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Solid-State and X-Ray Physics

(PAUL E. SHEARIN presiding)

Contributed Papers

D1. Changes in Thermoelectric Power of Silver and Gold with Cold Work at Liquid Nitrogen Temperature. E. W. KAMMER, *U. S. Naval Research Laboratory.*—The thermoelectric power of high purity silver and gold wires was measured during a sequence of plastic elongation at the temperature of liquid nitrogen. After certain amounts of elongation the specimens were annealed at room temperature to reduce the number of vacancy and interstitial imperfections generated by the cold working. The thermoelectric power was then remeasured at liquid nitrogen temperature without any intervening plastic or elastic deformation. Finally the specimens were annealed above the recrystallization temperature to remove cold work induced dislocations and again the thermoelectric power was measured at liquid nitrogen temperature. The changes in thermoelectric power following each anneal are consistent with the interpretation that increasing the number of vacancy and interstitial lattice imperfections tends to make the absolute thermoelectric power more negative; increasing the number of dislocations makes the absolute thermoelectric power more positive. This could explain the fact that many elements, particularly those in the first column of the periodic table, have positive absolute thermoelectric powers at or near liquid helium temperature. At low temperatures the electron scattering may be dominated by the large number of dislocations which are permanently incorporated into a crystal during its growth from the melt and not removable to any appreciable extent by subsequent annealing.

D2. Pyroelectric Effect in Lead Zirconate-Titanate. C. V. STEPHENSON, *Alabama Polytechnic Institute.*—Berlincourt[1] has reported the peculiar behavior of the pyroelectric output of polarized polycrystalline lead zirconate-titanate. This report is concerned with the further study of this effect. The total pyroelectric output can be separated into three different effects. The first region occurring at low temperatures up to about 375°C is the normal release of the polarization charge from a ferroelectric. A second region of interest occurs in the approximate temperature range 160°C–440°C. A third region occurs at high temperatures from above 600°C down to about 250°C. The experimental data showing the pyroelectric behavior of this material and possible explanations of the differ- effects will be presented.

[1] From Sandia Corporation Report SC-3859 (TR) by Don Berlincourt, Clevite Research Center, Cleveland, Ohio.

D3. Paramagnetic Resonance in X-Irradiated Potassium Chlorate.* A. R. HUGHES, W. B. ARD, JR., AND T. E. HASTY, *University of Alabama.*—The paramagnetic resonance spectrum of x-irradiated potassium chlorate has been observed. Four groups of strongly orientation-dependent lines have been found which appear to be due to the interaction of an unpaired electron with the chlorine nucleus. These hyperfine lines have an over-all separation which changes from a minimum near zero to a maximum of approximately 250 gauss as the crystal is rotated. The g values of the interacting electron lies near 2.01 and has a small anistropy. A strong single line with a g value near 2 is also observed. This line is believed to be due to an electron trapped in an ion vacancy.

* This work supported by the Office of Ordnance Research and the Research Committee of the University of Alabama.

D4. K-Series Fluorescence Yield Measurements of Low Z Elements. RICHARD E. JOHNSTON, WILLIAM F. FREY, AND JOHN I. HOPKINS, *Vanderbilt University.*—Some studies have been made to determine the K-series fluorescence yields of V^{51} and Mn^{55} using EC capture isotopes and a proportional spectrometer. The source used in the measurement of V^{51} was a thin electroplated preparation of the radioisotope Cr^{51}. For Mn^{55} the source was Fe^{55}. Both radionuclides decay by K capture with a half-life of 27.8 days and 2.94 years, respectively. The values obtained for the K-series fluorescence yield of V^{51} and Mn^{55} are 0.305 ± 0.027 and 0.308 ± 0.037, respectively. The limitations of the method will be discussed and a comparison of the results with other values will be made.

