

Abstracts of Bell System Technical Papers* Not Published in This Journal

Experimental Verification of the Theory of Laminated Conductors. H. S. BLACK¹, C. O. MALLINCKRODT⁵ and S. P. MORGAN¹. *I.R.E., Proc.*, **40**, pp. 902-905, August, 1952.

Clogston has discovered that if a conductor is properly laminated, there exists a particular phase velocity along the conductor for maximum penetration of the fields and minimum loss due to skin effect. An experimental coaxial line was constructed whose center conductor was laminated and whose phase velocity could be varied by changing the dielectric constant of the main dielectric. As predicted by theory, the measured attenuation was critically dependent upon phase velocity. With optimum phase velocity the attenuation, though greater than predicted by theory, was less than that of a conventional coaxial cable of the same dimensions and same main dielectric. A theoretical analysis of the experimental laminated conductor is described in an appendix x.

ASTM Standards—Their Effect on Plastics Technology. R. BURNS¹. *A.S.T.M. Bull.*, No. 183, pp. 78-80, July, 1952.

Typical Block Diagrams for a Transistor Digital Computer. J. H. FELKER¹. *A.I.E.E., Trans., Commun. & Electronics Sect.*, No. 1, pp. 175-182, July, 1952.

The first electric digital computers were built around the properties of relays. The superior speed capabilities of vacuum tubes has led in recent years to their use in new computer designs to replace relays. Because of the small size, low power consumption, and expected long life of transistors, it now appears that the transistor will replace the vacuum tube as a computer element. This paper presents a study of binary computer functions with recommended mechanizations that were selected because they appeared to be readily attainable with transistors now under development. Block diagrams are presented of switches, memory units, arithmetic units, and other basic components. Estimates are given for the number of parts required in the units. It is concluded that a high-performance all-semiconductor computer can be built with germanium diodes and transistors.

* Certain of these papers are available as Bell System Monographs and may be obtained on request to the Publication Department, Bell Telephone Laboratories, Inc., 463 West Street, New York 14, N. Y. For papers available in this form, the monograph number is given in parentheses following the date of publication, and this number should be given in all requests.

¹ Bell Telephone Laboratories.

⁵ Hughes Aircraft Company, Culver City, California

A Broad-Band Interdigital Circuit for Use in Traveling-Wave-Type Amplifiers. R. C. FLETCHER¹. *I.R.E., Proc.*, **40**, pp. 951-958, August, 1952.

Because of its high power-handling capacity, the interdigital circuit has been considered for use in traveling-wave-type amplifiers. An analysis is presented here which indicates that this type of circuit can be arranged to give constant phase velocity over a wide bandwidth (30 per cent), as required to give constant gain. The analysis is qualitatively checked experimentally. The impedance parameter (proportional to the cube of the gain in db) is approximately the same as the flattened helix, (such as has been used for the magnetron amplifier) and about one-third that of the conventional circular helix.

Copper as an Acceptor Element in Germanium. C. S. FULLER¹ and J. D. STRUTHERS¹. *Phys. Rev.*, **87**, pp. 526-527, August 1, 1952.

Properties of Thermally Produced Acceptors in Germanium. C. S. FULLER¹, H. C. THEUERER¹ and W. VAN ROOSBROECK¹. *Phys. Rev.*, **85**, pp. 678-679, February 15, 1952.

Initial Permeability and Related Losses in Ferrites. J. K. GALT¹. *Ceramic Age*, **60**, pp. 29-33, August, 1952.

Three-Phase Power From Single-Phase Source. A. L. HOLCOMB⁶, *S.M.P.T.E., Jl.*, **59**, pp. 32-39, July, 1952.

Described is the development of a nonrotating device for the conversion of single-phase 115-volt power to a three-phase 230-volt form for the synchronous operation of cameras, sound recorders and other film pulling mechanisms associated with production of motion pictures.

Dominant Wave Transmission Characteristics of a Multimode Round Waveguide. A. P. KING¹. *I.R.E., Proc.*, **40**, pp. 966-969, August, 1952.

This paper presents some dominant wave transmission characteristics of multimode round waveguide lines in the 4-kmc range of frequencies. The use of such waveguide lines offers the advantages of lower transmission losses than obtainable with single-mode rectangular waveguide, and relative ease of making good joints. Possible mode conversion effects, including dominant mode elliptical polarization, have been examined and found to be innocuous. As a result, cross-polarized dominant waves can be used to provide two reasonably independent signaling channels at the same frequency in one pipe. The experimental results obtained with a straight line 2.812-inch inside diameter and length of 150 feet are given.

