READER-SERVICE CARD FOR MORE INFORMATION

TV Antenna

High In Performance



Emphasizing the "compact completeness" found in the Winegard Color-Beam, Color 'Ceptor, and Minute-Mount, the "303," an all channel vhf (2-13) antenna, stresses these deluxe features: a) the ends of all elements are crimped; b) booms are plugged; c) hi-impact polystyrene insulators; d) 300 ohm driven elements to ensure 100% signal transfer to transmission lines; e) streamlined appearance of top quality aluminum construction; f) metal phasing lines.

It can be used conveniently with top performance in the city-single bay, and in the country-double bay.

Winegard Co., Dept. ED, Burlington, Iowa.

CIRCLE 128 ON READER-SERVICE CARD FOR MORE INFORMATION

Varipad Variable Attenuator

Compactly Built

Low cost VARIPAD 3 to 50 db variable attenuators, to provide smooth, stable control of rf signals up to 250 mc, has a flat frequency response for wide band applications.

A 3 to 30 db variable attenuator in conjunction with a switchable 20 db pad affords a continuously variable output in two ranges.

Three ruggedly built models are available for use on 75 or 300 ohm cables. One model also includes a broad band matching transformer for application in the 50 to 250 mc band.

Test bench setups are greatly simplified by eliminating the need for large quantities of fixed attenuators, since VARIPADS provide an infinite number of settings.

Entron Inc., P.O. Box 287, Dept. ED, 4902 Lawrence St., Bladensburg, Md.

CIRCLE 130 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetic Pushbutton

Has Holding Relay

This magnetic pushbutton is the same size as normal pushbutton keys and should have many switching applications. It combines the features of a position indicator with a holding relay. By means of the two colored buttons, the position of the key is easy to determine. The unit is held in actuated position by means of a built-in electro-magnet and is released by switching off the holding current. According to the circuit requirements, this operation can be performed by a separate release key, a relay, or manually (by pulling the depressed button up). The second key may be located anywhere.

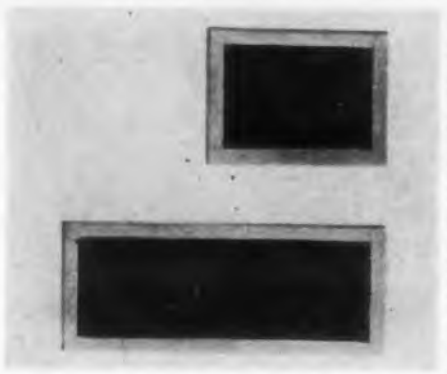
Holding current operating voltage of the pushbutton is 15 ma; operating voltage is 12 v; and key pressure in pressed down position is 250 gr. Contact sets are available in 12 varieties. Should higher operating voltages be required, a resistor can be placed in series with the magnet coil.

International Standard Trading Corp., Dept. ED, 22 Thames St., New York 6, N.Y.

CIRCLE 131 ON READER-SERVICE CARD FOR MORE INFORMATION

"K" Gaged Mica

Permits Smaller Capacitors



"K" gaged mica is offered to design engineers as an aid in creating transistorized printed circuits utilizing much smaller components than formerly possible. Mica capacitors can be designed to have the same capacity but only 1/2 to 1/4 the size as those previously used in transistorized and other printed circuits.

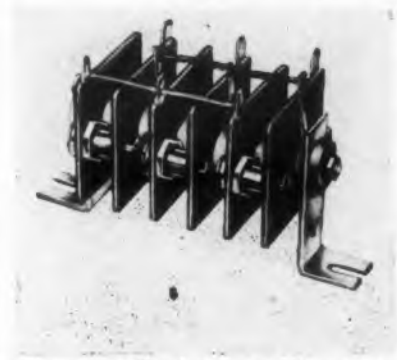
"K" gaging is a new electronic method of accurately gaging mica film, which permits utilizing smaller area mica to obtain predetermined capacity. Any desired tolerance can be held on electronically "K" gaged mica film, including tolerances as close as the mechanical equivalent of 0.00025 in. After silvering, costly time-consuming hand adjusting or scraping on mica may be entirely eliminated because capacity is accurately predetermined. In addition, waste in cut 40% to 50%.

Perfection Mica Co., Dept. ED, 20 N. Wacker Dr., Chicago 6, Ill.

CIRCLE 135 ON READER-SERVICE CARD FOR MORE INFORMATION

Rectifier Stacks

High Temperature Silicon



Silicon rectifier stacks, "TL" series, combines the superior performance of silicon rectifiers with the versatility of stack mounting. These rectifiers overcome the basic limitations of germanium, selenium and copper oxide to provide trouble-free operation under severe environmental conditions. The "TL" rectifier stack series provides reliable operation at temperatures up to 150 C, and features voltage ranges up to 5100 v rms, and current ratings up to 10 amp. Standard stack types are available for single-phase, three-phase and six-phase power supply circuits.

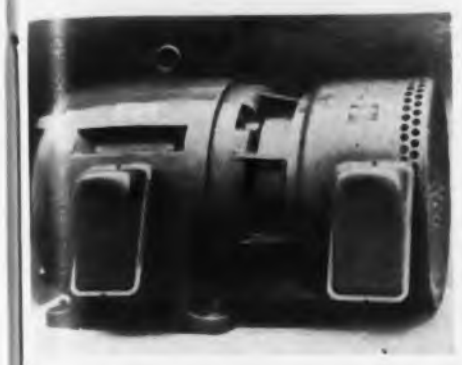
This stack series is especially designed to meet the critical requirements of missile, aircraft and other military equipments. Four JAN type rectifiers, the 1N253, 1N254, 1N255 and 1N256, may be optionally incorporated into these stacks.

Transitron Electronic Corp., Dept. ED, Melrose 76, Mass.

CIRCLE 136 ON READER-SERVICE CARD FOR MORE INFORMATION

Brushless Frequency Converter

400 Cycle 25 KVA



"Nobrush" 25 KVA alternator, direct mounted on a continuous duty induction motor, offers a 3 phase, 4 wire, 120/208 v output. Exciter is unnecessary. Due to the absence of rf disturbance, suppression is not required. For loads of high power factor, intrinsic regulation is adequate, thus eliminating need for regulator.

The generator is virtually immune to damage by grit, moisture or short circuits and conversion efficiency is high. Temperature rise is less than 40 C. Due to absence of brushes, the unit is non-sparking.

Overall dimensions of unit is little larger than the motor alone, 36 x 20 x 20 in.; weight is 925 lb. Usual maintenance is limited to infrequent lubrication of motor bearings. Unit is especially adapted for highly dependable, continuous operation under adverse environmental conditions.

Georator Corp., Dept. ED, Manassas, Va.

CIRCLE 138 ON READER-SERVICE CARD FOR MORE INFORMATION

Pressure Cells

For Pressure-Sensing Systems

These highly sensitive pressure-sensing devices are for use as transducers, strain gages, inverters, altimeters, non-mechanical switches and push buttons, weighing scales, shock and force recorders, and scores of other applications. They have wide resistance ranges, some types as much as 1,000,000 ohms per lb of force. Over 300 types are regularly carried in stock to fit many special conditions.

The cells have excellent repeatability; for example, a low resistance type shows 2.6 ohm at 10 lb force, ±0.01 ohm every reading for 5000 times, without fatigue or drift. Illustrated is the 5 w size for pressures of 0-10 lb. This unit is 1 in. diam x 1/4 in. thick and can easily carry its rated load without the use of an amplifier.

The cells are made of metal inlaid on one side with "Celab" plastic. Highly specialized cells are also available in pressure ranges from a few grams to many tons, for either steady pressure or shock.

Clark Electronic Laboratories, Dept. ED, Box 165, Palm Springs, Calif.

CIRCLE 139 ON READER-SERVICE CARD FOR MORE INFORMATION

W. W. Crissinger
Chief Field Engineer
Galion, Ohio

P. Van Valkenburgh
Field Engineer
Northeast

John Billis
Field Engineer
Mideast

Uriah L. Allen, Jr.
Field Engineer
Washington, D. C.

Ned B. Earley
Field Engineer
Central

Clayton Kielich
Field Engineer
Midwest

H. E. Peters
Field Engineer
Pacific Coast

HAVE YOU PUT THESE MEN TO WORK?

Meet the Industrial Field Engineering Staff of North Electric Company. Their job is to serve your design groups as engineering consultants (without fee) in determining whether and how to use relays as control components.

This exclusive North engineering service pays off for you, and for North, because of the many cases in which they can aid in the development of simplified dependable systems . . . with all relay controls. These competent engineers are based near the key centers of industry. One of them can be at your doorstep promptly if you will write, wire or call the Galion office — Galion 2-4201 . . . regarding

NORTH RELAYS

as components or control assemblies

"BUILDING BRAINS IS OUR BUSINESS"

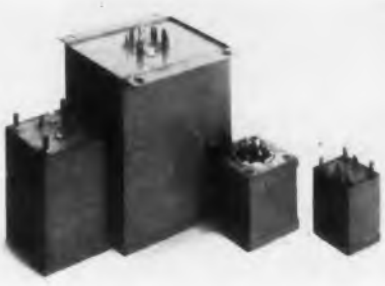
INDUSTRIAL DIVISION

NORTH ELECTRIC COMPANY

490 S. Market St. Galion, Ohio

Transformers

Rugged Resin-Potted Miniatures



These resin-potted transformers, to withstand temperatures up to 170 C, are hermetically sealed and designed for airborne use. They are impervious to humidity and altitude, and withstand abuse without electrical or mechanical damage.

The potting material permits making transformers of smaller size and weight due to the improved thermal conductivity. The material also welds core, coil, case, and terminals into an integral unit. Shrinkage is precluded, eliminating separation from the case.

The transformers may be qualized under MIL-T-27A, Grade 1, 2, 4, or 5 as required. In addition, less expensive commercial types can be supplied with most of the benefits required by military specifications.

Electro Engineering Works, Inc., Dept. ED, 401 Preda St., San Leandro, Calif.

CIRCLE 143 ON READER-SERVICE CARD FOR MORE INFORMATION

Broad Band DC Amplifier

Chopper Stabilized

This unit features 10 feedback controlled gain ranges from 20 to 1000 with a gain accuracy of ± 2 uv drift. Input impedance is 100,000 ohms and output impedance is less than 1 ohm. Frequency response is ± 0.3 db to 10 kc and less than 3 db down at 40 kc. Equivalent input noise is less than 5 μv peak-to-peak from 0 to 3 cps and less than 12 μv rms from 0 to 50 kc. The Model 111 contains an integral power supply. The amplifier output capability is ± 35 v or ± 40 ma. These amplifiers are light and compact and may be mounted in modules where multiple units are required.

Kay Lab., Dept. ED, 5725 Kearney Villa Rd., San Diego 11, Calif.

CIRCLE 144 ON READER-SERVICE CARD FOR MORE INFORMATION

Quarter-Turn Fastener

In Many Head Styles

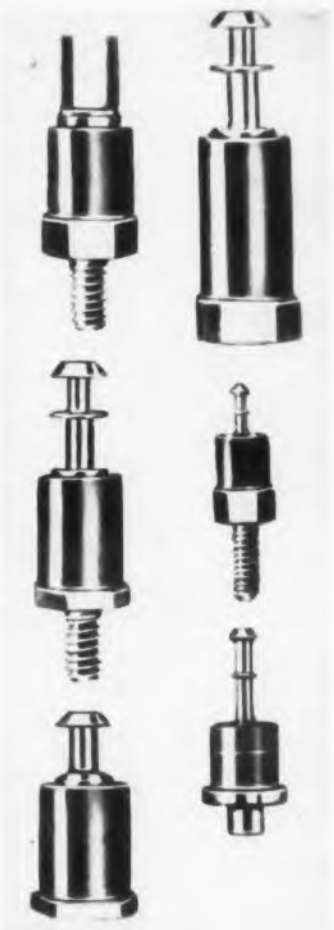
The 5F, a quarter-turn fastener, is a small, lightweight, inexpensive device that provides a high strength-weight ratio particularly adaptable to thin materials and miniaturized equipment. Designed for use on such equipment as airborne electronics, small electro-mechanical and computing devices, and communications components, it is offered in many different head styles. It is valuable for attaching lightweight components in "packaged" equipment, or for holding access panels on equipment ranging from washing machines to radar units.

Camloc Fastener Corp., Dept. ED. 61 Spring Valley Rd., Paramus, N. J.

CIRCLE 147 ON READER-SERVICE CARD FOR MORE INFORMATION

Standoff and Feed Through Terminals

Complete Range of Sizes



Standoff and feed through terminals in a full range of sizes are offered in fork, single and double turret and miniature types, male or female threaded or with rivet mountings. Both metal or molded bases can be furnished. Hardware and insulating materials include a wide variety of combinations to meet military or other specifications.

Standard body materials are melamine, electrical grade (MIL-P-14 Type MME); and melamine, impact grade (MIL-P-14 Type MMI). A wide variety of plating combinations for terminals and mountings are available. Individual specifications, sizes or materials, can be furnished to fit special requirements.

Feed through terminals are also offered either standard or in sizes and materials to specification.

Whitso Inc., Dept. ED, 9330 Byron St., Schiller Park, Ill.

CIRCLE 148 ON READER-SERVICE CARD FOR MORE INFORMATION

Miraculous!

SILICON RECTIFIERS

by

SARKES TARZIAN

For your future power supply in all radio, television, electronic devices and other rectifier replacements. Write for complete information.

Patent Applied For

Sarkes Tarzian, INC.

RECTIFIER DIVISION

DEPT. C-5, 415 NORTH COLLEGE AVE., BLOOMINGTON, IND.

In Canada: 700 Weston Rd., Toronto 9, Tel. Murray 7535
Export: Ad Auriema, Inc., New York City

CIRCLE 149 ON READER-SERVICE CARD FOR MORE INFORMATION

Two-Channel Audiometer

For Wide Range of Hearing Tests

A clinical 2-channel audiometer, that conducts nearly all types of hearing tests with speed and accuracy, is designed for use by physicians, clinicians, and audiologists, in either one or two-room arrangements. The audiometer, Model 15-A, can perform all types of speech tests, including recorded and live voice.

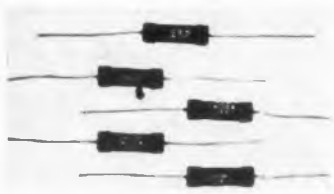
The audiometer has a complete range of octave frequencies from 125 to 8000 cy and intermediate frequencies from 750 to 6000 cy. It has extra 500 to 1000 cy oscillators and provides both manual and automatic pulsing of tones.

Beltone Hearing Aid Co., Dept. ED, 2900 W. 36th St., Chicago, Ill.

CIRCLE 151 ON READER-SERVICE CARD FOR MORE INFORMATION

Glass Resistors

Increased Max Resistance Values



Precision film-type glass resistors are now available with greatly increased maximum resistance values. The range of the 1 and 2 w, 1% tolerance resistors has been increased by a factor of 10.

Improvement of the range of the Type N resistor has increased the maximum resistance in the lw size from 40 k to 400 k and in the 2 w size from 100 k to 1 megohm.

Temperature coefficients on the improved resistors have been reduced from 50 ppm to 300 ppm/°C. Other basic characteristics conform to specification MIL-R-10509B. These resistors are recommended for computer circuits, pulse networks, high frequency circuits, and low signal level, high-gain amplifier stages.

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

CIRCLE 152 ON READER-SERVICE CARD FOR MORE INFORMATION

Battery Holders

Made in 25 Types

A standard line of battery holders is offered in 25 types designed for use in transistor circuits, meters, radios, Geiger counters, etc. Made of spring temper aluminum alloy, they hold batteries securely in specially designed snap clips. Mounting holes are provided for screws, eyelets, or rivets.

Keystone Electronics Corp., Dept. ED, 423 Broome St., New York 13, N.Y.

