Technical Articles by Bell System Authors Not Appearing in the Bell System Technical Journal

Measurement Method for Picture Tubes. M. W. BALDWIN.[1] *Electronics*, V. 22, pp. 104–105, Nov., 1949.

Diffusion in Binary Alloys.† J. BARDEEN.[1] *Phys. Rev.*, V. 76, pp. 1403–1405, Nov. 1, 1949.

ABSTRACT—Darken has given a phenomenological theory of diffusion in binary alloys based on the assumption that each constituent diffuses independently relative to a fixed reference frame. It is shown that diffusion via vacant lattice sites leads to Darken's equations if it is assumed that the concentration of vacant sites is in thermal equilibrium. Grain boundaries and dislocations may act as sources and sinks for vacant sites and act to maintain equilibrium. The modifications required in the equations if the vacant sites are not in equilibrium are discussed.

Variable Phase-Shift Frequency-Modulated Oscillator. O. E. DE LANGE.[1] *I.R.E., Proc.*, V. 37, pp. 1328–1331, Nov., 1949.

ABSTRACT—The theory of operation of a phase-shift type of oscillator is discussed briefly. This oscillator consists of a broad-band amplifier, the output of which is fed back to the input through an electronic phase-shifting circuit. The instantaneous frequency is controlled by the phase shift through this latter circuit. True FM is obtained in that frequency deviation is directly proportional to the instantaneous amplitude of the modulating signal and substantially independent of modulation frequency.

A practical oscillator using this circuit at 65 mc is described.

Erosion of Electrical Contacts on Make.† L. H. GERMER[1] and F. E. HAWORTH.[1] *Jl. Applied Phys.*, V. 20, pp. 1085–1108, Nov., 1949.

ABSTRACT—When an electric current is established by bringing two electrodes together, they necessarily discharge a capacity. Unless the current which is set up is above 1 ampere, the erosion which is produced in a low voltage circuit is appreciable only when the capacity is of appreciable size and when it is discharged very rapidly by an arc. When the arc occurs, its energy is dissipated almost entirely upon the positive electrode and, when the circuit inductance is sufficiently low, melts out a crater intermediate in volume between the volume of metal which can be melted by the energy

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and that which can be boiled. Some of the melted metal lands on the negative electrode and, with repetition of the phenomenon, results in a mound of metal transferred from the anode to the cathode. This transfer, which is about 4×10^{-14} cc of metal per erg, is the erosion which occurs on the make of electrical contacts.

The arc voltage is of the order of 15. If the initial circuit potential is more than about 50 volts, there may be more than one arc discharge, successive discharges being in opposite directions and resulting in the transfer of metal in opposite directions—always to the electrode which is negative.

The occurrence of an arc is dependent upon the condition of the electrode surfaces and upon the circuit inductance. For "inactive" surfaces an arc does not occur for inductances greater than about 3 microhenries. Platinum surfaces can be "activated" by various organic vapors, and in the active condition they give arcs even when the circuit inductance is greater than this limiting value by a factor of 10^3.

The Conductivity of Silicon and Germanium as Affected by Chemically Introduced Impurities. G. L. PEARSON.[1] Paper presented at A. I. E. E., Swampscott, Mass., June 20–24, 1949. Included in compilation on semiconductors. *Elec. Engg.*, V. 68, pp. 1047–1056, Dec. 1949.

ABSTRACT—Silicon and germanium are semiconductors whose electrical properties are highly dependent upon the amount of impurities present. For example, the intrinsic conductivity of pure silicon at room temperature is 4×10^{-6} (ohm cm)$^{-1}$ and the addition of one boron atom for each million silicon atoms increases this to 0.8 (ohm cm)$^{-1}$, a factor of 2×10^5.

Although such impurity concentrations are too weak to be detected by standard chemical analysis, the use of radioactive tracers and the Hall effect has made it possible to make quantitative measurements at impurity concentrations as small as one part in 5×10^8.

