Abstracts of Bell System Technical Papers Not Published in This Journal

*A Full Automatic Private Line Teletypewriter Switching System.** W. M. BACON[1] and G. A. LOCKE.[1] *Elec. Engg.*, v. 70, pp. 408–413, May, 1951.

ABSTRACT—A full automatic teletypewriter message switching system has been developed for use in private line networks involving one or more switching centers and a multiplicity of local or long distance lines, each of which may have one or more stations. This system provides fast teletypewriter communication from any station to any other station or group of stations in the network.

*Crossbar Tandem System.** R. E. COLLIS.[1] *A.I.E.E., Trans.*, v. 69, pt. 2, pp. 997–1004, 1950.

*A Study of Nuclear and Electronic Magnetic Resonance.** K. K. DARROW.[1] *Elec. Engg.*, v. 70, pp. 401–404, May, 1951.

ABSTRACT—Since the discovery of magnetic resonance in solids, liquids, and gases in 1945, the phenomenon has been used in the determination of nuclear magnetic moments and magnetic field strengths, as well as in the study of crystal structure and relaxation times.

The Genesis of Submarine Cables. L. ESPENSCHIED.[1] Bibliography. *Elec. Engg.*, 70, pp. 379–383, May, 1951.

ABSTRACT—It was a century ago that the first submarine cable was laid between Dover and Calais. To mark this centenary the author reviews some of the events leading up to this achievement which made possible further advances in the communications field, such as laying of the transatlantic cable by the Great Eastern escorted by four ships, as shown in the picture.

Borocarbon Film Resistors. R. O. GRISDALE,[1] A. C. PFISTER[1], and G. K. TEAL.[1] *Natl. Electronics Conference, Proc.*. v. 6, pp. 441–442, 1950.

ABSTRACT—The carbon film type of resistor is particularly useful at high frequencies, for not only can it be made to have small reactance but it is, in effect, all skin so that there is no increase in resistance at high frequencies due to skin effect. The film is also well cooled through its intimate contact with the core and this makes possible the dissipation of large amounts of power per unit area. While primarily developed for high frequency applications in this country, the pyrolytic carbon resistor possesses other

characteristics which have led and are leading to greatly expanded fields of application. Principal among these are the tolerances of one per cent or better attainable in production, the stability in use, the relatively small and predictable temperature coefficient of resistance, and the low noise level. These properties result in large part from the ultimate crystalline structure of the carbon films.

Some Methods of Solving Hyperbolic and Parabolic Partial Differential Equations. R. W. HAMMING.[1] International Business Machines Corp. Computation seminar. *Proceedings, Dec., 1949, Ed. by C. C. Hurd. N. Y., I.B.M.,* pp. 14–23, 1951.

ABSTRACT—The main purpose of this paper is to present a broad, non-mathematical introduction to the general field of computing the solutions of partial differential equations of the hyperbolic and parabolic types, as well as some related classes of equations. I hope to show that there exist methods for reducing such problems to a form suitable for formal computation, with a reasonable expectation of arriving at a usable answer.

I have selected four particular problems to discuss. These have been chosen and arranged to bring out certain points which I feel are important. The first problem is almost trivial as there exist well-known analytical methods for solving it, while the last is a rather complicated partial differential-integral equation for which there is practically no known mathematical theory.

Electrography and Electro-Spot Testing.*H. W. HERMANCE[1] and H. V. WADLOW.[1] *Physical Methods in Chemical Analysis; Ed. by W. G. Berl. N. Y., Academic Press,* v. 2, pp. 155–228, 1951.

Correlation Energy and the Heat of Sublimation of Lithium. C. HERRING.[1] Letter to the editor. References. *Phys. Rev.,* v. 82, pp. 282–283, Apr. 15, 1951.

Some Theorems on the Free Energies of Crystal Surfaces.* C. HERRING.[1] References. *Phys. Rev.,* v. 82, pp. 87–93, Apr. 1, 1951.