CIRCLE 154 ON READER-SERVICE CARD FOR MORE INFORMATION

Direct Reading Dosimeter

Calibrated, Compact, Unlimited Life

RADAD Dosimeter, a new major exposure radiation detector for personnel, provides both cumulative measurement and instantaneous reading of dangerous amounts of gamma ray exposure. Consisting of a hollow, hermetically sealed ionization chamber containing Polystyrene beads which serve as indicators of exposure to radiation, these indicator beads are electrostatically charged simply by shaking the tube.

Pacific Transducer Corp., Dept. ED, 11836 West Pico Blvd., Los Angeles 64, Calif.

CIRCLE 155 ON READER-SERVICE CARD FOR MORE INFORMATION

Microscope-Telescope

Fits in Pocket

This handy pocket instrument combines a 50 power microscope and a 10 power telescope. Approximating a fountain pen in size, it can be used for close-up examinations of small parts and components, and it is handy for checking machining operations, threads, chamfers, etc. For use as a telescope, the metal reflector is unscrewed, and the eyepiece tube and sight drawn out. The instrument is equipped with a clip to hold it in coat or shirt pocket.

Edmund Scientific Corp., Dept. ED, Barrington 13, N.J.

CIRCLE 156 ON READER-SERVICE CARD FOR MORE INFORMATION

look to AMPHENOL for RF Connector PROGRESS

AMPHENOL's Subminax have provided the electronic industry *for the first time* with extremely reliable subminiature RF connectors. Where space and weight savings are important, but not at the expense of reliability, AMPHENOL Subminax are finding ever-increasing utilization. Now, four new 50 ohm connectors have been added: 27-27 hermetic seal receptacle, 27-801 cable termination, 27-800 printed circuit receptacle and 27-28 Subminax to BNC adapter. Write for data sheet, which includes a listing of all thirty available Subminax RF connectors.

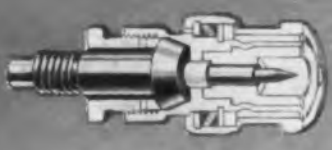
4 NEW SUBMinax®

(shown actual size)

27-27

27-801

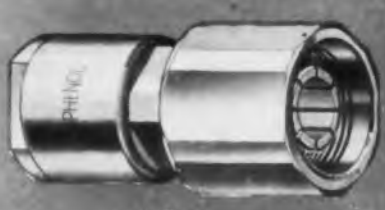
27-800



27-28

NEW LT SERIES

(shown one-half size)



82-116

82-117

AMPHENOL now adds modified versions of the LT series of RF connectors to its large availability listing. Specifically designed for use with Teflon RG-117/U coaxial cable (also made by AMPHENOL), the LT series 82-116 plug and its matching 82-117 receptacle are made largely of aluminum to keep weight low and cadmium-plated for durability. Impedance is 50 ohms, maximum voltage rating is 5000 volts. Write for data.

AMPHENOL

AMPHENOL ELECTRONICS CORPORATION
chicago 50, illinois
AMPHENOL CANADA LIMITED • *toronto 9, ontario*

Null Indicator

Has 50% Longer Scale

This new 2-1/2" null indicator offers far greater readability than conventional round instruments of the same size, yet occupies no more panel space. Increased readability results from the longer dial arc, larger numerals and better scale illumination from all angles.

High null point sensitivity allows accurate observation of large amounts of unbalance in bridge or other detection circuits, without physical or electrical overload of the instrument.

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

CIRCLE 159 ON READER-SERVICE CARD FOR MORE INFORMATION

Oscillograph

Has 12 Chart Speeds

Known as the S25 oscillograph, this new instrument features: 12 chart speeds from 1/16 to 160 ips; speed changes possible during operation; timing line intervals from one to 1/1000-sec automatically controlled by chart speed or selected manually; and the galvanometer trace zero adjustment is featured on an easy-to-use sloping top panel.

Hathaway Instrument Co., Dept. ED, 1315 S. Clarkson St., Denver, Colo.

CIRCLE 160 ON READER-SERVICE CARD FOR MORE INFORMATION

Silicone Power Rectifiers

For Airborne Power Supplies

The new rectifiers are ideally suited for airborne power supplies and other airborne electronic equipment. They may also be applied wherever minimum size, high operating temperature and resistance to vibration and shock are required.

Electrically, the rectifiers exhibit exceptionally low forward voltage drop when passing full rated forward current and negligible leakage current.

Federal Telephone & Radio Co., Dept. ED, 100 Kingsland Road, Clifton, N. J.

CIRCLE 161 ON READER-SERVICE CARD FOR MORE INFORMATION

◄ CIRCLE 158 ON READER-SERVICE CARD

Trimmer Potentiometer

From 100 to 15,000 Ohms

Using 20 ppm resistance wire exclusively, the resistance range of this unit has been expanded to cover from 100 ohms to 15,000 ohms. Standard values are 100, 150, 220, 330, 475, 680, 1000, 1500, 2200, 3300, 4700, 6800, 10,000 and 15,000 ohms.

The environmental range has been improved so that in addition to withstanding 30 G shock, the potentiometers will now pass rigid humidity, salt spray and vibration requirements.

Carter Mfg. Corp., Dept. ED, 23 Washington St., Hudson, Mass.

CIRCLE 162 ON READER-SERVICE CARD FOR MORE INFORMATION

Dual Range Power Supply

Low Voltage Outputs

This dual range dc Power Supply has a continuous duty rating of either 0-32 v dc at 40 amp, or 0-64 v dc at 20 amp. Ripple is held to within 1% of the average at maximum output. The Model KM95B operates on either 115 v or 230 v ac, 60 cycles single phase. All controls are conveniently arranged on the front panel. To prevent accidental switching, the line voltage selector is equipped with a special safety locking device.

Opad Electric Co., Dept. ED, New York 7, N.Y.

CIRCLE 163 ON READER-SERVICE CARD FOR MORE INFORMATION

Scaler

For Scintillation Counter Uses

The N-W1 is a high-speed scaler for scintillation counter application. It is patterned after a P. R. Bell design. The discriminator section has a speed compatible with the instrument's unusually small scaler dead time.

The N-201 is built on a "Vari-Flex" chassis for relay rack mounting or table top use.

Hunner Electronics Co., Inc., Dept. ED, Box 531 Princeton, N.J.

CIRCLE 164 ON READER-SERVICE CARD FOR MORE INFORMATION

DC-MILLIVOLTMETER

0-1mV to 0-1kV

The MV-17C millivoltmeter, shown above (and its current-measuring companion, our MV-11C DC micro-micro-ammeter--10 x 10^{-12}A to 10A), has helped substantially to advance both research and production throughout the entire electronic field. Crystal diodes and transistors, for instance, have benefited from it due to its ability to measure small DC voltages with minimum circuit loading. As a null detector, in bridges, the MV-17C can be overloaded up to 100,000 fold, thereby eliminating suspension galvanometer trouble and increasing measuring ranges and sensitivity. Grid current measurements, small voltage drops in regulated power supplies, delicate temperature measurements, insulation material research are but a few other applications which have made this instrument a reliable stand-by in nearly all leading laboratories in America and abroad.

MILLIVAC INSTRUMENT CORPORATION

BOX 997, SCHENECTADY, N.Y.

CIRCLE 167 ON READER-SERVICE CARD FOR MORE INFORMATION

Rubber

Bonds to Metal

Called compound RRD-992, this super-soft rubber has a softness characteristic of 5 durometer, and can be used in temperatures up to 200 F. It is a reasonably good electrical insulator and can be vulcanized or bonded to metal and other materials.

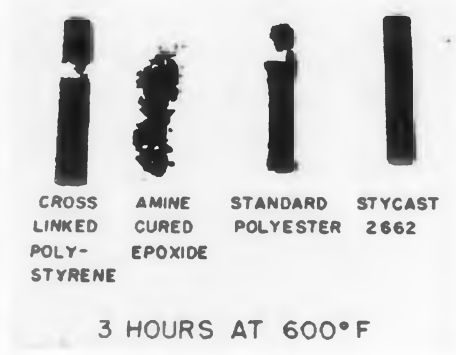
The company makes this rubber in sheets or strips up to 1 in. thick, or will mold or bond it to metal or other odd shapes to meet the customer's needs.

Roth Rubber Co., Dept. ED, 1860 S. 54th Ave., Chicago 50, Ill.

CIRCLE 168 ON READER-SERVICE CARD FOR MORE INFORMATION

Casting Resin

For Use at 600F



This epoxide casting resin can be used at temperatures as high as 600 F. Designated Stycast 2662, the resin is simple to use. It pours readily and cures at low temperature. Once cured heat distortion point is above 500 F.

High volume resistivity is maintained at elevated temperature, making it ideal as a potting and encapsulating compound.

Emerson & Cuming, Inc., Dept. ED, 869 Washington St., Canton, Mass.

CIRCLE 169 ON READER-SERVICE CARD FOR MORE INFORMATION

Solenoid-Wound Chokes

In 1.1-120 μh values

A complete line of solenoid-wound chokes is offered in values ranging from 1.1 to 120 μh. Inductance values are in accordance with MIL-C15305A. These chokes are impregnated with fungus-resistant varnish to conform to MIL-V173A. They are designed specifically for top performance and durability in applications such as filament chokes, peaking coils, and resonant elements in high frequency rf or if circuits.

National Co., Dept. ED, 61 Sherman St., Malden 48, Mass.

CIRCLE 170 ON READER-SERVICE CARD FOR MORE INFORMATION

NOW!

Unlimited Phasing with Extreme Compactness

Phasing clamps available on three sizes of Gamewell RL-270A Blue Line Precision Potentiometers

This special Gamewell Phasing Clamp design has two important extras: Extreme compactness and High Temperature compatability. Check these features . . .

• Only ½" depth per section • Continuous service up to 150C available • Stainless steel clamps give unlimited phasing • Large number of taps, limited only by physical spacing • Exclusive Gamewell high unit pressure contacts give permanent, low resistance tap connection, no linearity distortion • Will withstand High "G" and operation under severe vibration • Three styles of mounting: Servo, Bushing and 3-hole bushing • Available in ball or sleeve bearings, shafts as specified • Comes in models RL-270A-1 ½; RL-270A-2 and RL-270A-3.

More information, prices and delivery available from Gamewell representatives or write:

THE GAMEWELL COMPANY
Newton Upper Falls 64, Mass.

GA 6-14

GAMEWELL®

PRECISION POTENTIOMETERS
SPECIAL!
Send for New Gamewell Catalog on complete line.

CIRCLE 171 ON READER-SERVICE CARD FOR MORE INFORMATION

NEW—self-locking UNBRAKO socket head cap screws

The Nylok* self-locking feature locks these screws securely in place, seated or unseated, wherever you stop wrenching! They won't work loose. Can be used repeatedly. Tough, resilient nylon locking pellets permanently installed. Successfully withstand temperatures ranging from —70 to 250°F. Familiar UNBRAKO knurled heads for sure finger grip and fast assembly—accurate hex sockets for positive, nonslip internal wrenching. Heat treated alloy steel, controlled fillets, continuous grain flow lines, fully formed Class 3A threads for maximum strength and exact fit. Can be used as adjusting screws. Pellets act as liquid seals. Standard sizes from #6 to 1 in. diameter. Also available in plated finishes and in stainless steel. Write for Bulletin 2193. Unbrako Socket Screw Division, STANDARD PRESSED STEEL Co., Jenkintown 12, Pa.

*TM Reg. U.S. Pat. Off., The Nylok Corporation

STANDARD PRESSED STEEL CO.

UNBRAKO® SOCKET SCREW DIVISION

Unbrako Products are sold through Industrial Distributors

SPS
JENKINTOWN ■ PENNSYLVANIA

CIRCLE 172 ON READER-SERVICE CARD FOR MORE INFORMATION

NEW! Silicone Foam Rubber

complete flexibility -100°F to 480°F . . . extreme lightweight . . . molds into complex shapes, thick sections.

Available for the first time, silicone foam rubber . . . COHRfoam . . . is the lightest, most resilient form of silicone rubber. COHRfoam remains soft and resilient from -100°F to 480°F, recovers shape instantly when compressed for long periods at high temperatures. COHRfoam is immune to ozone and weathering, is odorless, tasteless, non-sticking and exhibits excellent electrical characteristics. Readily moldable into thick sections (up to 8") and complex shapes, COHRfoam presents a new design medium for mechanical sealing, thermal, electrical and vibration packing and insulation.

Specific Gravity: .20 to .35 (80 to 138 cu. in./lb.)

Compression-deflection: .75 to 1.25 psi. (25% compression, 1" thickness)

Compression Set: 14% (300°F, 22 hrs., 50% compression, 1" thickness)

COHRFOAM®
Silicone Foam Rubber

FREE SAMPLE—
and additional data . . . write, phone or use inquiry card . . . today.

THE CONNECTICUT HARD RUBBER CO.
407 East St., New Haven 9, Conn., SPruce 7-3631

CIRCLE 173 ON READER-SERVICE CARD FOR MORE INFORMATION

REGULATED POWER SUPPLY

0.001% Regulation and 0.1 Millivolts Ripple

MODEL UHR-220

The KROHN-HITE Model UHR-220 is a compact Power Supply for applications requiring up to 0.2 ampere of d-c at 0 to 500 volts with ULTRA-HIGH REGULATION, extremely low ripple and unusual stabilization under severe input line voltage transients. The internal impedance is less than 0.01 ohm for low frequencies and d-c, and less than 0.1 ohm for frequencies as high as 100 kc. Stabilization for ±10% change in line voltage is 0.003%. Transient response is 0.001 millisecond and typical 10-hour drift is 300 ppm. A 0-150 volt, 0-5 ma, bias supply with 0.05% stabilization and 0.002% ripple is available in addition to two 6.3 volt unregulated a-c outputs of 5A capacity. Price $350.00, f.o.b. factory.

For Further Details Write

KROHN-HITE INSTRUMENT CO.
Dept. ED, 580 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 174 ON READER-SERVICE CARD FOR MORE INFORMATION

Electric Counter

Reset by Key

The PIC-600 is an electric counter that is reset by a key from the front of the panel and is designed for use where it is necessary to guard against indiscriminate or unauthorized resetting. A single turn of the key resets the counter to zero.

Production Instrument Co., Dept. ED, 706-34 W. Jackson Blvd., Chicago 6, Ill.

CIRCLE 175 ON READER-SERVICE CARD FOR MORE INFORMATION

New Teflon Tape

Abrasion Resistant

Pressure sensitive, adhesive Permacel 421, designed especially for application where Class H electrical insulation and resistance to abrasion are required, can be used as a dielectric for condensers where its nearly zero moisture absorption and high dielectric are needed, and as an insulation medium for fm and TV transmission lines, where its low power factor and high operating temperature are important. Industrially, it can be used as a barrier or protective coating against highly reactive chemicals and solutions.

Weather resistant Permacel 421 is also chemically inert to such active reagents as aqua regia, hydrofluoric, sulphuric and nitric acids. The slippery nature of Teflon makes the tape a good protective agent against abrasion and suitable as a bearing surface where oil would be impractical.

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

CIRCLE 176 ON READER-SERVICE CARD FOR MORE INFORMATION

Random Noise Generator

Provides Signals to 100 db

The Model 1 Random Noise Generator is designed to supply a random noise signal up to 100 db for testing the attenuation of screened enclosures, performing susceptibility tests to military specifications, checking communications equipment, and for many other tests. It may be operated from a 6 v storage battery, "Hot-Shot" battery, or any 6 v dc power supply delivering from 5-10 amp.

Starr Instrument Co., Dept. ED, 44 Starr Lane, Jamaica Plain 30, Mass.