Superconductivity in the Cobalt-Silicon System. B. T. MATTHIAS¹. Letter to the Editor. *Phys. Rev.*, **87**, p. 380, July 15, 1952.

¹ Bell Telephone Laboratories

⁶ Westrex

Simple Phase-Angle Measurement Technique. J. A. RUDISILL, JR.³. *Electronics*, **25**, pp. 228, 232, 236, September, 1952.

Solid State Physics in Electronics and in Metallurgy. W. SHOCKLEY¹. *Jl. Metals*, **4**, pp. 829-842, August, 1952. (Monograph 2011).

Impurity Effects in the Thermal Conversion of Germanium. W. P. SLICHTER¹ and E. D. KOLB¹. *Phys. Rev.*, **87**, pp. 527-528, August 1, 1952.

Traffic Engineering Design of Dial Telephone Exchanges. J. A. STEWART⁴. *Midwest Engr.*, **4**, pp. 3-5, 17-18, May, 1952.

Single-Crystal Germanium. G. K. TEAL¹, M. SPARKS¹ and E. BUEHLER¹. *I.R.E., Proc.*, **40**, pp. 906-909, August 1952.

Significant advances have been made in the development of new types of transistors, photocells, and rectifiers and in the improvement of the reproducibility and reliability of the point-contact transistor. A key factor in this development has been the use of single-crystal germanium having a high degree of lattice perfection and compositional control. Of particular interest to the device-development engineer is the fact that the rectifying barriers between the *p*-type and *n*-type sections behave in a manner predictable from the measured properties of each section. The exceptionally long lifetime of injected carriers observed in the material and the high degree of control over its chemical composition make it ideally suitable for the production of *p-n* structures. The ranges of properties of germanium single crystals which are now realizable are given, as well as their present degree of control.

Lead-Acid Stationary Batteries. U. B. THOMAS¹. *Electrochem. Soc. Jl.*, **99**, pp. 238C-241C, September, 1952.

Polymorphism of $ND_4D_2PO_4$. E. A. WOOD¹, W. J. MERZ¹ and B. T. MATTHIAS¹. *Phys. Rev.*, **87**, p. 544, August 1, 1952.

Lightning Protection for Mobile Radio Fixed Stations. D. W. BODLE¹. *I.R.E. Trans., P.G.V.C.-1*, pp. 122-133, February, 1952.

Equipment in fixed stations of a mobile radio system is susceptible to damage from lightning strokes to either the antennas or the connecting power and land communication facilities unless special protection is provided. The problem, however, is not alone one of protecting the station equipment, but consideration must also be given to the protection of these connecting facilities to insure their continuity of service. The causes of and factors affecting lightning damage are discussed, including the probable incidence of strokes to the antennas. General protection principles are outlined, and the application of specific protection methods is described.

¹ Bell Telephone Laboratories

³ Western Electric Company

⁴ Illinois Bell Telephone Company

Matching Coax Line to the Ground-Plane Antenna. R. T. DeCAMP². *QST*, **36**, pp. 18-19, 120, 122, September, 1952.

This article describes a method for predetermining antenna and matching-stub dimensions for matching any selected transmission line. Although applied particularly to the ground-plane antenna, the curves are useful for half-wave dipoles if allowance is made, when necessary, for the effect of ground on the antenna characteristics.

The Telephone System in National Defense. C. M. MAPES². *Military Engr.*, **44**, pp. 375-377, September-October, 1952.

Multi-Element Directional Couplers. S. E. MILLER¹ and W. W. MUMFORD¹. *I.R.E.*, *Proc.*, **40**, pp. 1071-1078, September 1952.

It is shown that the backward wave in a directional coupler is related to the shape of the function describing the coupling between transmission lines by the Fourier transform. This facilitates the design of directional couplers for arbitrary directivities over any prescribed frequency band. Tightly coupled directional couplers are analyzed in simple terms, and it is shown that any desired loss ratio, including complete power transfer between lines, may be achieved. The theories are verified using waveguide models operating at 4,000, 24,000, and 48,000 mc, and it is indicated that the work is applicable to many types of electrical and acoustic transmission lines.

Segregation of Two Solutes, with Particular Reference to Semiconductors. W. G. PFANN¹. *Jl. Metals*, **4**, pp. 861-865, August, 1952. (Monograph 2020).