ABSTRACT—Although the interpretation of experiments in such fields as the shapes of small particles and the thermal etching of surfaces usually involves problems of kinetics rather than mere equilibrium considerations, it is suggested that a knowledge of the relative free energies of different shapes or surface configurations may provide a useful perspective. This paper presents some theorems on these relative free energies which follow from the Wulff construction for the equilibrium shape of a small particle, and some relations between atomic models of crystal surfaces and the surface free energy function used in this construction. Equilibrium shapes of

crystals and of non-crystalline anisotropic media are classified, and it is pointed out that the possibilities for crystals include smoothly rounded as well as sharp-cornered forms. The condition is formulated for thermodynamic stability of a flat crystal face with respect to formation of hill-and-valley structure. A discussion is presented of the limitations on the applicability of the results imposed by the dependence of surface free energy on curvature; and it is concluded that these limitations are not likely to be serious for most real substances, though they are serious for certain idealized theoretical models.

*The Crystal Structures of NiO·3BaO, NiO·BaO, BaNiO₃ and Intermediate Phases With Composition Near Ba₂Ni₂O₅ ; With a Note on NiO.** J. J. LANDER.[1] References. *Acta Cryst.*, v. 4, pp. 148–156, Mar., 1951.

ABSTRACT—The crystal structures of $NiO \cdot 3BaO$, $NiO \cdot BaO$ and $BaNiO_3$ have been determined from X-ray diffraction data, and data are given for phases with composition near that represented by $Ba_2Ni_2O_5$. In each of these structures nickel behaves in a novel fashion. A coplanar triangular arrangement of oxygen around nickel is found in $NiO \cdot 3BaO$. In $BaNiO_3$ nickel has a valence of four and the structure is a close-packed hexagonal stacking of planar arrangements found in perovskite 111 planes. The compound $NiO \cdot BaO$ has a magnetic moment corresponding to two unpaired electrons, whereas the deduced coplanar square arrangement of oxygen around nickel suggests that there should be no unpaired electrons. Compounds with composition near $Ba_2Ni_2O_5$ contain an amount of oxygen which is a continuous function of temperature and possibly contain mixtures of bi- and tetravalent nickel.

The problem of NiO having octahedral co-ordination of oxygen is considered.

New Ferroelectric Tartrates. B. T. MATTHIAS[1] and J. K. HULM. Letter to the editor. *Phys. Rev.*, v. 82, pp. 108–109, April 1, 1951.

*A Negative Impedance Repeater.** J. L. MERRILL, JR.[1]. *A.I.E.E., Trans.*, v. 69, pt. 2, pp. 1461–1466, 1950.

Interexchange Tandem Trunking in the Los Angeles Metropolitan Area. W. F. PFEIFFER[1]. *A.I.E.E., Trans.*, v. 69, pt. 2, pp. 1071–1079, 1950.

ABSTRACT—Twenty-four years have elapsed since the first large-scale machine switching tandem system was designed and installed for service in Los Angeles. As an intermediate switching center, the tandem office enabled operators to use the dial method of operation for establishing interexchange telephone connections over the associated trunking network. During the intervening years, it has facilitated the rapid handling of tele-

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phone calls between the various communities in and around the city. Step-by-step tandem equipment was employed and, as the volume of calls grew, the trunk capacity was increased by installing additional switching equipment. In 1946 it became evident that the abnormal rate of growth required additions substantially beyond the practical size limit of the step-by-step tandem unit. To solve the resulting problem, it became necessary to reorganize the tandem trunking system and select a multiunit tandem switching plan. It also provided an opportunity to consider the application of the more recently developed crossbar tandem switching system. This paper reviews the factors affecting the general problem of interexchange trunking which have led to the development of the present tandem network in the Los Angeles metropolitan area. It describes the major elements of a system which now employs a total of five tandem switching units, three of which are crossbar tandem offices.

p-n Junction Rectifier and Photo-cell. W. J. PIETENPOL[1]. Letter to the editor. *Phys. Rev.*, v. 82, pp. 120–121, Apr. 1, 1951.

*Formulas for the Determination of Residual Stress in Wires by the Layer Removal Method.** W. T. READ, JR.[1]. *Jl. Applied Phys.*, v. 22, pp. 415–416, Apr., 1951.

ABSTRACT—The distribution of residual axial stress in a beam or wire of circular cross section is derived as a function of the moment required to straighten the wire after removal of successive layers of material. Application of the formulas involves two graphical differentiations and integrations of experimental curves.