CIRCLE 177 ON READER-SERVICE CARD FOR MORE INFORMATION

Double Metal

Single Metal

Double Carbon

Single Carbon

for **miniature** and **sub-miniature** parts soldering

IDEAL

THERMO-TIP

RESISTANCE SOLDERING TOOL

Soldering large telephone jack with Thermo-Tip Resistance Soldering Tool and low voltage Ideal power unit.

Smaller, lightweight — for easy handling over prolonged periods of time. Thermo-Tip Tools are expressly designed as a production line tool. Reduces fatigue factor for women workers.

Pin-point accuracy. Pencil-small element fits into tight spots for foolproof soldering of small or miniature parts.

Fast, sure — Thermo-Tip elements concentrate high amperage current at soldering point for instant heat. Solder is melted by the parts to be joined—eliminates "cold flow joints", makes for positive union.

Versatile attachments—a variety of Thermo-Tip elements are available for every precision soldering purpose. Feed-thru electrodes on double metal, single metal and single carbon attachments provide longer life and easy length adjustment for specific job requirements.

IDEAL INDUSTRIES, INC.
5098 Park Ave., Sycamore, Ill.

Gentlemen:
Kindly send us complete catalog information of Ideal's Thermo-Tip Resistance Soldering Tools.

Name.....
Company.....
Address.....
City.....Zone....State.....

CIRCLE 178 ON READER-SERVICE CARD FOR MORE INFORMATION

Digital Encoder

Accepts 0-10 v Input Levels

This advanced digital encoder, Model R-1047-40-1, is an all electronic unit designed to accept 0-10 v input levels and generate 24,000 8-bit binary code groups per second defining the input at an over-all accuracy of one part in 256.

The overall dimensions of this piece of equipment are only 6-13/16 x 9-9/16 x 6-3/4 in.

Radiation, Inc., Dept. ED, Melbourne, Fla.

CIRCLE 180 ON READER-SERVICE CARD FOR MORE INFORMATION

Fan-Blower

For Airborne Applications

This is a new fan-blower unit for airborne application, which compensates for low air density by increasing blower speeds. The unit, BC 2914 F-1, has been designed especially to provide higher cfm rates at upper altitudes. The blower will provide 8000 rpm with 210 cfm at 2 in. back pressure at sea level. At 60,000 feet, blower speed is increased to 11,000 rpm.

Induction Motors Corp., Dept. ED, 570 Main St., Westbury, Long Island, N. Y.

CIRCLE 181 ON READER-SERVICE CARD FOR MORE INFORMATION

Batch Counter

With Speeds to 4000 Counts/sec

The Model 99 Electronic Batch Counter is for predetermined counting in the range of 0 to 99 counts. It will count speeds up to 4000/sec.

The unit incorporates a mechanical indicator on the front panel which is limited to counts of 1000/min and shows batch counts up to 999,999. The internal relay has two sets of spst contacts; one set is normally open and the other normally closed.

Spellman Television Co., Dept. ED, 3029 Webster Ave., Bronx, N.Y.

CIRCLE 182 ON READER-SERVICE CARD FOR MORE INFORMATION

Wide Range Multimeter

Sealed Aluminum Case

Model NE 7-20-M Electronic Multimeter is a compact, portable multirange meter identical to the Military Model TS-505B/U for measuring rms values of 0 to 150 vac, 0 to 1000 v dc, and dc resistance from 0 to 1000 megohms. An rf adapter is furnished to extend the range into the values of rf voltages up to 40 v rms at frequencies up to 500 Mc. The overall accuracy of the unit ± 4 per cent in ohms, ± 5 per cent in v dc and ± 6 per cent in v ac.

Northeastern Engineering Inc., Dept. ED, Manchester, N.H.

CIRCLE 187 ON READER-SERVICE CARD FOR MORE INFORMATION

Voltage Divider

Encapsulated, Subminiature Unit

Designed for use where space is at a premium, these disk resistors are capable of replacing two or more precision resistors employed as voltage dividers in circuitry. Available with temperature coefficients of ppm/C° or better, matched ratios over wide temperature ranges are possible with the selection of resistance wire matched to within 5 ppm/C°.

Eastern Precision Resistor Corp., Dept. ED, 675 Barbey St., Brooklyn, N.Y.

CIRCLE 188 ON READER-SERVICE CARD FOR MORE INFORMATION

Linear Actuators

For Aircraft Applications

The R-5160 series of electro mechanical 26 v dc load-sensitive linear actuators is available in strokes to 7-1/4 in. The units feature an adjustable load, sensitive switches, magnetic braking, radio noise filter, optional thermal protection, positive stops, and an anti-rotation device. Maximum operating load is 650 lb with 18-ipm speed. Ultimate static load is 1500 lb. Size is 3 x 3.5 x 4.66 in. (plus stroke length and overtravel).

Airborne Accessories Corp., Dept. ED, Hillside, N.J.

CIRCLE 189 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

A-C Induction Motor Drives 192

A brochure has been made available describing the company's ac adjustable speed drives. The company has incorporated into its ac drive the reliable, rugged and simplified features of the squirrel-cage induction motor through the addition of an equally-ruggedized and simplified ac tachometer. The bulletin includes typical operating curves, how the ac drives function, and efficiency and power factor curves.
WacLine, Inc., 35 S. Clair St., Dayton, Ohio

Angular Position Encoders 193

A comprehensive 8-page bulletin has been published describing the new 13-digit and 16-digit optical-type analog to digital angular position encoders. The bulletin gives detailed information on the operation and construction of the two models and describes the manufacture of binary and other type code disks. Encoder and code disk specifications are also included.
The Baldwin Piano Co., 1813 Gilbert Ave., Cincinnati, Ohio.

Materials Handling 194

Case histories on how six prominent manufacturers in unrelated fields improved their methods of handling materials has been made available. Entitled "Materials in Motion," this booklet describes the use of lightweight vulcanized fibre containers to increase efficiency, reduce costs, and simplify methods of materials handling.
National Vulcanized Fibre Co., 1056 Beech St., Wilmington, Del.

Plastic, Light Metals Testers 195

Leaflet P-560 has been issued describing 31 instruments in the company's line used for testing plastics, light metals, paper, textiles, and other materials. Included are illustrations, applications, and dimensions of each of the units described.
Thwing-Albert Instrument Co., Penn St. at Pulaski Ave., Philadelphia, Pa.

NEW COMPUTING INDICATOR

Normalizing; eliminates conversion calculations; reads ratios directly in digital form.

The new DY-2500 Computing Indicator is a variable time-base counter providing direct, normalized ratio readings of unlike parameters in simple digital form. New dual input permits ratios between (for example) RPM and gallons-per-minute be read directly. Speed, pressure, thickness, weight, etc., may also be measured or compared with suitable transducers. In single input operation, DY-2500 may be easily switched from one transducer to another and results read directly in different kinds of units without calculation. A self-check assures correct operation; DY-2500 is portable, rugged, easily used by non-technical personnel. Frequency range 1 cps to 100 KC, variable sensitivity to 0.2 v minimum. Display variable 1 to 10 sec. $1,350.00 f.o.b. factory (single input). Product of Hewlett-Packard affiliate, Dynac, Inc., 3961K Page Mill Rd., Palo Alto, Calif. Write Dynac for details.

CIRCLE 197 ON READER-SERVICE CARD FOR MORE INFORMATION

Infrared Spectroscopy 203

A handy package of reprints has been made available on the subject of infrared spectroscopy for scientists, engineers, and technicians interested in learning more about it. Also included in the package is bulletin 472 on the new IR-4 infrared spectrophotometer, a copy of infrared notes, and a complete index of all infrared reprints now available.
Scientific Instruments Div., Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif.

Laboratory Instruments 204

"Cenco News Chats" No. 82 has been published containing descriptions and photos of new and redesigned instruments and apparatus for laboratory use. Included are a refrigerating incubator, vacuum pumps, pump plates for vacuum evaporation, projection meter, a new line of all metal ovens, and many others.
Central Scientific Co., 1700 Irving Park Rd., Chicago, Ill.

Batteries 205

A catalog has been offered describing and illustrating a new line of batteries featuring increased life and higher instantaneous discharge rates. Listed in the catalog are typical applications in electric utilities, emergency lighting, rural electrification, communications, railway signaling, electronics, laboratories, and industrial plants.
Exide Industrial Div., The Electric Storage Battery Co., Box 8109, Philadelphia, Pa.

Wire Wound Resistors 206

Catalog data bulletin D-1a has been made available describing Military type precision wire wound resistors. Comprehensive data on winding technique, testing, tolerance, inductance, insulation, terminals, temperature coefficient, etc., are included in the bulletin.
International Resistance Co., 401 N. Broad St., Philadelphia, Pa.

Shock and Vibration Mountings 207

Bulletin No. 1000 has been offered describing all metal shock and vibration control mountings for smoother, quieter operation of machine tools, business equipment, and many other types of industrial applications. Included are illustrations, dimensions and load ranges of tested mounts and their recommended applications, as well as a review of the design factors.
Robinson Aviation, Inc., Teterboro, N.J.

Transformers 212

General catalog TR-56 has been released describing and illustrating the company's line of electronic transformers. Included are nearly 700 items, of which 76 are new to the line. Applications, specifications, descriptions, dimensional drawings, and a price list and index are also included.
Triad Transformer Corp., 4055 Redwood Ave., Venice, Calif.

Printed Circuit Tolerances 213

A 2-page bulletin designated technical bulletin P-9 has been offered describing "Standard Printed Circuit Tolerances." Included in the bulletin are such items as diameter tolerances of unplated and plated holes, location tolerances between holes, hole to pattern tolerances, alignment tolerances, circuit pattern to outside dimension tolerances, and line width and spacing tolerances.
Photocircuits Corp., Glen Cove, N.Y.

Knitted Wire Products 214

A new 8-page bulletin, A-1, entitled "Knitted Alloy Wire Products," has been made available. The bulletin presents detailed descriptions of the interesting fields of application for knitted stainless steel and nickel alloy wire. Included in the bulletin are filters, liquid entrainment separators, shock absorption cushions, and electronic weatherstripping.
H. K. Porter Co., Inc., Prospect Park, Pa.

Radio-TV Valves 215

A second edition of the "World Radio Television Valve Handbook" has been published. This second edition contains characteristics on radio tubes, cathode-ray tubes, crystal diodes and transistors manufactured throughout the world. This edition contains tube data up to and including those tubes released in November 1955. Copies of this book are immediately available from the address shown below. Price per copy is $2.50.
Gilfer Associates, P.O. Box 239, Grand Central Station, N.Y. 17, N.Y.

Aluminum Nameplates 216

A 2-color catalog sheet has been made available describing accessories for heat or solvent activated aluminum nameplates. The catalog describes four accessories used to apply the company's color anodized and etched aluminum foil nameplates to crinkled, uneven or curved surfaces. Each item is illustrated and described.
North Shore Nameplate Inc., 214 Northern Blvd., Bayside, N. Y.

Microwave Silicon Diodes 223

Catalog 56BG has been offered as a handy reference for performance data of microwave silicon diodes. Included are a complete listing of magnetrons, TR-ATR switch tubes, reference cavities, waveguide pressure windows, waveguide components and test equipment. Four new magnetron data sheets are enclosed. Described in the group are three new millimeter magnetron types ideally suited for airborne or mobile use.
Microwave Associates, Inc., 22 Cummington St., Boston 15, Mass.

Nickel and Nickel Alloys 224

A new 20-page catalog has been published entitled "Nickel and Nickel Alloy Tubing," featuring brief but highly serviceable handbook information on nickel and nickel alloys for use by designers, production engineers, and purchasing executives. The catalog tabulates for ready reference the specific mechanical properties and chemical compositions of 13 analyses of nickel and nickel alloy tubing.
Superior Tube Co., 1521 Germantown Ave., Norristown, Pa.

Neutron Thermopile 225

A specification sheet has been published describing the Model 3782 neutron thermopile. This instrument, approximately 6-1/2″ long and 1/2″ in diam is a differential type detector for the measurement of high level slow neutrons. Included in this data sheet are illustrations and applications. Various thermopiles connected in series within a pile are useful for the measurement of pile power when the ratio of the total neutron flux at such points to a total neutron flux in the pile is constant.
Nuclear Instrument & Chemical Co., 223 W. Erie St., Chicago 10, Ill.

Heat Exchangers 226

A 28-page booklet has been released containing articles on heat exchanger design, diesel-electric drilling rig power packages for the oil industry. The illustrated booklet specifies leaded steel for forged rings and gears. Addition of lead to steel lends cost-reducing machinability without changing basic steel properties; these are available in rolled forgings and rings. The fin-tube heat exchangers give high heat transfer performance, economy of installation, and building block flexibility. Also described are the Model 251 diesel engines which tests have proven have a variety of stationary and marine applications.
ALCO Products, Inc., P.O. Box 1065, Schenectady, N. Y.

No Levigation Required

with *Linde* FINE ABRASIVES

Trade-Mark

These fine alumina powders are directly calcined at a carefully controlled temperature to assure a uniform particle size that makes levigation unnecessary. Eliminating this preparatory step cuts polishing time and saves abrasive. Uniform particle size also assures an excellent, scratch-free finish on materials ranging from metallographic specimens to gem stones and noble metals.

Depending on the application, these powders can be used direct from the container or mixed with water or other vehicles to make a thin slurry or heavy paste. Users have also compounded them with waxes to make a convenient stick form. LINDE Fine Abrasives are available in two types. Type A removes stock faster than Type B, but Type B produces a superior finish.

For detailed information on the properties of these polishing powders, call or write your nearest LINDE office.

Linde Air Products Company

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30 East 42nd Street UCC New York 17, N. Y.

Offices in Other Principal Cities

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CIRCLE 231 ON READER-SERVICE CARD FOR MORE INFORMATION

Synchro Resolvers 233

Bulletin 374 has been issued giving specifications and characteristics of 36 precision resolvers available in standard frame sizes—10, 11, 15 and 23. They are offered from coarse ±0.2% to precision ±0.05%. They provide accurate solutions to problems encountered in high precision phase shifting, data transmission, industrial process controls, rectangular to polar coordinate transformations and rectangular coordinate rotations.
Norden-Ketay Corp., 99 Park Ave., New York, N.Y.

Cap Screws 234

A 4-page pamphlet has been published entitled "Cap Screws . . . How Much Torque?" giving many answers for cap screws. A cap screw is ideally tight when it is tightened with a wrench more than it will ever be in use. Dynamic stresses, flexing and relaxing an imperfectly tightened fastener, are the cause of fatigue failure whereas a properly preloaded screw cannot fail through fatigue. The booklet includes illustrations, tables and recommended torques for cap screw and place bolts.
Cleveland Cap Screw Company, Box 202, 2917 E 79th St., Cleveland 4, Ohio.

■ NEW METER-RELAYS

FROM 0-5 MICROAMPERES - UP

Ruggedized-Sealed, Black Bakelite, or Clear Plastic Cases

D'Arsonval indicating meters with built-in locking contacts for sensitive and accurate control or alarm

TRIP POINT ADJUSTABLE to any point of scale arc. Sensitive to changes as little as 1%. One contact carried on moving pointer. The other on an adjustable pointer. When two pointers meet, contacts close and lock. Holding coil is wound directly over moving coil, locking action is electro-magnetic. Reset can be manual or automatic. Spring action in contacts kicks them apart forcefully.

Model 255-C, Single Contact, High Limit, 0-10 Volts DC $42.50

Model 461-C, Double Contact 10-0-10 Microamps DC $83.25

Ranges from 0-5 microamperes or 0-5 millivolts up, full scale. Temperature ranges from 0-300°F. (10 ohms external) have bimetal cold junction compensation.
Standard Contact Rating 5 to 25 milliamperes DC. Can be built up to 100 milliamperes DC.
Ruggedized-Sealed metal cases are 2½", 3½" and 4½" round, shock-mounted, gasket-sealed.
Black Bakelite case, 4½" rectangular.
Clear Plastic cases are 2½", 3¾", and 4½" rectangular. Maximum visibility and lower cost.