Silicon and germanium are elements of the fourth group of the periodic table with the same crystal structure as diamonds and they have respectively 5.2×10^{22} and 4.5×10^{22} atoms per cubic centimeter. The addition of impurity elements of the third group such as boron or aluminum gives defect or p-type conductivity. Elements from the fifth group such as phosphorous, antimony or arsenic give excess or n-type conductivity.

The conductivity at room temperature, where it has been shown that each impurity atom contributes one conduction charge, is given by equation (1) where N is the number of solute atoms per cubic centimeter.

$$\sigma = A + BN. \tag{1}$$

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The constants A and B for the various alloys investigated are given in the following table:

Alloy	A	B
Si + B	4×10^{-6}	1.6×10^{-17}
Si + P	4×10^{-6}	4.8×10^{-17}
Ge + Sb	1.7×10^{-2}	4.2×10^{-16}

Equation (1) applies to solute atom concentrations as high as 5×10^{19} per cc. At higher concentrations the mobilities are lowered due to increased impurity scattering so that the computed conduction is higher than the measured.

Microstructures of Silicon Ingots.† W. G. PFANN[1] and J. H. SCAFF.[1] *Metals Trans.*, V. 185 (*Jl. Metals*, V. 1) pp. 389–392, June, 1949.

Increasing Space-Charge Waves.† J. R. PIERCE.[1] *Jl. Applied Phys.*, V. 20, pp. 1060–1066, Nov. 1949.

ABSTRACT—An earlier paper presented equations for increasing waves in the presence of two streams of charged particles having different velocities, and solved the equations assuming the velocity of one group of particles to be zero or small. Numerical solutions giving the rate of increase and the phase velocity of the increasing wave for a wide range of parameters, covering cases of ion oscillation and double-stream amplification, are presented here.

Traveling-Wave Oscilloscope. J. R. PIERCE.[1] *Electronics*, V. 22, pp. 97–99, Nov., 1949.

ABSTRACT—This paper describes a 1,000 volt oscilloscope tube with a traveling-wave deflecting system. The tube is suitable for viewing periodic signals with frequencies up to 500 mc. A signal of 0.037 volt into 75 ohms deflects the spot one spot diameter. A few milliwatts input gives a good pattern, so that the tube can be used without an amplifier. The pattern is viewed through a sixty power microscope.

P-type and N-type Silicon and the Formation of Photovoltaic Barrier in Silicon Ingots.† J. H. SCAFF,[1] H. C. THEURERER[1] and E. E. SCHUMACHER.[1] *Metals Trans.*, V. 185 (*Jl. Metals*, V. 1) pp. 383–388, Jan., 1949.

Longitudinal Noise in Audio Circuits. H. W. AUGUSTADT[1] and W. F. KANNENBERG.[1] *Audio Engg.*, V. 34, pp. 22–24, 45, Jan., 1950.

Transistors. J. A. BECKER.[1] Compilation of three papers presented at A. I. E. E. meeting Swampscott, Mass., June 20–24, 1949. *Elec. Engg.*, V. 69, pp. 58–64, Jan., 1950.

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Application of Thermistors to Control Networks.† J. H. BOLLMAN[1] and J. G. KREER.[1] *I. R. E., Proc.*, V. 38, pp. 20–26, Jan., 1950.

ABSTRACT—In connection with the application of thermistors to regulating and indicating systems, there have been derived several relations between current, voltage, resistance, and power which determine the electrical behavior of the thermistor from its various thermal and physical constants. The complete differential equation describing the time behavior of a directly heated thermistor has been developed in a form which may be solved by methods appropriate to the problem.

Sensitive Magnetometer for Very Small Areas.† D. M. CHAPIN.[1] *Rev. Sci. Instruments*, V. 20, pp. 945–946, Dec., 1949.