Observation of Magnetic Domains by the Kerr Effect. H. J. WILLIAMS[1], F. G. FOSTER[1], and E. A. WOOD[1]. Letter to the editor. *Phys. Rev.*, v. 82, pp. 119–120, Apr. 1, 1951.

*Particle Size in Suspension Polymerization.** F. H. WINSLOW[1] and W. MATREYEK[1]. Bibliography. *Ind. & Engg. Chem.*, v. 43, pp. 1108–1112, May, 1951.

ABSTRACT—Control of size and geometrical form of densely cross-linked hydrocarbon polymers yields fluid spherical powders useful as dielectrics and in rheological studies. Such studies also bear on polymer forms important in ion exchange resins.

Several significant factors influencing the preparation of polymer spheroids have been established on a semi-quantitative basis: Polyvinyl alcohol proved to be a highly efficient stabilizer for polymer spheroid preparations. Under comparable conditions, (a) high molecular weight grades, (b) partially hydrolyzed grades, and (c) high concentrations of stabilizer were

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associated with spheroids of lower mean diameters. These generalizations cover suspension stabilization down to roughly 0.1% stabilizer. The concentration limits where suspending action begins are, however, of special interest. Here it was found that the number of polyvinyl alcohol molecules present became important—that is, for equal weight concentrations in the vicinity of 0.005%, low molecular weight polymer (19,000) produced stabilized (although large) spheres whereas the usual high molecular weight polymer (95,000) was ineffective.

Close to the maximum possible yield of well-formed spheroids was reproducibly obtained in narrow size distribution and with average spheroid diameters ranging from 5 microns to several millimeters in diameter—a thousand-fold variation in dimensions.

Elastic and Electromechanical Coupling Coefficients of Single-Crystal Barium Titanate. W. L. BOND[1], W. P. MASON[1], and H. J. McSKIMIN[1]. Letter to the editor. *Phys. Rev.*, v. 82, pp. 442–443, May 1, 1951.

Making Small Spheres. W. L. BOND[1]. *Rev. Sci. Instruments*, v. 22, pp. 344–345, May, 1951.

Submarine Telephone Cable With Submerged Repeaters. J. J. GILBERT[1]. *Electronics*, v. 24, pp. 164, 168, 172+, June, 1951.

*Electrode Reactions in the Glow Discharge.** F. E. HAWORTH[1]. References. *Jl. Applied Phys.*, v. 22, pp. 606–609, May, 1951.

ABSTRACT—The reactions which occur at silver electrodes in a normal glow discharge in air have been determined. These are: (1) formation of $AgNO_2$ and some Ag_2O at the anode at the rate of 3.4 µg/coulomb; (2) loss of metal from the cathode by chemical action at the rate of 3.5 µg/coulomb (probably the same reaction as (1) with subsequent loss of the reaction products by the greater heating of the cathode, but this hypothesis has not been established); and (3) normal sputtering loss at the cathode at the rate of 0.4 µg/coulomg. These processes result in building a conducting layer on the anode. If the electrode separation is so small that the anode extends into the region of the cathode fall, then the high electric field pulls the newly formed and not very coherent growth upon the anode across into a bridge between the electrodes.

*Storing Video Information.**A. L. HOPPER[1]. *Electronics*, v. 24, pp. 122–125, June, 1951.

ABSTRACT—Comparison of signal amplitudes along adjacent television scanning lines can be made by storing the video information of one line for 63.5 microseconds. Storage is done in an ultrasonic delay line employing a fused silica bar with quartz transducers.

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ABSTRACT—The phase system BaO–NiO has been studied largely by means of X-ray diffraction. The two compounds NiO BaO and NiO 3BaO occur in the system. Their preparation and properties are described. NiO BaO is black, stable in air, orthorhombic, and melts at 1240°. NiO 3BaO is gray-green, unstable in air, hexagonal, and melts at 1160°. A eutectic melting at 1080° is observed between these compounds, but none between NiO 3BaO and BaO. Intersolubility of all solid phases in the system is small, even at high temperatures, but quantitative data have not been obtained.

*A Phenomenological Derivation of the First- and Second-Order Magnetostriction and Morphic Effects for a Nickel Crystal.** W. P. MASON[1]. References. *Phys. Rev.*, v. 82, pp. 715–723, June 1, 1951.