Panel meters and indicating pyrometers are also available in ruggedized-sealed, black bakelite or clear plastic cases. New 40-page catalog lists prices and specifications for meter-relays, meters, pyrometers and automatic controls using meter-relays. Write for Catalog 4-A, **Assembly Products Inc., Chesterland 17, Ohio.** HAmilton 3-4436 (Cleveland, O.) West Coast: Desert Hot Springs 17, Calif. Phone: 4-3133 & 4-2453.

Booth 1702, Metals Show
October 8-12, Cleveland, Ohio

CIRCLE 237 ON READER-SERVICE CARD FOR MORE INFORMATION

free send for the most widely used ELECTRONIC SUPPLY GUIDE

ALLIED'S COMPLETE 356-PAGE 1957 CATALOG

SEND FOR IT!

your buying guide to the world's largest stocks of ELECTRONIC SUPPLIES FOR INDUSTRY

Here's how to simplify and speed *all* your purchasing of electronic supplies and equipment: send your orders to us for fast shipment from the world's largest stocks of electron tubes (all types and makes), transistors, test instruments, audio equipment, electronic parts (transformers, capacitors, controls, etc.). Our expert Industrial supply service saves you time, effort and money. Send today for your FREE 1957 ALLIED Catalog—your *complete* Buying Guide to the world's largest stocks of quality Electronic Supplies for Industrial use.

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OUR 36th YEAR

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FREE SELECTION CHART for AGASTAT® time delay relays

Now you can select exactly the right Agastat time delay relay for your particular timing need—in a hurry. This free selection chart lists data on every popular model in the Agastat line—the most complete line of pneumatic time delay relays in the industry. They're adjustable for timing from 0.1 second to 10 or more minutes, unaffected by voltage variation, dustproof, light, and mountable in any position. And there's an Agastat model to precisely fit your requirements, including two-step, electrical interlock and double head units. A glance at the free selection chart tells you which model to order.

Write for your free copy to Dept. A26-1024

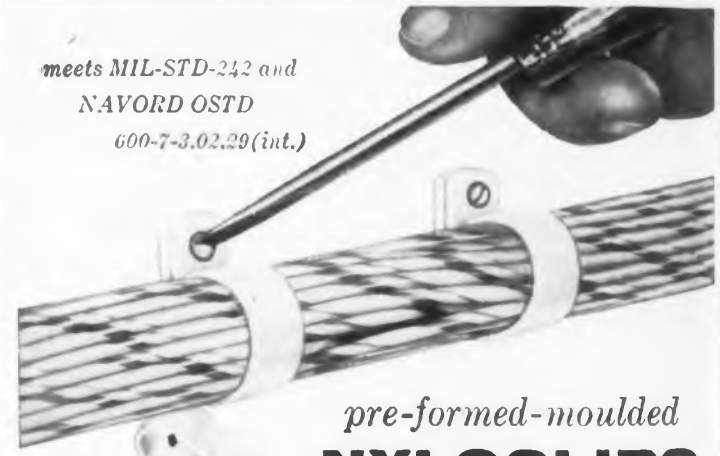
AGA DIVISION

Elastic Stop Nut Corporation of America

1027 Newark Avenue, Elizabeth, New Jersey
Pioneers in pneumatic timing.

CIRCLE 235 ON READER-SERVICE CARD FOR MORE INFORMATION

meets MIL-STD-242 and NAVORD OSTD 600-7-3.02.20(int.)



pre-formed-moulded

NYLOCLIPS

Nyloclips fill the bill completely on all applications requiring light, self-insulating cable clamps. Seventy per cent lighter in weight than comparable metal clamps. Smooth, non-abrasive surfaces; rounded edges will not chafe conductors or cause grounds or shorts. Insulating properties reduce failures caused by grounds and shorts. Insoluble in common solvents, alkalies, dilute mineral acids and most organic acids. Retains strength at temperatures up to 300° F. (150° C.), and is unaffected by petroleum oils and greases, lubricants, hydraulic fluids, lactic acid and photographic solutions. Good for −60° F. to 300° F.

SAMPLES of these Burndy Nyloclips will be sent you without cost upon your written request.

BURNDY

Norwalk, Connect. • Toronto, Canada • Other Factories: New York, Calif., Toronto • Export: Philips Export Corp.

CIRCLE 238 ON READER-SERVICE CARD FOR MORE INFORMATION

Catalog of Welding Products 243

A 56-page catalog of resistance welding products, accessories and materials was made available recently. It describes and specifies standard and special spot welding electrodes, seam welding electrode wheels, dies, back-up bars, shafts, and bushings. In addition, illustrated and specified in this catalog are water-cooled electrode holders, adapters, horn-clamp-holder assemblies, and other accessories.

Sections are devoted to recommendations and usage of special alloys and electrode materials, applications, specification charts on physical and mechanical properties. Also included is a glossary of metallurgical processing and production terms.
Weldaloy Products Co., 11551 Stephens Dr., Van Dyke, Mich.

Rivets 244

A 16-page catalog has been offered containing detailed dimensional descriptions of 1388 standard precision-made semi-tubular, full tubular and split rivets and bag studs and rivet caps. All are available in a wide selection of rivet metals and finishes. Information is included on how to select the proper size of rivet for any given assembly together with tables showing necessary clinch allowances.
Chicago Rivet & Machine Co., 950 So. 25th Ave., Bellwood, Ill.

Miniature Tubes 245

A catalog has been published discussing the company's line of miniature electronic tubes. These tubes have a minimum of 10,000 hours operating life. The tubes have been combined with a minimum of fault risk, even under heavy vibration conditions. Very fine grid wire and very small pitch in the first grids ensure small variations in cathode current density along cathode, resulting in superior transconductance life and closely-controlled plate-current cutoff characteristics. The catalog gives complete ratings and specifications of tubes in the Longlife series, such as 404A, 407A, 408A, 417A, 2C51 and many others.
State Labs., Inc., 649 Broadway, New York 12, N. Y.

Microwave Test Equipment 246

A 28-page catalog has been published on "Microwave and uhf Test Equipment," covering a complete line of coaxial and u-h-f equipment, microwave test equipment, bolometers and thermistors. Text, specification tables, and illustrations describe existing equipment and such recent additions as fixed and variable attenuators, high power impedance meters, tees, fixed and sliding terminations, and uhf coaxial directional couplers.
The Narda Corp., 160 Herricks Rd., Mineola, N.Y.

Oscillators 253

A 2-page bulletin has been published describing Model 3420B pulse oscillator. It produces repetition rates from 100 cps to 3.3 mc. The improved version of this instrument is useful as a clock pulse generator, for flip-flop resolving time studies, and high speed circuitry development.
Electro-Pulse Inc., 11861 Teale St., Culver City, Calif.

Program Computer 254

Reprints are available describing two articles on electronic analog computers. One is titled "Toggle Switch Programmed Computer," and describes the equipment made by the company. A sample problem and a solution is presented. The other article is entitled "High Power From Miniature Tubes," and discusses the circuitry used in the company's computer. Both these articles appeared originally in ELECTRONIC DESIGN, Mar. 15 and Apr. 1, 1956.
Weber Aircraft Corp., 2820 Ontario St., Burbank, Calif.

Copper Alloy 255

A data bulletin has been issued describing an age-hardened alloy, precision rolled beryllium copper strip. This material, in thin gages and very close tolerances, is applicable to miniature relays, switches, pressure sensitive instruments and many others. Available thicknesses down to 0.0005 in., and in tolerances as close as ±0.0001 in.
American Silver Co., 36-07 Prince St., Flushing 54, N. Y.

Cold Heading 256

The second 4-page pamphlet has been released covering examples of how cold heading cuts costs in manufacturing small parts. Problem-solution text briefly gives the essentials of case histories, including advantages gained by making the parts by the cold heading process. One of the major objectives of the 2-color illustrated booklet is to provide designers with information on the many possibilities of cold heading.
John Hassall, Inc., Westbury, N. Y.

Radiation Pyrometers 257

An 8-page booklet has been offered describing two new pyrometers applicable to a wide variety of industrial and laboratory measurements. They combine good spectral response, high sensitivity, and rapid response, with stability and accuracy adequate for most requirements. These factors are discussed in relation with the design of pyrometers.
Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, L. I., N. Y.

Microwave Catalog 262

A 4-page brochure is now available providing useful microwave silicon mixer and video diode performance data and operating characteristics of pulse and CW magnetrons, TR and ATR radar switch tubes, reference cavities and narrow and broadband waveguide pressure windows. In addition, a complete list of waveguide components and test equipment conveniently arranged by function and waveguide frequency range is included.

Included in catalog 56BG are magic tees, frequency meters, standard horns, precision attenuators, directional couplers, barreters (balometers) low and high power dummy loads and a series of new TE_{01} mode circular wavequide components.
Microwave Associates, Inc., 22 Cummington St., Boston, Mass.

Voltage Stabilizing Transformer 263

Bulletin GEA 5754C has been issued giving the transformer's features and data on where to use the equipment. The 16-page, 2-color publication includes operating characteristics and specifications. The bulletin is illustrated with application pictures as well as wiring diagrams and performance graphs.
General Electric Co., Schenectady 5, N. Y.

Services and Facilities 264

Two illustrated brochures have been published describing the activities of the company's Field Engineering Div. and the laboratory facilities of its Research and Development Div. The ability to furnish engineering services and personnel at all technical levels from Electronics technicians through Senior Communications engineers is emphasized. The service is world wide and is available to both industry and Government. The illustrated booklet describes the broad fields of interest covering electronic devices, transistor applications, radio-interference measurement and suppression studies, electro-mechanical, and technical and operations study and analysis.
National Scientific Laboratories Inc., 2010 Massachusetts Ave., Washington 6, D. C.

Printed Circuit Connectors 265

A 12-page brochure has been published describing an expanded line of printed circuit receptacles designed for 1/16, 3/32 and 1/8 in. printed circuit boards. Gold plated phosphor bronze spring retains tension, allows use of undersized or oversized board while maintaining low contact resistance of less than 20 mv at 5 amp. Wiring styles are eyelet, lig, solderless wire, taper tap solderless wiring, and contacts for dip soldering.
DeJur-Amsco Corp., Electronic Sales Div., 45-01 Northern Blvd., Long Island City, N. Y.

CIRCUIT INSTRUMENTS INC.

moisture-sealed POTENTIOMETERS

keep moisture, dust, and price in line

Once you use these Model H-MS Potentiometers, you'll see why it pays to call upon CIRCUIT INSTRUMENTS for all your requirements. CIRCUIT INSTRUMENTS is big enough to engineer the latest refinements in potentiometers. But it is small enough to keep production procedures highly flexible. This means greater ease in obtaining special features . . . greater assurance of obtaining quick deliveries.

MODEL H-750-MS
POTENTIOMETER
(actual size)

EFFECTIVE SEALING . . .

The next best thing to hermetic sealing, Model H-MS more than meets JAN-R-19 moisture and humidity requirements. Its all-metal case is rolled and securely bonded at the joints. Terminals are glass sealed. The shaft is sealed by means of an "O" ring.

WIDE CHOICE . . .

Model H-MS is yours in ¾", 1" or 1½" standard case sizes . . . in 1, 5 or 10 turn design . . . with resistance values from 50 to 400,000 ohms . . . with a wide spread of tolerances . . . in 2 or 3 watts or higher . . . with many special features.

CIRCUIT INSTRUMENTS INC.

Subsidiary of
INTERNATIONAL RESISTANCE COMPANY

CIRCUIT INSTRUMENTS INC. Dept. D
P.O. Box 1438, 2801 Anvil St., North St. Petersburg 1, Florida

Send data sheets on Moisture Sealed ☐ Hermetically Sealed ☐ Helical ☐ Servo ☐ Sub-Miniature ☐ High Temperature ☐ High Precision ☐ Potentiometers.

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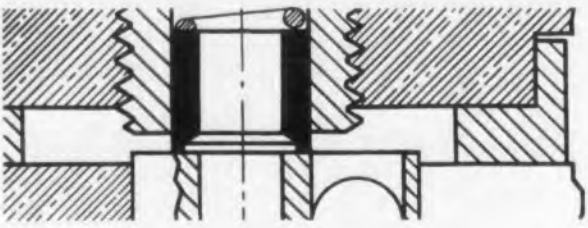
ADDRESS_____

CITY_____ STATE_____

CIRCLE 266 ON READER-SERVICE CARD FOR MORE INFORMATION



MECHANICAL ENGINEERS

Continually expanding programs at Northrop Aircraft are creating new opportunities for mechanical engineers in the following areas: launching and landing gear design, hydraulics and pneumatics, control systems, and equipment.

You'll enjoy the fine spirit of cooperation at Northrop. The new multi-million-dollar engineering and science center, now nearing completion, will be a great place to work in, both as to its modern architectural design and newest scientific installations. You'll be associated with a top engineering team on such notable projects as Northrop's new supersonic trainer airplane, Snark SM-62 intercontinental missile, and other advanced aircraft and missile programs.

You'll be given constantly fresh, challenging assignments. Remuneration will be substantial, with many benefits that are unexcelled in the entire industry—health and life insurance, college educational reimbursement plan, regular vacations plus extra year-end vacations with pay, and a generous retirement plan.

At Northrop, the progress of personnel is important. Initiative and ability are recognized and encouraged, and full opportunity is given to present and discuss ideas.

You will find the career opportunity you are seeking at Northrop, pioneer in the design and production of all weather and pilotless aircraft. If you qualify for one of these attractive positions, contact the Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., ORegon 8-9111, Extension 1893, or write to: 1015 East Broadway, Department 4600-S Hawthorne, California.

NORTHROP

NORTHROP AIRCRAFT, INC., HAWTHORNE, CALIFORNIA

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

Patents

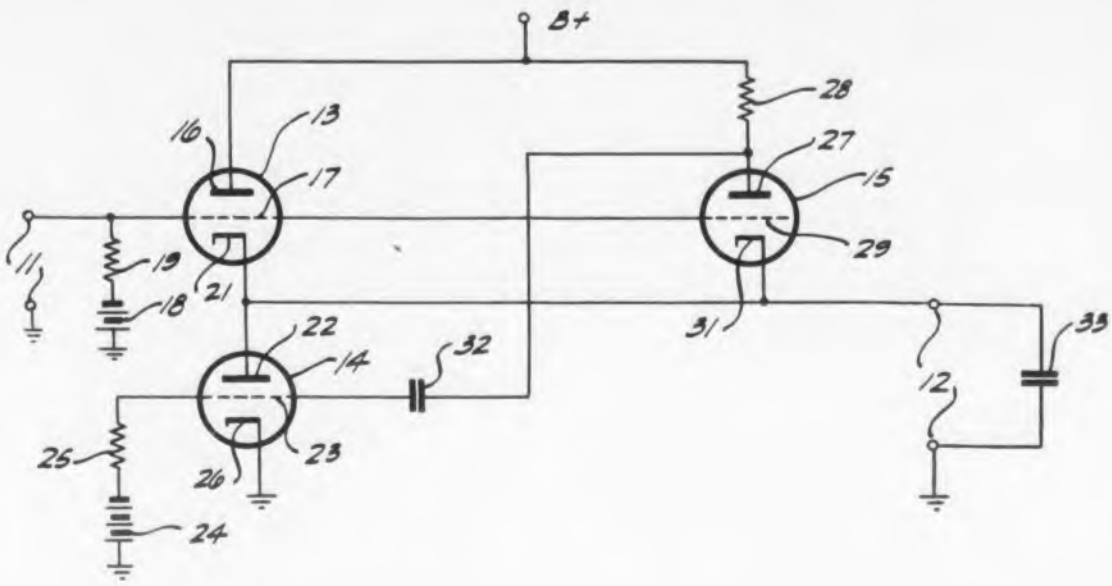
Cathode Follower Circuits

Patent No. 2,737,547. C. R. Deming. (Assigned to Hughes Aircraft Co.)