ABSTRACT—A vibrating wire system for measuring weak magnetic fields is described for use in very small spaces. Quartz crystals are used for drivers to get sufficient velocity with very small displacements. To adjust the driving voltage to correspond exactly to the natural crystal frequency, the crystal is also used to regulate the oscillator.

Method of Calculating Hearing Loss for Speech from an Audiogram.† H. FLETCHER.[1] *Acoustical Soc. Am., Jl.*, V. 22, pp. 1–5, Jan., 1950.

ABSTRACT—The question frequently arises, Can one compute the hearing loss of speech from the audiogram and thus make it unnecessary to make a speech test after the hearing loss for several frequencies has been recorded. This paper shows that this can be done by taking a weighted average of the exponentials of the hearing loss at each frequency. Or if β_s is the hearing loss for speech and β_f the hearing loss at each frequency,

$$10^{(\beta_s/10)} = \int G\, 10^{(\beta_f/10)} df$$

The weighting factor G was determined by Fletcher and Galt from threshold measurements of speech coming from filter systems. As specifically applied to the case of hearing loss at the five frequencies 250, 500, 1000, 2000 and 4000 cps, the above equation is approximately equivalent to

$$\beta_s = -10 \log [.01 \times 10^{-(\beta_1/10)} + .13 \times 10^{-(\beta_2/10)} + .40 \times 10^{-(\beta_3/10)} + .38 \times 10^{-(\beta_4/10)} + .08 \times 10^{-(\beta_5/10)}]$$

where β_1 is hearing loss at 250 cps
β_2 is hearing loss at 500 cps
β_3 is hearing loss at 1000 cps
β_4 is hearing loss at 2000 cps
β_5 is hearing loss at 4000 cps

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Designing for Air Purity. A. M. HANFMANN.[2] *Heating & Ventilating*, V. 47, pp. 59–64, Jan., 1950.

Reciprocity Pressure Response Formula Which Includes the Effect of the Chamber Load on the Motion of the Transducer Diaphragms.† M. S. HAWLEY.[1] *Acoustical Soc. Am., Jl.*, V. 22, pp. 56–58, Jan., 1950.

ABSTRACT—In order to reduce the effects of wave motion in the coupling chamber to permit reciprocity pressure response measurements to higher frequencies, only two of the three transducers involved are coupled at a time to the chamber. Given for these conditions is a derivation of the pressure response formula which includes the effect of the chamber load on the motion of the transducer diaphragms.

Theory of the "Forbidden" (222) Electron Reflection in the Diamond Structure.† R. D. HEIDENREICH.[1] *Phys. Rev.*, V. 77, pp. 271–283, Jan. 15, 1950.

ABSTRACT—The dynamical or wave mechanical theory of electron diffraction is extended to include several diffracted beams. In the Brillouin zone scheme this is equivalent to terminating the incident crystal wave vector at or near a zone edge or corner. The problem is then one of determining the energy levels and wave functions in the neighborhood of a corner. The solution of the Schrödinger equation near a zone corner is a linear combination of Bloch functions in which the wave vectors are determined by the boundary conditions and the requirement that the total energy be fixed. This leads to a multiplicity of wave vectors for each diffracted beam giving rise to interference phenomena and is an essential feature of the dynamical theory.

At a Brillouin zone edge formed by boundaries associated with reciprocal lattice points S and O the orthogonality of the unperturbed wave functions in conjunction with the periodic potential requires that another reciprocal lattice point λ be included in the calculation. The indices of λ must be such that $(\lambda_1\lambda_2\lambda_3) = (s_1s_2s_3) - (g_1g_2g_3)$. The perturbation at the zone edge results in non-zero amplitude coefficients Cg, Cs and Cj for the diffracted waves irrespective of whether or not the structure factor for λ , s or g vanishes. This is the basis of the explanation of the (222) reflection and since it arises through perturbation at a Brillouin zone edge or corner the term "perturbation reflection" is advanced to replace the commonly used "forbidden reflection."