ABSTRACT—In order to account for experimental results which showed that the saturation elastic constants of a single nickel crystal varied with the direction of magnetization, a phenomenological investigation has been made of the stress, strain, and magnetic relations for single nickel crystals. The variation in elastic constants is shown to be a "morphic" effect caused by the change in the crystal symmetry due to the magnetostriction effect. In the energy equation this effect is represented by additional terms which involve squares and products of both the magnetic intensities and stresses. These terms are as large as the magnetostrictive terms when the stresses are of the order of 10^{10} dynes/cm². The energy equation has been used to derive the first- and second-order magnetostrictive effect, and the resulting terms agree with Becker and Döring's empirical constants for saturation conditions. For smaller magnetic intensities the terms divide up into first- and second-order terms which vary differently with magnetic field intensity. It is shown that the morphic effects involve six measurable constants, and some of these are evaluated experimentally.

*Dielectric Properties of Sodium and Potassium Niobates.** B. T. MATTHIAS[1] and J. P. REMEIKA[1]. *Phys. Rev.*, v. 82, pp. 727–729, June 1, 1951.

ABSTRACT—The following paper deals with evidence of ferroelectricity in $KNbO_3$ and $NaNbO_3$. Temperatures at which both materials undergo crystallographic changes and corresponding changes in dielectric constant and loss tangent are reported. Photographs of dielectric hysteresis loops and values of saturation polarization taken at various points over a temperature range are given for $KNbO_3$.

Ferroelectricity. B. T. MATTHIAS[1]. Bibliography. *Science*, v. 113, pp. 591–596, May 25, 1951.

ABSTRACT—Under the name of Ferroelectrics one classifies those materials which exhibit dielectric anomalies phenomenologically similar to the mag-

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netic behavior of the ferromagnetics. Perhaps it would have been more logical to use the term Rochelle electrics, thus emphasizing the similarity in the dielectric behavior to that of Rochelle salt, for which this behavior was first discovered by J. Valasek.

In this discussion the known ferroelectrics will be listed, and the various theories that have been created to explain them will be examined.

Theory of Ferroelectric Behavior of Barium Titanate. P. W. ANDERSON[1]. References. *Ceramic Age*, v. 57, pp. 29–30, 33+, April, 1951.

Criterion for Superconductivity. J. BARDEEN[1]. Letter to the Editor. *Phys. Rev.*, v. 82, pp. 978–979, June 15, 1951.

*Magnetic Domain Patterns.** R. M. BOZORTH[1]. Bibliography. *Jl. de Physique*, v. 12, pp. 308–321, March, 1951.

Electron Temperature vs Noise Temperature in Low Pressure Mercury-Argon Discharges. M. A. EASLEY[1] and W. W. MUMFORD[1]. Letter to the Editor. *Jl. Applied Phys.*, v. 22, pp. 846–847, June, 1951.

*The Origin of Bombardment-Enhanced Thermionic Emission.** J. B. JOHNSON[1]. References. *Phys. Rev.*, v. 83, pp. 49–53, July 1, 1951.

ABSTRACT—Measurements on bombardment-enhanced thermionic emission from oxide cathodes show that (a) the effect is not related to normal fading and recovery of thermionic emission; (b) the emitted electrons have energies in the thermal range rather than in the secondary range. Calculations indicate that the electron bombardment releases more than enough internal secondaries to account for the effect as increased thermionic emission. A more comprehensive theory is needed for explaining why the observed effect is not even larger.

Dipolar Domains in Paramagnetic Crystals at Low Temperatures. C. KITTELL[1]. Letter to the Editor. *Phys. Rev.*, v. 82, pp. 965–966, June 15, 1951.

*Methods of Measuring Adjacent-Band Radiation from Radio Transmitters.** N. LUND[1]. *I.R.E. Proc.*, v. 39, pp. 653–656, June, 1951.

ABSTRACT—A review of three possible methods of measuring or estimating adjacent-band radiation characteristics of a radio transmitter is given. These three methods differ in the type of signal applied to the transmitter and may be termed the two-tone, normal signal, and thermal noise methods. Measurements on a multichannel single-sideband transmitter using each of these methods are presented to show that there is a good correlation between the normal signal and thermal noise methods.