Cathode follower circuits have been designed to improve operational characteristics of this type of circuit. One such design, using a load tube in place of the cathode resistor, provides an anode resistor and connects the control grid with the anode of the follower tube to vary the conductance of the load tube in accordance with the input signal. In this circuit, the anode resistor reduces circuit efficiency as well as causes a delay in the charging of the capacity existing in the output load so that the circuit does not respond simultaneously to a steeply rising input signal. This circuit also must be operated in the linear portion of its characteristic curve.

Another circuit design also uses a load tube in place of the cathode resistor of the cathode follower tube. A pre-amplifier, however, is used which sets up two out of phase signals, one being applied to the follower tube and the other to the load tube. In this circuit, the impedance of the two tubes varies with the input signal, but it is the follower tube, only which has negative feedback. This circuit is subject to distortion and has frequency limitations.

In the circuit of the figure, a cathode load tube *14* is in series with the cathode follower tube *13*. A control tube *15* has its control grid connected with the control grid of the follower tube so that the input signal is applied to both tubes. Upon receiving a negative going input signal, the current through the follower tube and the control tube decreases, the result of which is an increase



in the potential on the anode 27. This increase in potential is transmitted to the control grid 23 of the load tube 14. The conduction through the load tube is increased so that the potential at the anode of this tube and hence at the output terminals 12 decreases. The increase in the conduction of the load tube causes a rapid discharge of the output capacitance 33 so it does not effect any delay of the output signal in following the input signal. The cathode follower circuit is permitted to follow the input signal instantaneously. Essentially, the equivalent operation occurs upon a positive going input signal.

In the circuit so far described, the circuit would function properly if the instantaneous slope of the input signal is less than the discharge slope of the ouput capacitance. By connecting the cathode of the control tube with the output terminal and anode of the load tube, the circuit is freed from the influence of the discharge characteristic of the capacity in the output circuit.

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.

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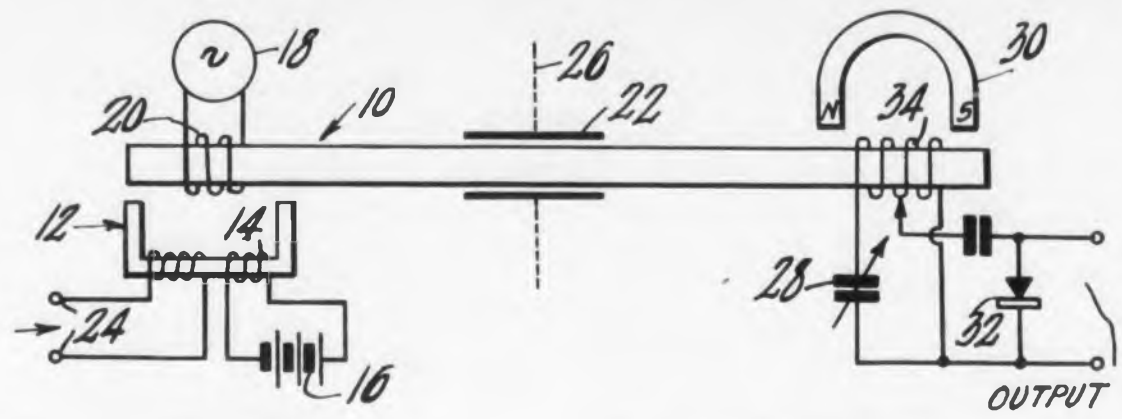


Magnetostrictive Amplifier
Patent No. 2,738,386 W. Van B. Roberts (Assigned to Radio Corporation of America)

An amplifier, as disclosed in the figure, uses a circuit with a magnetostrictive element *10* by means of which signals of slowly varying magnitude can be effectively amplified. The magnetostrictive element is shown as a straight bar capable of mechanical vibration. The bar has a non-magnetostrictive section at the center, and a magnetostrictive section at each end. It is desirable for each section to have a length of one halfwave length. Shielding *22* and *26* is provided at the central section. The magnetostrictive element provides a rugged means, functioning as a sharply tuned mechanical filter.

An oscillator *18* is coupled by a coil *20*. The frequency is the same as the natural frequency of the bar. A magnetic field is set up by a battery *16* and a coil *14* around an armature *12*, at the same end of the bar as that carrying the oscillator coil *20*. The signal to be amplified is applied at the terminals *24* and a coil connected to the terminals controls the magnet field. Control of the field controls the magnitude of the vibration of the bar.

At the other or output end of the bar, a magnet, shown as a permanent magnet *30* adjacent to the output end of the bar, creates a field at this end. A tuned circuit is coupled to the bar and includes the condenser *28* and a coil *34* around the bar. A rectifier *32* is provided across the output terminals. This magnetostrictive amplifier secures amplification of either voltage or

current of the signal applied to the input terminals.

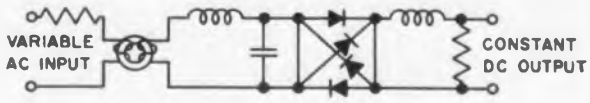
Other forms of magnetostrictive devices may be used in place of the straight rod particularly illustrated. The patent also describes two other forms of amplifiers which are modifications of the amplifier of the figure. A form of feedback circuit is also illustrated.

Thermal Control System

Patent No. 2,726,312. W. C. Dunlap Jr. (Assigned to General Electric Co.)

This patent discloses a temperature responsive element and circuit which is definitely responsive to a predetermined temperature and which generates a voltage difference of about 4 mv with a temperature difference of about 10°.

The control system uses as its thermal element a P-type germanium element. This type of non-conductor changes sharply from its P-type characteristic to that of an intrinsic germanium at a particular temperature. This depends upon the proportion of impurities in the non-conductor which makes it the P-type. It is convenient also in that the resistive characteristic of the germanium is a measure of its point of inversion temperature. Germanium having a resistive characteristic of 2 ohms CM will have an inversion temperature in the neighborhood of 240°. By selection of a germanium element having a particular resistive characteristic, the inversion temperature is selected.



Voltage Reference Devices

Patent No. 2,739,282. William G. Evans. (Assigned to Westinghouse Electric Corp., East Pittsburgh, Pa.)

A saturable reactor voltage reference device designed to supply a constant dc voltage or current, independent of supply voltage magnitude and frequency variations. The saturable reactor is driven into saturation on each cycle so that the average voltage on the secondary winding is proportional to the frequency of the supply voltage, but independent of the magnitude. An integrating circuit is then used to eliminate the frequency dependence, and a full wave voltage rectifier and filter supply a constant output voltage. A simplified circuit is shown.

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Because of similarity in size, new product editorial in ELECTRONIC DESIGN often resembles paid advertising space. This has confused some readers in the past, so for the record we have selected two items at random and reproduced them above.

The item in front is *editorial.* It is a free, concise, write-up of a manufacturer's product, based on its newness and its relevance to the design engineer's work. Once brought to the design engineer's attention, however, it's up to the manufacturer to *remind* our readers, if he wishes, in paid advertising space.

If you have a new product, send information about it to our editors. You need not advertise in our publication in order to have your material qualify for acceptance. And, of course, there is no charge for this service.

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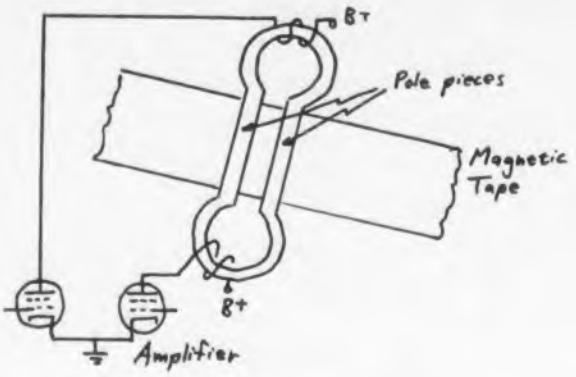


Variable Area Magnetic Recording System
Patent No. 2,743,320. Howard L. Daniels and Sidney M. Rubens. (Assigned to Sperry Rand Corp., New York, N. Y.)

A magnetic recording means which produces a gradient of flux concentration across the width of the tape. The figure shows a schematic diagram of the system which utilizes two electromagnets driven by a push-pull amplifier.

Voltage Limiter
Patent No. 2,732,494. O. C. Hall. (Assigned to The United States of America.)

A voltage limiter ordinarily uses vacuum tubes when it is to be used for frequency shift keying in the operation of teletypes, in order to secure frequency deviation. A vacuum tube changes its gain upon any change of either anode supply voltage or the voltage applied to the filament heaters. This change in gain effects variation of the output voltage of the tube and produces undesired frequency deviation. A voltage regulated power supply may be used to supply a stable anode voltage; however, variation in voltage for the cathode heaters presents a problem.

The voltage limiter circuit shown in the figure is unaffected by anode or cathode voltage changes and consequently there is no deviation in the output voltage. The input signal is applied to the terminals *11* and *12;* however when no signal is applied, the tube *15* is non-conducting. When the tube *15* is non-conducting, the control grid of the second tube *21* which is coupled to the anode of the tube *15*, carries a bias which causes tube *21* to conduct. As long as tube *21* is conducting, the anode current of this tube through the resistor *34* maintains the potential on the anode 29 of the thyratron *28* below its firing potential. If now a positive pulse is applied to the input terminals and hence to the control grid of the tube *15*, this tube becomes conducting and the control grid *22* is biased by current through resistor *33* so that tube *21* becomes nonconducting. Full power supply potential,

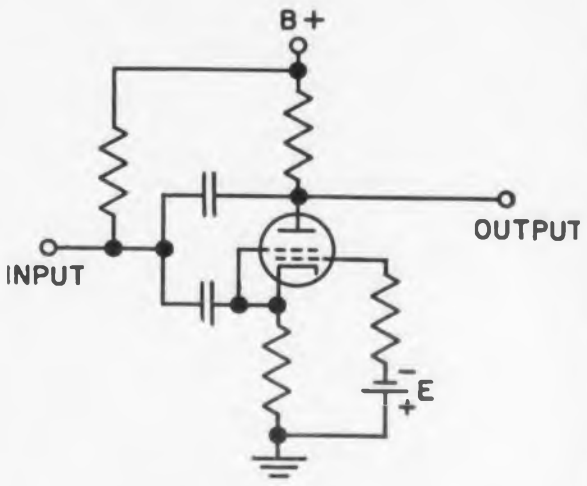
therefore, is applied to the anode of the thyratron 28 so that it fires.

Normally the potential across the output terminals 38 and 39 is determined by the potential across the cathode resistors 36 and 37 which are in series with a resistor 35 directly connected with the power supply. When the thyratron fires, the added current through this tube and resistors 36 and 37 raises the potential across the output terminals. The output potential is maintained stable as to one level by the regulated power supply. The thyratron is of the cold cathode type which does not have a cathode heater to affect the output potential. The output potential is therefore unaffected by any variations in cathode supply voltage and is stable at both its high and low potential level.

Imperfection Counter

Patent No. 2,739,239. Edward J. Bernet. (Assigned to Institute of Textile Technology, Charlottesville, Va.)

An apparatus to count imperfections in material in the form of yarn and the like. The apparatus determines the yarn diameter and a differentiating circuit produces an output whenever the diameter of the yarn changes in the order of 1/16". By adjusting a threshold level it is possible to count all imperfections larger than some present size.



Gas Discharge Tube Binary Device

Patent No. 2,739,235. George Vande Sande. (Assigned to General Railway Signal Co., Rochester, N. Y.)

A gas tube circuit with two stable states. An input signal is coupled simultaneously to the plate and cathode in such a manner that a negative input pulse will switch the device from its present state to the other stable state. A simplified schematic is shown.

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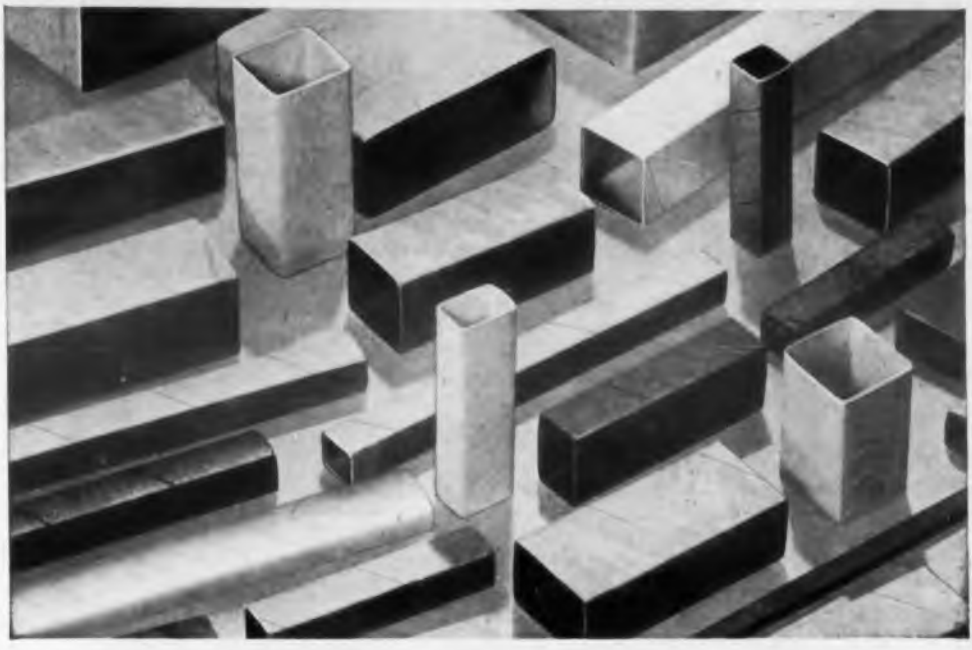

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Books

Pulse & Digital Circuits

Jacob Millman & Herbert Taub. McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N. Y. 687 pages; Price: $12.50.

Response of linear networks, both active and passive, to the types of waveforms commonly encountered in pulse circuits is analyzed in the beginning of this book. Basic nonlinearities of tubes and semiconductor devices are described, and the efforts of these nonlinearities on waveform transmission are studied. Waveform generating circuits are analyzed in detail. Other fundamental circuits or components are given consideration. These basic building blocks are assembled into pulse and digital systems such as radar, television, and digital computers.

A number of illustrative examples are worked out in detail in the body of the text. Material is organized into a logical pedagogic presentation.

International Dictionary of Physics and Electronics

D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J.

Here in one volume, are definitions of all the principal terms used in classical and modern physics, useful not only to physicists but also many more scientists and engineers in fields who have frequent need for information about terms used in physics.

Prepared by an international group of scientists and educators, this dictionary has terms from sixteen major subject divisions, over 300 illustrations, all designed to provide the exact and unambiguous definitions needed in everyday work.

The terms defined here include laws, relationships, equations, basic principles and concepts, as well as the most widely used instruments, apparatus and their components. In short, this treatment comprises the terms of pure science as well as those of its applications.

The units and systems of units are treated both by definitions and by a comprehensive discussion at the beginning of this book. All definitions, wherever possible, which have been established or recommended by professional groups are included. Many terms have been defined from the subject-areas bordering on physics.

Frequency Response
Rufus Oldenburger, The MacMillan Co., 60 Fifth Ave., New York 11, N.Y. 372 pages. Price: $7.50.

Papers and addresses presented at the 1953 ASME Frequency Response Symposium are disclosed in this book.

Featured are discussions and criticisms of each ASME paper; a complete eight-page bibliography of important works on frequency response; and 428 illustrations supporting the text material.

Electrical Circuits
Charles S. Siskind, McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N.Y. 516 pages. Price: $6.75.