The octahedron formed by the (222) Brillouin zone boundaries exhibits an array of lines due to intersections with other boundaries to form edges. This array of lines is called a "perturbation grid" and the condition for the occurrence of a (222) reflection is simply that the incident wave vector terminate on or near a grid line. Numerical intensity calculations are pre-

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sented which show that a strong (222) can be accounted for by the dynamical theory.

An impedance network model is briefly discussed which may aid in qualitative considerations of the dynamical theory for the case of several diffracted waves.

Determination of g-Values in Paramagnetic Organic Compounds by Microwave Resonance. A. N. Holden,[1] C. Kittel,[1] F. R. Merritt[1] and W. A. Yager.[1] Letter to the Editor, *Phys. Rev.*, V. 77, pp. 146–147, Jan. 1, 1950.

Nonlinear Coil Generators of Short Pulses.† L. W. Hussey.[1] *I.R.E., Proc.*, V. 38, pp. 40–44, Jan., 1950.

Abstract—Small permalloy coils and circuits have been developed which produce pulses well below a tenth of a microsecond in duration with repetition rates up to a few megacycles.

The construction of these coils is described. Low power circuits are dicussed suitable for different types of drive and different frequency ranges.

Subjective Effects in Binaural Hearing. W. Koenig.[1] Letter to the Editor, *Acoustical Soc. Am., Jl.*, V. 22, pp. 61–62, Jan., 1950.

Abstract—Experiments with a binaural telephone system disclosed some remarkable properties, notably its ability to "squelch" reverberation and background noises, as compared to a system having only one pickup. No explanation has been found for this subjective effect. It was also discovered that a well-known defect in the directional discrimination of binaural systems was remedied by a mechanical arrangement which rotated the pickup microphones as the listener turned his head.

Corrosion Testing of Buried Cables. T. J. Maitland.[3] *Corrosion*, V. 6, pp. 1–8, Jan., 1950.

40AC1 Carrier Telegraph System. A. L. Matte.[1] *Tel. & Tel. Age*, No. 2, pp. 7–9, Feb., 1950.

Giving New Life to Old Equipment. P. H. Miele.[3] *Bell Tel. Mag.*, V. 28, pp. 154–163, Autumn, 1949.

Thermionic Emission of Thin Films of Alkaline Earth Oxide Deposited by Evaporation.† G. E. Moore[1] and H. W. Allison.[1] *Phys. Rev.*, V. 77, pp. 246–257, Jan. 15, 1950.

Abstract—Monomolecular films of BaO or SrO were deposited by evaporation on clean tungsten or molybdenum surfaces with precautions to eliminate effects caused by excess metal of the oxide or by heating. Thermionic emissions of the same order of magnitude as from commercial oxide cathodes have been obtained from these systems. The results can be explained qualitatively by considering the adsorbed molecules as oriented dipoles. Although

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the results may suggest a possible mechanism for a portion of the emission from thick oxide cathodes, there exist serious obstacles to such thin film phenomena as a complete explanation.

Long Distance Finds the Way. W. H. Nunn.[3] *Bell Tel. Mag.*, V. 28, pp. 137–147, Autumn, 1949.

Private Line Services for the Aviation Industry. H. V. Roumfort.[3] *Bell Tel. Mag.*, V. 28, pp. 165–174, Autumn, 1949.

Growing and Processing of Single Crystals of Magnetic Metals.† J. G. Walker,[1] H. J. Williams[1] and R. M. Bozorth.[1] *Rev. Sci. Instruments*, V. 20, pp. 947–950, Dec., 1949.

Abstract—Single crystals of nickel, cobalt and various alloys are grown by slow cooling of the melt. They are oriented by optical means and by X-rays, and ground to the desired shape using the technique described.

A Look Around—and Ahead. L. A. Wilson.[3] *Bell Tel. Mag.*, V. 28, pp. 133–136, Autumn, 1949.

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