An empirical method for calculating the slope of the adjacent-band radiation as a function of frequency from the measured two-tone distortion values

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is given, and the measured and calculated slopes are shown to be in fairly good agreement.

Microwave Spectrum in NO_2. K. B. Mc AFEE, JR.[1]. Letter to the Editor. *Phys. Rev.*, v. 82, p. 971, June 15, 1951.

A Simple Electronic Differential Analyzer as a Demonstration and Laboratory Aid to Instruction in Engineering. M. H. NICHOLS[1] and D. W. HAGELBARGER[1]. *Jl. Engg. Education*, v. 41, pp. 621–630, June, 1951.

Telecommunications. H. S. OSBORNE[1]. *Ordnance*, v. 36, pp. 87–90, July–August, 1951.

Triangular Permutation Numbers. J. RIORDAN[1]. References. *Am. Math. Soc., Proc.*, v. 2, pp. 429–432, June, 1951.

*Measurements of Dynamic Internal Dissipation and Elasticity of Soft Plastics.** H. C. RORDEN[1] and A. GRIECO[1]. *Jl. Applied Phys.*, v. 22, pp. 842–845, June, 1951.

ABSTRACT—In order to measure the mechanical properties of soft plastics over wide frequency and temperature ranges two new techniques have been devised. The first one, which operates in the frequency range of a few cycles, uses a horizontal oscillating pendulum. The shear impedance of the sample is measured by mounting a small pad of the material between the vibrating pendulum and a fixed platform and determining the change in frequency and the change in the decrement caused by the sample. From these measurements the shear mechanical resistance and reactance of the specimen can be determined. The other technique, which is applicable in the frequency range from 100 cycles to 10,000 cycles, makes use of a vibrating tuning fork. Two identical samples are mounted between a stationary weight and the moving tines, and the shear mechanical impedance is determined by determining the change in frequency and change in decrement caused by the specimen. These two techniques have been applied to measuring the shear properties of a number of soft plastics including Pyralin, Koroseal, Keldur, polyvinyl butyral, Thiokol, and gum rubber. All of these show relaxation effects. The polyvinyl butyral appears to be approaching a crystalline elastic stage at the low frequency of 1000 cycles, while gum rubber remains in a quasi-configurational stage from 2 cycles to 1000 cycles.

*The Mobility of Electrons in Silver Chloride.** J. R. HAYNES[1] and W. SHOCKLEY[1]. References. *Phys. Rev.*, v. 82, pp. 935–943, June 15, 1951.

ABSTRACT—Techniques are described which utilize the "print out effect" to obtain both the direction and velocity of photoelectrons in silver chloride crystals in an electric field. Hall mobility of the electrons is calculated from their change in direction produced by crossed electric and magnetic fields.

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Drift mobility of the electrons is obtained by measurement of their velocity in known electric fields. The value obtained for the Hall mobility ($R\sigma$) multiplied by $8/3\pi$ is 51 cm²/volt sec at 25°C. The values obtained for the drift mobility are shown to be a function of temperature. A value of 49.5 cm²/volt sec was obtained at 25°C, which is within experimental error of $(8/3\pi)R\sigma$, indicating that acoustical scattering is the principal mechanism and that temporary trapping is unimportant. A summary of the behavior of conduction electrons in silver chloride, calculated from the results of these experiments, is included.

*p-n Junction Transistors.** W. SHOCKLEY[1], M. SPARKS[1], and G. K. TEAL[1]. References. *Phys. Rev.*, v. 83, pp. 151–162, July 1, 1951.

ABSTRACT—The effects of diffusion of electrons through a thin p-type layer of germanium have been studied in specimens consisting of two n-type regions with the p-type region interposed. It is found that potentials applied to one n-type region are transmitted by diffusing electrons through the p-type layer although the latter is grounded through an ohmic contact. When one of the p-n junctions is biased to saturation, power gain can be obtained through the device. Used as "n-p-n transistors" these units will operate on currents as low as 10 microamperes and voltages as low as 0.1 volt, have power gains of 50 db, and noise figures of about 10 db at 1000 cps. Their current-voltage characteristics are in good agreement with the diffusion theory.

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