Fundamental principles of electric and magnetic circuits are featured in this book. Material is divided into two major parts: Part 1 deals with circuits in dc systems, while Part 2 builds upon the former and deals with circuits in ac systems.

Also included are circuit diagrams, and mathematical derivations involving the use of calculus.

Engineering Formulas and Tables
Lefax, Sheridan Building, Philadelphia 7, Pa.

This is a pocket-size system of loose-leaf data sheets and blank forms. The twelve categories include Math. Tables; Measures: Materials: Gages, Screws, etc; Mechanics; Elect. & Magnet; Hydraulics; Struc. Data; Reinf. Concrete; Pipe & Fittings; Steam Tables; Math. Tables.

Applied Electrical Measurements
Isaac F. Kinnard. John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. 600 pages. Price: $15.00

This book is concerned with the framework of the familiar branches of physics. The material has been chosen to apply the principles of electrical measurements in industrial practice.

The book is divided into two parts, the first concerned with the measurement of electrical quantities and the second to non-electrical quantities.

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Write for Technical Bulletin EP-75

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Russian Translations

What The Russians are Writing

J. George Adashko

Measurement Engineering, No. 2, March-April 1956

Test Setup to Check Absorption Attenuators in the 3-cm Band, E. I. Strelkova (4 pp 2 figs).

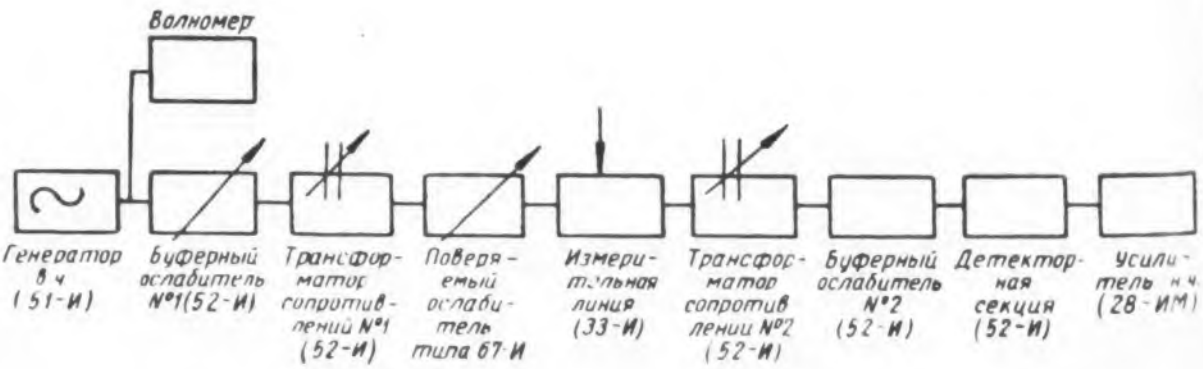
The setup shown in Fig. 1 was developed and tested by the All-Union Scientific Research Institute for Measures. It is used to check absorption attenuators in the 3-cm (8700-9600-mc) band when a relatively high measurement accuracy is required.

Operation of the setup is based on the low-frequency substitution method, whereby the unknown power ratio in the high-frequency channel is determined from the ratio of coresponding low-frequency voltages obtained across the load resistor in the detector circuit. A crystal detector with square-law characteristics is used.

The measurement procedure is as follows: The generator and calibrated line are tuned to the prescribed frequency. An oscillograph is used to check the waveform of the detector-output envelope. Before connecting the unknown attenuator into the line, the impedance of the detector and generator sections are matched to the wave impedance of the line until the VSWR is less than 1.02. The detector power level is then set at a value not exceeding the upper limit of the square-law portion of its characteristic. The ratio of the lf amplifier output with and without the attenuator determines the value of the attenuation.

The article contains a detailed discussion of the random and system errors inherent in such a procedure.

1—wavemeter,
2—hf generator,
3—buffer attenuator No. 1,
4—impedance matching transformer No. 1,
5—unknown attenuator,
6—calibrated line,
7—impedance-matching transformer No. 2,
8—buffer attenuator No. 2,
9—detector,
10—lf amplifier.



Inductive Recording Meter for Small Displacements, V. S. Chaman (3 pp 3 figs). The problem of attaining both phase and amplitude balance in an ac bridge consisting of a pair of inductances and a pair of pure resistances is solved in Fig. 1 by using a phase shift RC network. Here the unbalance voltage between point *1* and ground is compensated by the voltage between points *2* and *3*. Fig. 2 shows that as the brush *2* of the rheostat moves relative to the center tap *3*, the voltage between points *1* and *2* is represented by vectors *FA*, *HA*, *GA*, etc, while the respective voltages between points *2* and *3* are represented by vectors *OF*, *OH*, *OG* before the phase shift is introduced by the RC network, and by vectors, *FM*, *HL*, *GM*, etc. after the phase shift. The voltage applied to the servo amplifier is *AF*+*FM*, *AH*+*HL*, *AG*+*GN*, respectively, and it is evidently zero at the point *H*, corresponding to the minimum unbalance.

A complete circuit of the system, including the amplifier, is shown in Fig. 3. The instrument was constructed by the "Bureau on Interchangeability" of the Committee on Standards, Measures, and Measuring Instruments of the USSR. The recording error on a 200-mm strip charge at magnifications of 500 and 5000 to 1 did not exceed the error of the inductive transmitter itself. (The latter error was not specified in the article).

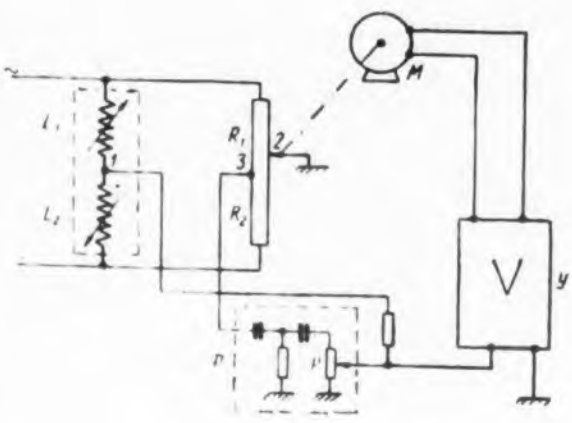


Fig. 1

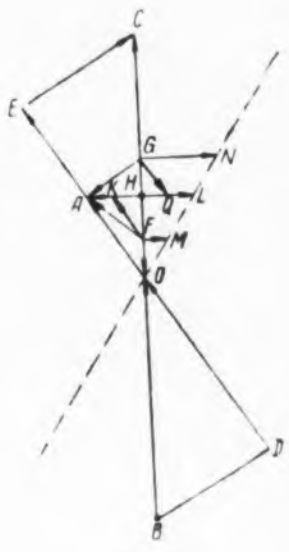


Fig. 2

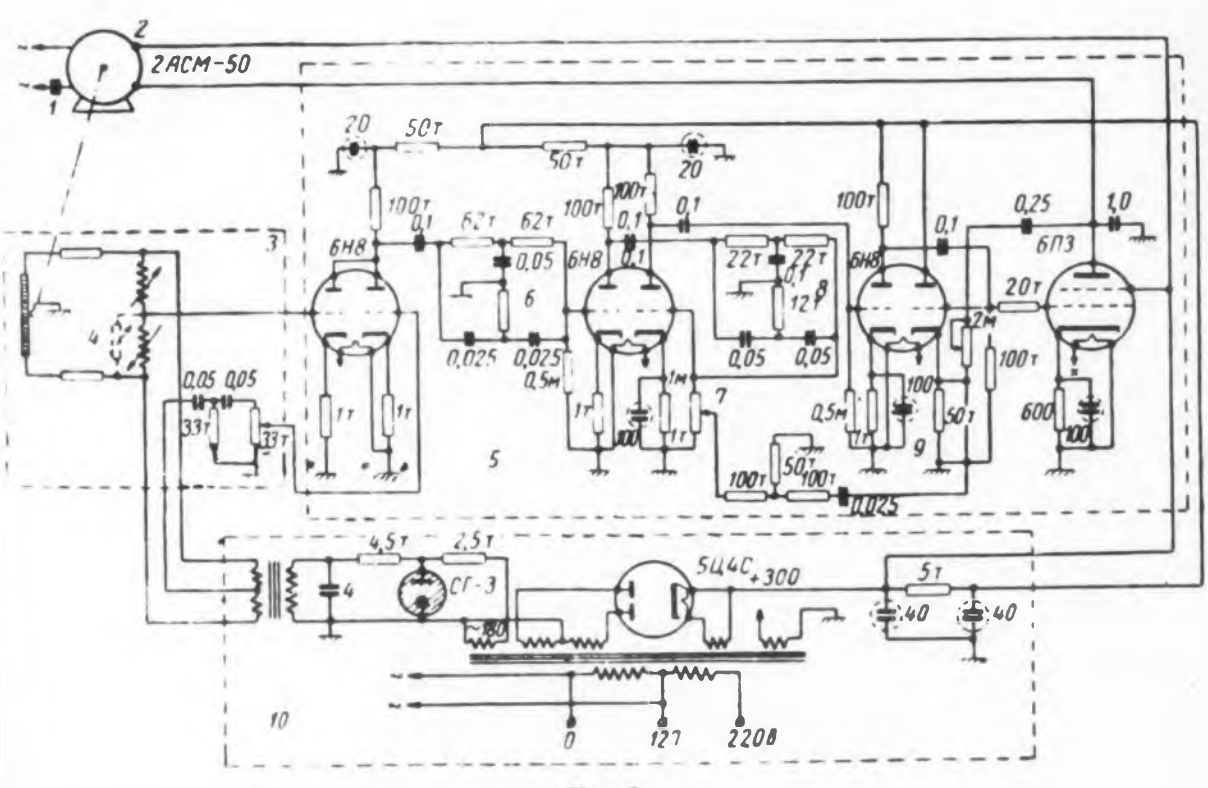


Fig. 3

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Line Voltage:	± 10%	± 0.25
Line Frequency:	± 20 cps	± 0.1
Load Current:	20-100%	± 0.1
	0-100%	± 0.2

Ripple: Less than 0.05% rms at full load.

Output Adjustment: 5% adjustment available on request at slightly higher price.

Environmental: Meets specification MIL-E 5272 A for acceleration, vibration, altitude, humidity and temperature operating at 20% to 100% rated load.
Also meets MIL-I 6181 B.

Connector: AN-type connector.

Mounting: Stud-mounted.

(Write for Bulletin 200)

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Model 5 S 10

ARNOUX

Input Power: 115 volts, 400 cps

Regulation:	Input (Variation)	Output (% Rated)
Line Voltage:	± 15 volts	± 0.10
Line Frequency:	± 20 cps	± 0.15
Output Load:	20-100%	± 0.05
	0-100%	± 0.10

Temperature Stability: 0.5% per 100°F. (— 60°F. to + 160°F.)

Ripple: Less than 0.1% rms at full load.

Output Adjustment: Screwdriver adjustment provides ± 0.5 volt change. Wider range of adjustment available on request.

Connector: Standard AN-type connector, or hermetically sealed header on request.

Mounting: Stud-mounted.

Environmental: Meets specification MIL-E 5272 A for acceleration, vibration, altitude, temperature and humidity.

(Write for Bulletin 100)

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CIRCLE 290 ON READER-SERVICE CARD FOR MORE INFORMATION

New German Tubes

Alfred Jorysz

New Tube For Pulse Work

Many problems in pulse circuitry require a vacuum tube with the following characteristics: *1.* two independent control grids, *2.* two independent plates, *3.* high mutual conductance g_m with optimum g_m/C ratio (required for wide frequency band amplification) and *4.* high plate current with optimum current distribution between plate and screen grid. Siemens and Holske, Germany, have developed such a tube.

The design is based on the use of a fine wire structure for both control grids and the screen grid, resulting in high g_m values and low internal capacities. The fine wire grid is not self supporting but is held inside a frame around which very fine tungsten wires are wound. These wires are welded to the frame under high mechanical tension.

The use of this construction for the control grids permits a spacing of 45×10^{-4} cm between first grid and cathode, resulting in a mutual conductance of 13 ma/v and a good sharp cut-off. The second control grid g_m is 7.5 ma/v. To reduce the current to the first screen grid, which separates the two control grids, another fine wire structure is used. Since even a small amount of screen grid current will produce a screen grid temperature rise and therefore expansion of the screen grid wires, the latter are mechanically pre-tensioned to such a degree that they will not shift under normal operating conditions.

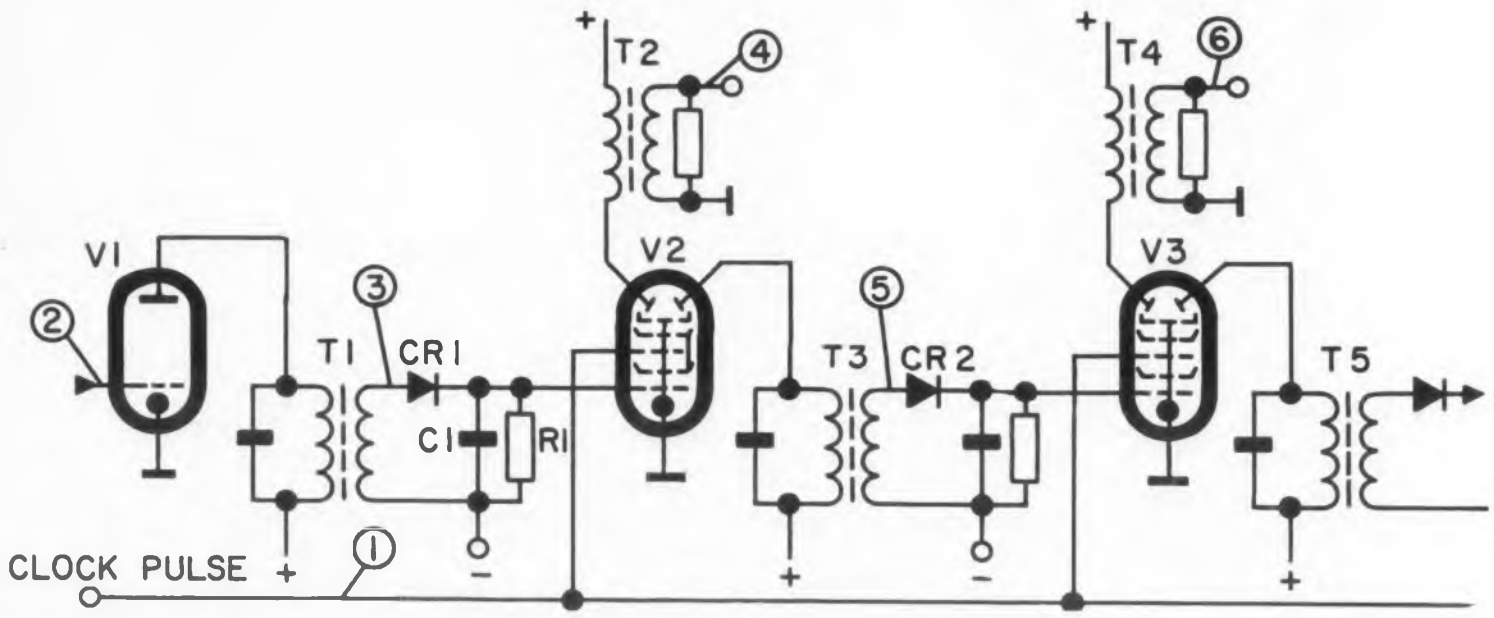
Due to the parallel and symmetrical construction of the tube, the two plates are almost completely decoupled. The mutual capacity between them is only 0.18 mmfd.

The tube has a nine-pin base and a miniature size envelope. Its characteristics are shown in the table which makes a comparision to those of a *6AS6* tube.

The use of this tube in a coincidence circuit has the advantage of almost complete decoupling between inputs, practically infinite input impedances and amplification rather than attenuation as found in diode gates. Semiconductor switching time problems due to hole storage do not exist in a tube.