The simultaneous segregation of two solutes during the directional solidification of an ingot is treated mathematically on the basis of simplifying assumptions. Expressions are derived for the difference in concentration of two solutes, and for the location and concentration gradient of a pn barrier formed in a semiconductor by the segregation of a donor and an acceptor.

Nonsynchronous Time Division with Holding and with Random Sampling. J. R. PIERCE¹ and A. L. HOPPER¹. *I.R.E.*, *Proc.*, **40**, pp. 1079-1088, September, 1952.

There is a general type of system in which an indefinitely large number of transmitters can have access to any of an indefinitely large number of receivers over a medium of limited band-width. In these systems, signal-to-noise ratio goes down as more transmitters are used simultaneously. This paper describes a particular system which sends samples by means of coded pulse groups sent at random times. The signal-to-noise ratio is good in the absence of interference and the effect of interference is minimized by holding the previous sample if a sample is lost. An experimental system worked satisfactorily and gave close to the predicted signal-to-noise ratio might be used to provide communication and automatic switching in rural telephony, or for other applications.

¹ Bell Telephone Laboratories

² American Telephone and Telegraph Company

An Improved Electrolysis Switch. V. B. PIKE¹. *Corrosion*, **8**, pp. 311-313; disc. pp. 322-323, September, 1952. (Monograph 2021).

An improved electrolysis switch has been placed in use in the Bell System for mitigation of electrolysis of cables by stray currents. It consists of three relays operating in sequence, namely control, intermediate and drain relays. It automatically closes a drainage bond between a lead-covered underground cable and a power return ground when stray current is picked up by the cable to such an extent as to make some of the sheath positive with respect to its environment. It also opens bond when the drainage current falls to zero and drainage is no longer required. Two sizes are used capable of draining 200 amperes and 400 amperes, respectively. Its action is very fast, only 0.015 second elapsing from the time the control circuit releases until opening of the drainage bond. Separate adjustments are available for setting the voltage at which the switch closes and opens the drainage bond. A capacitive voltage booster enables switch operation over longer battery power supply wires than is possible if the booster is not used. A power supply unit consisting of a stepdown transformer and selenium rectifier is also available to operate the switch with power drawn from an AC power source if the switch must be installed beyond reach of the battery power. A sealed steel housing enables the switch to withstand submersion and permits installation in very damp locations.

Statistics of the Recombinations of Holes and Electrons. W. SHOCKLEY¹ and W. T. READ, JR.¹. *Phys. Rev.*, **87**, pp. 835-842, September 1, 1952. (Monograph 2022).

The statistics of the recombination of holes and electrons in semiconductors is analyzed on the basis of a model in which the recombination occurs through the mechanism of trapping. A trap is assumed to have an energy level in the energy gap so that its charge may have either of two values differing by one electronic charge. The dependence of lifetime of injected carriers upon initial conductivity and upon injected carrier density is discussed.

Motion of Gaseous Ions in a Strong Electric Field. G. H. WANNIER¹. *Phys. Rev.*, **87**, pp. 795-798, September 1, 1952. (Monograph 2023).

This paper continues an earlier one on the same subject. Its object is to elucidate the nature of the random motion of an ion about its drift. In Section F it is shown that this motion can be described as a diffusion with a diffusion tensor axially symmetric about the field. If the mean free time between the collisions of an ion with molecules is independent of speed, then explicit expressions may be derived for the two diffusion coefficients; these expressions are written down without proof in Section G; they are connected with the mobility by a natural extension of the Einstein relation. In Section H, the longitudinal diffusion coefficient is computed numerically for the hard sphere model, high field, and mass ratio 1; the method of computation is the same as in Section D. Finally, it is shown in Section I how approximate formulas of wider validity can be inferred from the ones obtained.

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High-Frequency Crystal Units for Primary Frequency Standards. A. W. WARNER¹. *I.R.E., Proc.*, **40**, pp. 1030-1033, September, 1952.

A new approach to the design of crystal units for primary frequency standard use has resulted in crystal units in the 3- to 20-mc frequency range characterized by high Q and low capacitance in the series arm of the equivalent electrical circuit. By utilizing the overtone frequency of specially shaped AT-cut quartz plates, both Q and the rate of impedance change with frequency are enhanced together, and in addition the stability with time of the crystal unit is increased because of a larger frequency-determining dimension. Additional characteristics of the crystal units include small size, stability under conditions of vibration and shock, and low-temperature coefficient. Crystal-oscillator stabilities of one part in 10^8 per month have been achieved without recourse to stabilized circuits.

¹ Bell Telephone Laboratories