A synchronized, pulse-delay circuit using the coincidence is illustrated. The input pulse to V_1 excites the tuned transformer T_1, thereby charging C_1 through CR_1. When CR_1 is cut off, C_1 discharges slowly through R_1. The time constant R_1C_1 is chosen to keep the grid No. 1 of V_2 open during the next clock pulse, but closed during the one following it. The clock pulses are applied to grid No. 2. A pulse appears therefore in T_2 which is delayed compared to the input pulse by one period of the clock pulses. By using the second plate of the coincidence tube to excite the next transformer T_3, the voltages appearing in T_1 are repeated delayed by one clock pulse period. The next coincidence tube produces then a pulse in T_4, which is delayed by two clock pulse periods. Preservation of the waveforms through a number of such steps is only possible due to the availability of two plates. In a typical circuit, the clock pulse period may be one microsecond and the pulse length 0.3 microsecond.

K. Gosslau and W. Guber, "A new multi-grid tube with very high g_m and its application in pulse circuits," *Frequenz, vol. 10, pp. 83-89; March 1956.*



Basic schematic of a synchronous pulse delay circuit.

	Three fine-wire grid tube Type V108	6AS6 (5725)	
Plate current	66.0	12.0	ma
Cut-off voltage:			
U_{g1}	−8.0	−5.0	v
U_{g3}	−13.0	−10.0	v
Mutual cond.:			
g_{m1}	13.0	3.2	ma/v
g_{m3}	7.5	0.5	ma/v
g_m/C			
Grid No. 1	1.2	0.8	ma/v/mmfd
Grid No. 3	0.58	0.18	ma/v/mmfd
Plate resistance	0.7	4.4	kiloohms
Current distr. $\frac{I_{p0}}{I_{g20}+I_{g40}}$	1.1	1.16	
Heater voltage	6.3		v
Heater current	0.37		a
Plate dissipation	2.0 max.		w
Screen dissipation	1.0 max.		w
Cathode current	20 max. dc		ma
Cathode current	250 max. pulse		ma

Analog Multiplier Tube

A new solution of the problem of multiplication in analog computers is obtained with the aid of this electron beam tube with three electrostatic deflection systems.

The three basic requirements for an analog multiplier are: Four quadrant operation, i.e. sign of product must be determined by signs of inputs, high accuracy and high computing speed, which means no inertia and large bandwidth. An electron beam tube with a hyperbolic deflection system, Fig. 1, yields an excellent solution. Input No. 1 is applied to the standard parallel plate deflection system No. 1. It is followed by the deflection system No. 2 which produces a hyperbolic field, Fig. 2. By connecting the second input to the four deflection electrodes as shown, a hyperbolic field is produced in a plane at right angle to the tube axis. The potential is zero on both the x and y axes, but the y component of the electrostatic field is negative in the two quadrants where x is positive and positive where x is negative. This arrangement makes four quadrant operation possible. The electron beam entering the hyperbolic field is already deflected proportional to U_1. In the second system it is deflected in the y direction proportional to the product U_1xU_2 into the quadrant corresponding to the sign of U_1xU_2.

The beam then traverses a feedback control system which operates as follows: The anodes are two adjacent plane electrodes. The undeflected beam strikes the dividing line between the anodes, thus producing two equal voltage drops in the resistors R. The difference between the two voltages, which is the input to the differential amplifier, is therefore zero. A deflected beam produces two different voltage drops and their difference results in an amplifier output which controls the third deflection system. The polarity of this voltage is chosen so as to return the beam to the border line between the two anodes, thus keeping

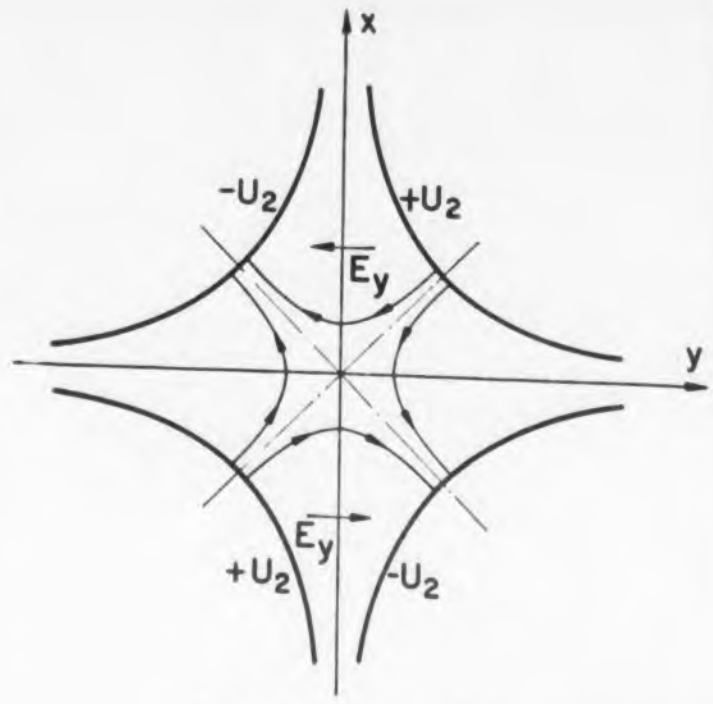


Fig. 2. Arrangement of electrodes for hyperbolic field.

the differential amplifier input almost at zero. The output voltage U_3 of the feedback amplifier is at the same time output of the multiplier, since it is proportional to U_1xU_2.

The maximum input voltages are 25 and 50 v respectively, while the maximum product voltage is limited to 60 v. The maximum error referred to maximum output is approximately 0.5 per cent. The upper frequency limit is indicated as about 200 kc. Problems of electrode geometry, beam cross section deformation and stability of the feedback control system are also discussed. *W. Schmidt*, "The hyperbolic field tube, an electron beam tube for multiplication in analog computers," *Zeitschr. f. angew. Physik, vol. 8, pp. 69-75; February 1956.*

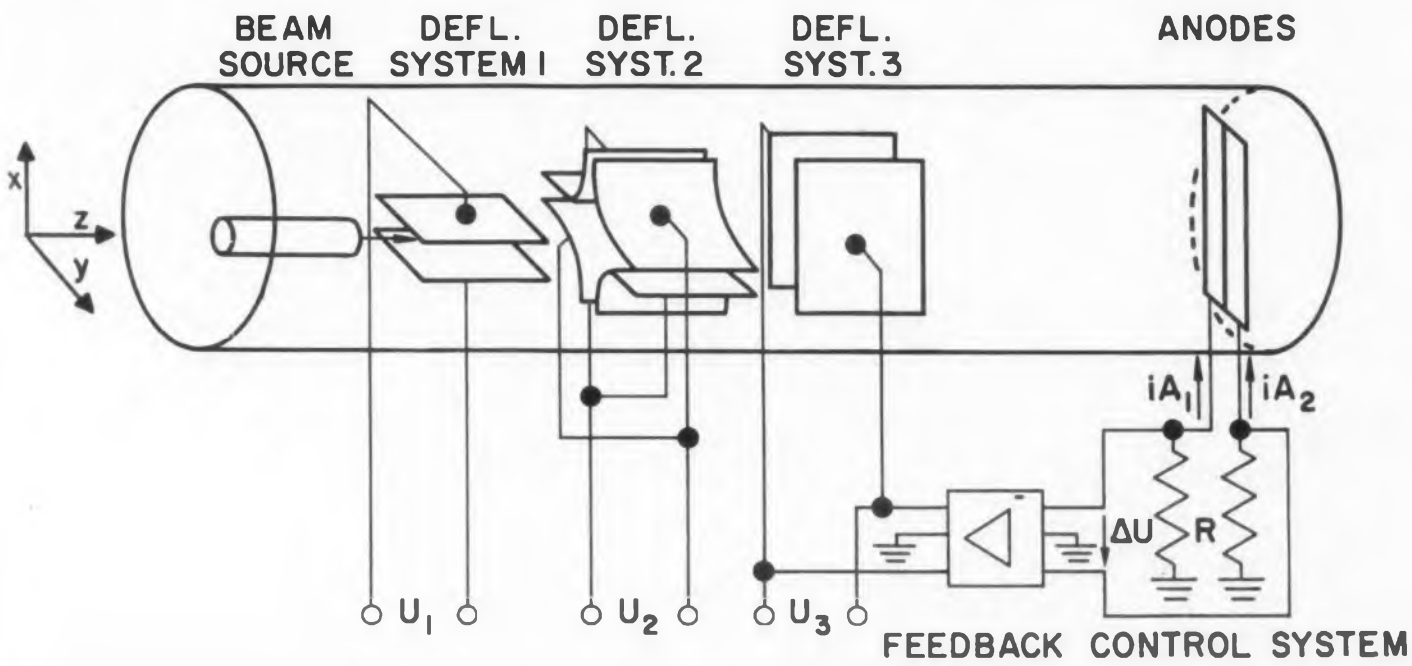


Fig. 1. Electrode arrangement of hyperbolic field multiplicator.

Govt. Abstract

Crystal Diodes–

Three types of crystal diodes are most common. They are; general purpose germanium and silicon diodes, power silicon diodes, and forward and reverse high-frequency silicon diodes. The last are commonly called mixer crystals.

Germanium diodes, such as the IN34A or IN69, are used for fairly low frequency applications such as video, audio, and pulse circuits. Many are used as detectors in radio and television equipment, and as mixers at frequencies up to 900 mc.

Silicon power diodes offer higher voltage and current outputs than the germanium type. They will operate at much higher ambient temperatures.

Mixer crystals, such as the IN21 or IN23, are designed for microwave detection and mixing. These are very carefully made with low-loss ceramic barrels and gold-plated brass tips and bases for close fits in waveguide and coaxial fittings.

Mixer crystals are available for use with frequencies of from 1000 to 35,000 mc. Those for use of 1000 to 10,000 mc will usually be of the cartridge type. Diodes for 10,000 mc and above are usually the coaxial type.

In the cartridge type, the active crystal is attached to a threaded end plug. The latter is then inserted into the end cap and the whole assembly fastened to the ceramic body. The opposite end of the body carries a contact pin, to which is attached a catwhisker of especially formed and tempered wire. The diameter and shape of the catwhisker are designed to provide correct contact pressure against the crystal of the silicon.

In the coaxial type of crystal, the silicon crystal is fastened to a metal end plug that is fitted to the external sleeve. The center conductor is mounted coaxially with the external sleeve, and is supported by an insulating bead, accurately machined to insure concentricity. One end of the catwhisker is welded to the center conductor.

Reverse mixer crystals, such as the IN21CR or IN23CR, are identical in characteristics to the ordinary type whose number they carry. Thus, a IN23CR is electrically identical to a IN23C except for the reversal of polarity. The crystal in the reverse type is fastened to the tip, making the tip the anode and the base the cathode.

Forward and Reverse Types

Sectional view of a germanium crystal diode.

Reverse type crystals were developed because the construction of most microwave crystal holders makes it impossible to use an ordinary or forward type of diode inserted in a reverse direction.

Another common usage is in certain types of balanced mixers. To obtain the cancellation of rf signals and reenforcement of the intermediate frequency, one of the crystals must be of reversed polarity. Most types of mixer crystals are available in both forward and reverse polarity.

Most radar receivers use balanced mixers, which provide a much better noise figure than the older single-ended mixers. Most balanced mixers require that the two crystals and holders have identical characteristics. Crystal pairs are matched for leakage, rectified current, and minimum noise in a precision magic-tee fitting, or equivalent balance mixer, with identical crystal holders. Maximum leakage power is 10% of input.

Matching of the rectified crystal current insures balance of the individual rf impedances and conversion loss values. The maximum rectified current unbalance permitted in matched pairs is 10 per cent of the smaller crystal current at 0.5 μamp.

Mixer crystals are subject to burnout either by very short pulses (0.1 μsec) of sufficient total energy, or by longer pulses (1 μsec) of sufficient peak power.

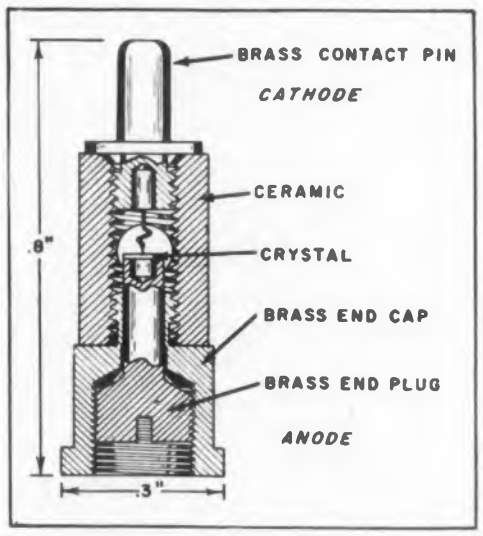
It should be noticed that deterioration of mixer crystals will occur at levels below that required for complete burnout. Deterioration is caused by slight fusing of the pointed metallic contact catwhisker. This increases the contact area, thereby increasing the shunt capacitance of the rectifier.

The increased capacitance in turn adversely affects the conversion loss and noise characteristics of the crystal. A good test for deterioration, when suitable test equipment for these characteristics is not available, is a measurement of the forward and reverse dc resistance with a sensitive meter. The ratio, at 1 v, of reverse to forward resistance that is to be measured should be at least 10 to 1.

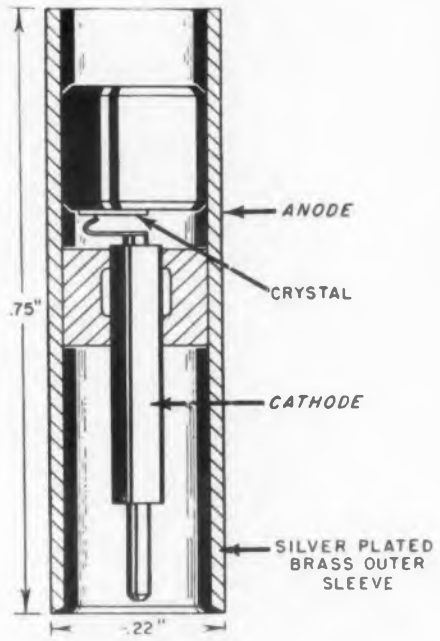
Performance of mixer crystals is not affected by orientation. However, care should be taken to avoid mechanical strain on the body of the contact pin. Soldered connections are not recommended. Spring contacts of beryllium copper are most frequently used.

In mixer applications, performance is a function of local oscillator injection. The local oscillator current is most easily determined by measurement of rectified current, the optimum value of which will generally lie between 0.5 and 1.0 ma. Current in excess of 5.0 ma may cause permanent damage to the crystal.

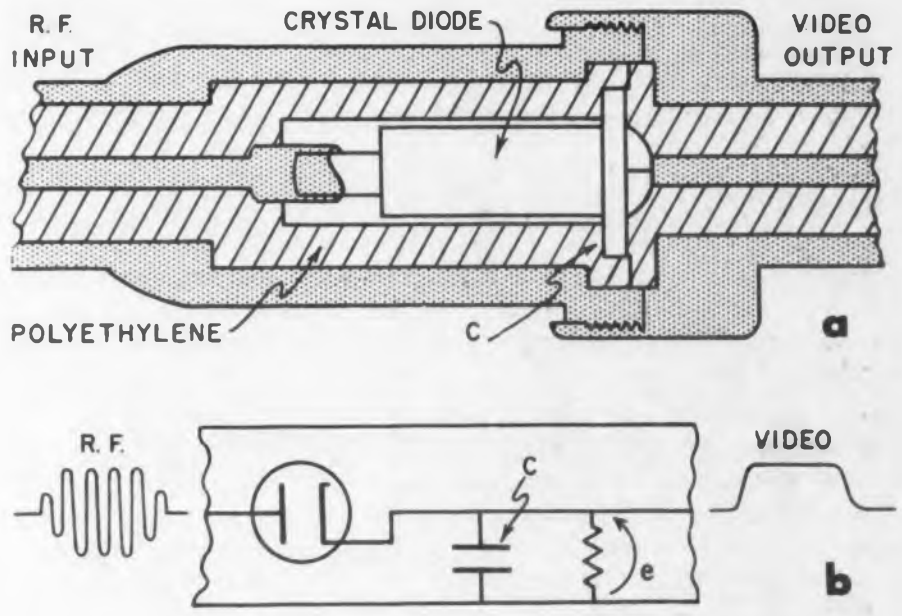
Abstracted from Crystal Diodes–Forward and Reverse Types, *Bureau of Ships Journal, July 1956, page 29.*



Cartridge type of silicon crystal diode.



Coaxial type of silicon crystal diode.



Reverse diode mounted in a coaxial line crystal holder, a. In the schematic, b, capacitance C represents capacitance from the crystal diode base to the shell.

Mr. P. Argyle Wigglesby, Board Chairman of Conglomerated Figleaf Enterprises, seen examining new SIGMA CDS PHOTORELAY. Although almost speechless, Mr. W. did finally manage the comment, "This is just great!"

and right you are, Mr. Wigglesby!

Now that commercial development of cadmium sulfide photocells has settled down a little and production lots arrive accompanied only by the less troublesome types of bugs, it seems reasonable to think about the useful applications these cells may have. To help such thinking and thinkers, Sigma has put together a 41 relay and a CdS cell in a neat, manageable and low-cost package. The CdS Photorelay — Model 1, now in production, offers these specs:

Operate: 5 foot-candles (max.); drop-out 0.1 f-c (min.)
Speed: 2 operations per sec., guaranteed minimum
Coil voltage: 115 AC
Temperature range: −40° C. to +95° C.
Mounting & enclosure: 5-pin base, dust-can cover.
Price: $12.00 each (quan. 1-19); $7.20 each (1000 and up).

The Series 41 relay used in this device was hailed (by us) about a year ago as "probably the best, low cost AC relay available with sufficient sensitivity (0.10-0.15 v-a) for such use." To date we haven't seen any reason to alter our ego concerning the 41.

So far Photorelays have been shipped only in limited numbers to various interested manufacturers, but repeat orders seem to indicate we may really have something (or more accurately, *they* have something that needs the Photorelay). Likely prospects include, in addition to Mr. Wigglesby, manufacturers of furnace flame-out controls, pinball machines*, elevators, conveyors, weighing equipment, etc. The Photorelay has already been incorporated in automatic bottle washing and bagging equipment designs. (Special models are pending, awaiting further word from Conglomerated Figleaf.)

The easiest way to see how you might use such a compact, low-cost, AC photoelectric control in your equipment, is to buy a sample and try it.

* *Pinball machines*

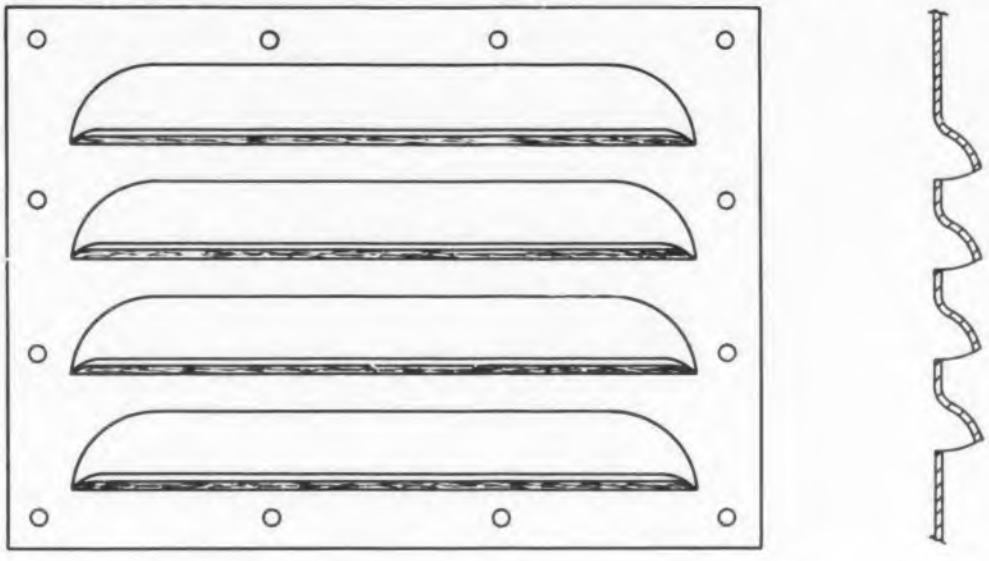
SIGMA INSTRUMENTS, INC.
91 Pearl Street, So. Braintree, Boston 85, Mass.

CIRCLE 293 ON READER-SERVICE CARD FOR MORE INFORMATION

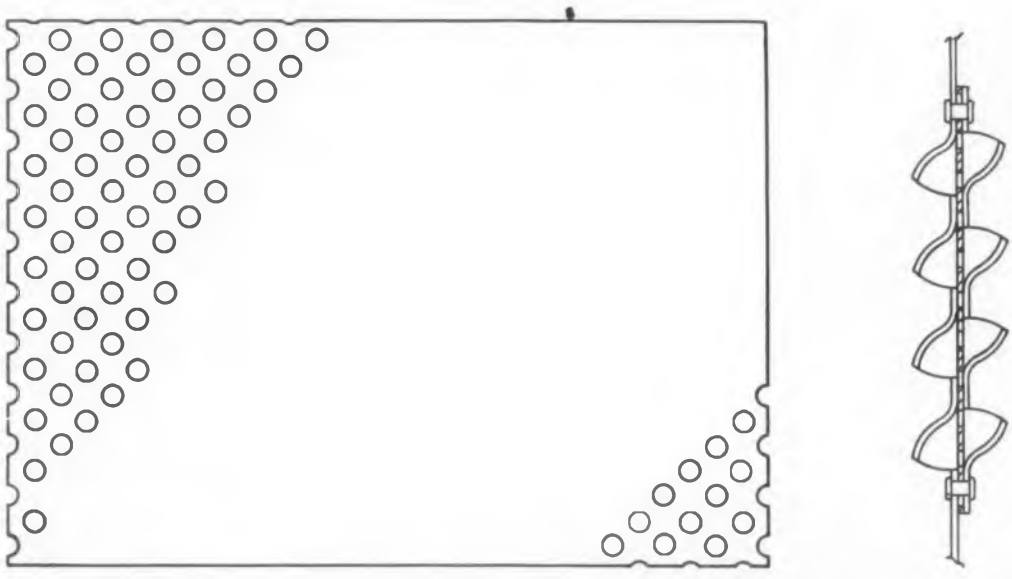
Making Electronic Chassis Splashproof

Several simple methods of improving splash resistance of louvers have been suggested by J. W. Sampsell and K. W. Wyckoff of the U. S. Navy Electronics Laboratory, San Diego, Calif. Drawings here are cross sections of configurations of several degrees of splash proofing. These configurations provide protection ranging from a slight improvement in splash resistance over that given by standard louvers, to complete splashproofing.

Abstracted from Bureau of Ships Journal, *July 1956, page 34.*



Front and side views of a standard louver of an electronic equipment cabinet.



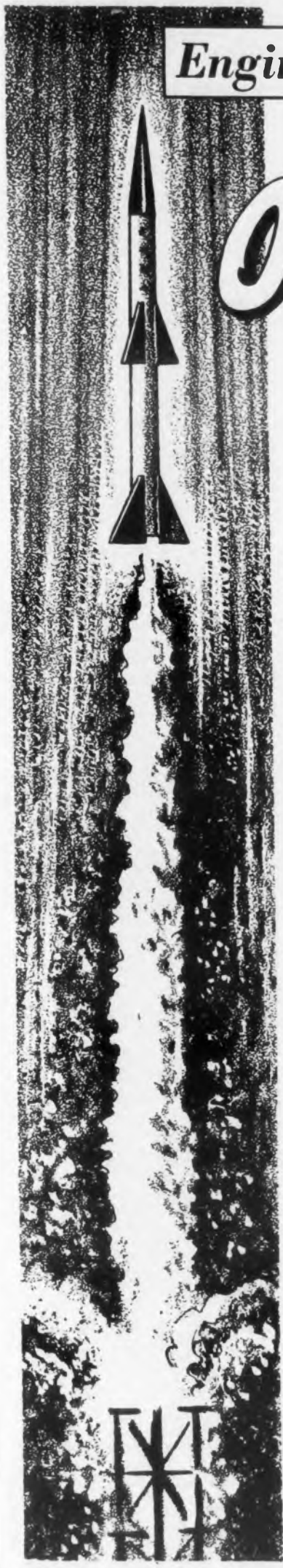
Addition of the perforated plate, left, to the back-to-back louvers, right, gives additional splash protection.

Govt. Abstract

Some improvement in splash resistance over the standard louver is achieved by mounting louvers back-to-back.

For complete splashproofing, a box-like arrangement was added to the double louvers. This arrangement is for an inside installation.

Complete splashproofing of an outdoor installation is obtained by modifying the box attachment used in the indoor installation.



Standards and Specs

Sherman H. Hubelbank

This department surveys new issues, revisions, and amendments, covering military and industry standards and specifications. Our sources of information include the Armed Services Electro-Standards Agency (ASESA), the cumulative indexes to Military Specifications, Vols, II, IV, American Standards Association (ASA) and other standards societies.

Standards Proposal-Request for Comment

The RETMA Engineering Office, 11 W. 42nd St., New York 36, N.Y., requests industry comments on the following proposed standards. Send for proposal number as indicated. (Although the official comment period may have expired, you are encouraged to comment if you are vitally interested.)

SP 504, Emergency Stand-By Power Generator And Accessories For Microwave Systems . . . Definitions and minimum requirements for engine driven generator sets used for providing emergency stand-by power to microwave communications systems are established by this standard. Covered in this standard are permanently installed engine driven generator sets of not over 25 kw.

SP-505, Addition To Retma Standard ET-109A, Measurement Of Direct Interelectrode Capacitances Of Electron Tubes Of T2 x 3 Shield . . . Fig. 10 has been added to the material previously submitted in SP-430. In publication, this shield will be known as No. 319.

SP-506, Nomenclature Of Tube Testers . . . Tube testers are divided into four numbered groups by this proposed standard. These groups are described and illustrated in this proposal, so that assignment of any tube tester to one of these groups will be simple and certain.

Electrical Conductors

ASTM Standards On Metallic Electrical Conductors, 1955 . . . This 300-page compilation includes in their latest form 52 ASTM standards, consisting of 43 specs, 7 test methods, 1 recommended practice, and 1 classification of coppers. The standards cover: (1) copper, copper alloy and copper covered steel; wire; stranded conductors; rods, bars, and shapes; pipes and tubes; (2) aluminum: wire; stranded conductors; rods and bars; and (3) galvanized steel core wire; and galvanized iron and steel guy, messenger, span, overhead ground, and line wire. Of the material contained in this book, 20 of the specs have been revised and one of the standards is new since the previous edition. Copies of this book can be obtained from American Society for Testing Materials Headquarters, 1916 Race St., Philadelphia 3, Pa., for $3.50 each.

Nameplates

MIL-N-25076 (ASG), NAMEPLATE, IDENTIFICATION, METALLIC FOIL, ADHESIVE-BACKED, 30 MARCH 1956 . . . Design and testing requirements for adhesive-backed aluminum-foil nameplates intended for identification and other marking information on aircraft equipment and accessories are established by this spec. Aluminum-foil nameplates may be furnished as either pressure sensitive with a water-removable cellophane backing or as an adhesive-backed solvent-activated film.

Switches

MIL-S-9419B (ASG), SWITCH, TOGGLE, MOMENTARY, FOUR-POSITION ON, CENTER OFF, 10 APRIL 1956 . . . A minimum envelope, four-position, momentary on, center off, positive action, free return toggle switch which shall ensure good contact and positive current-carrying capacity when operated under conditions of aircraft service is covered in this spec.

Missile Specs Amended

MIL-D-8684 (AER), DESIGN DATA CONTACT REQUIREMENTS FOR GUIDED MISSILE WEAPON SYSTEM, AMENDMENT 1, 6 APRIL 1956 . . . Specs MIL-W-3947, Weight and Balance Control Data for Guided Missiles and MIL-M-18872, Microfilming Engineering Drawings and Related Data, Requirements For, have been added to the list of applicable specs. The five Bureau of Aeronautic "SR" type specs have been replaced by specs MIL-T-18847, MIL-I18802, MIL-D-18300, and MIL-T-18306. Instructions regarding the distribution of the structural design and test data reports have been added.

Tech Manual Standardization Proceedings Published

Proceedings of the 1955 Symposium on Standardization of Technical Manuals, sponsored by the Technical Publishing Society, are now available. The Technical Publishing Society is a California non-profit corporation organized to serve the technical communications profession. Copies of the Symposium may be obtained from the Technical Publishing Society, P.O. Box 607, Tarzana, Calif. for $1.00 per copy.

Terminal Boards

MIL-T-16784A (SHIPS), TERMINAL BOARDS, 21 MARCH 1956 . . . Terminal boards used for connections in electrical and electronic circuits are covered by this spec. A typical type designation for a terminal board covered by this spec is 6TB10. A listing of standard terminal boards is included in this spec.

Filters

MIL-F-18344A (SHIPS), FILTERS, RADIO INTERFERENCE, NAVAL SHIP AND SHORE USE, AMENDMENT 1, 17 FEBRUARY 1956

A vibration test setup with full load current and voltage applied for ac and dc filters has been added by this amendment.

ADVERTISING INDEX

October 1, 1956

CIRCLE 299 ON READER-SERVICE CARD

CIRCLE 300 ON READER-SERVICE CARD ➤

New Concept in Transistor Design for High-Frequency Applications in Military and Commercial Equipment, and Entertainment-type Receivers

Designed to provide a "built-in" accelerating field in the base region that propels charge carriers from emitter to collector, RCA-2N247—a germanium p-n-p type transistor—begins a new era in transistor operation at radio frequencies extending from the Standard AM Broadcast band well up into the short-wave bands.

Here is a design that makes possible a significant reduction in base resistance and collector capacitance—substantially increases voltage- and current-handling capability, provides shielding between base and collector leads to minimize interlead capacitance and coupling to adjacent components. The resultant benefits to designers are: (1) high input circuit efficiency, (2) excellent operating stability, (3) good automatic-gain-control capabilities over wide input-signal variations, and (4) good signal-to-noise ratio.

In addition to its major application as a radio-frequency amplifier, RCA-2N247 is also well suited as a mixer-oscillator (converter) and intermediate-frequency amplifier in entertainment-type receivers.

Adaptable to mass-production techniques, RCA-2N247 can provide for the expanding needs of high-frequency commercial and military applications. It is one more example of RCA's intensive development program in semiconductor techniques to provide high-quality transistors—*in quantity*. For more data on Drift Transistor, Type-2N247, write RCA, Commercial Engineering. Or call your RCA Field Representative.

TYPICAL OPERATION AS CLASS A RF AMPLIFIER

Common-Emitter Circuit Base Input Ambient Temperature = 25°C

	1.5 Mc	10.7 Mc
DC Collector-to-Emitter Volts	-9	-9 volts
DC Base-to-Emitter Volts	-0.2	-0.2 volt
DC Collector Current	-1	-1 ma
Collector-to-Base Feedback Capacitance	1.7	1.7 μμf
Input Resistance	1350	170 ohms
Output Resistance	75000	4500 ohms
Power Gain▲	45	24 db

▲Measured in a single-tuned unilaterolized circuit matched to the generator and load impedance for maximum transfer of power (transformer insertion losses not included).

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