D5. Measurement of Low-Energy X-Ray Attenuation Coefficients in Low Z Elements. RANDALL W. CARTER, WILLIAM EVERETT HUNT, AND JOHN I. HOPKINS, *Vanderbilt University.*—A series of studies has been carried out to determine attenuation coefficients of several low Z elements for x-rays in the energy range from 6–14 kev. A Bragg spectrometer with a calcite crystal and a proportional spectrometer were utilized in the measurements. Suitable foil thicknesses have been prepared by the electrolytic, vacuum vaporization and rolling methods. It has been possible to measure the attenuation coefficients of nickel, copper, zinc, cobalt, aluminum, and chromium in the energy range indicated. Wherever possible the K-jump ratio has been determined from the absorption data. Results obtained are in very good agreement with calculated values reported by the National Bureau of Standards and are believed to be accurate within 3%. The experimental arrangement and results will be presented.

D6. Effects of Inhomogeneous Compression on Pure Quadrupole Resonances.* J. L. RANDALL AND W. G. MOULTON, *University of Alabama.*—The change in amplitude of the chlorine quadrupole resonance in $NaClO_3$ powder which has been subjected to high pressures has been reported previously.[1] These experiments were carried out with a superregenerative spectrometer. These experiments have been repeated utilizing a regenerative spectrometer and conventional recording techniques so that changes in line shape may be studied. The quadrupole line in unpressed powder has a width of 1.40 ± 0.05 kc/sec between inflection points, and the root second moment is 0.87 ± 0.05 kc/sec. In powder which has been subjected to a compression of 4×10^4 psi, (the highest pressure at which we could obtain good signal-to-noise ratio) the line is 1.90 kc/sec in width and has a root second moment of 1.67 ± 0.05 kc/sec. The integrated area under the absorption line drops at 22×10^3 psi to 40% of the integrated area of unpressed powder. The ratio of second moment to line width remains nearly constant over the pressure range studied.

* This work supported by grants from the Research Corporation and the University Research Committee.

[1] W. G. Moulton and D. L. Hollis, Bull. Am. Phys. Soc. Ser. II, **2**, 282 (1957).

D7. Mechanical Properties of Thin Metallic Films.* D. B. KRAFT, T. P. STRIDER, AND J. W. BEAMS, *University of Virginia.*—The mechanical properties of thin evaporated films of gold and silver have been studied as a function of their thickness by the "bulge" method. At thicknesses of about 2×10^{-5} cm, the films show an increase in tensile strength with decrease in thickness. These values are in rough agreement

with measurements by the centrifugal method[1] on electrodeposited films of the same metals. From the stress-strain curves of the films of various thicknesses, it is possible to estimate the surface tension of the films at room temperature. The values found were the order of 10^3 dynes/cm in air, the value for gold being greater than that for silver. The curves also gave Young's moduli. An explanation of the data will be advanced.

* Supported by Office of Ordnance Research, U. S. Army.

[1] Beams, Breazeale, and Bart, Phys. Rev. **100**, 1657 (1955).

Invited Papers

D8. Observation of the Structure and Growth of Thin Metal Oxide Layers on Single Crystals. W. W. HARRIS, *Union Carbide Nuclear Company.*

D9. Frequency-Dependent Conductivity of Superconductors and the Gap Model. ROLFE E. GLOVER, III, *University of North Carolina.*

D10. Some Resent Studies on Imperfections in Crystals. LAWRENCE SLIFKIN, *University of North Carolina.*

Theoretical Physics

(L. D. HUFF presiding)

Invited Paper

E1. Observations on Low and Medium Energy Nuclear Physics in the USSR. BERNARD L. COHEN, *Oak Ridge National Laboratory.*

Contributed Papers

E2. Interpretation of Experiments Utilizing a Stopping Potential. R. D. BIRKHOFF, *Oak Ridge National Laboratory.*—If the current-voltage curve is measured for an evaluated parallel plate chamber, both of whose plates emit electrons in equal numbers, the energy distribution of these electrons may be obtained from derivatives of the curve if the angular distribution of emission is known. For electrons of charge e emitted normal to the surfaces each of area A,

$$N(V)=\frac{1}{eA}\left(\frac{di}{dV}\right)_V.$$

If the angular distribution is isotropic

$$N(V)=-\frac{1}{eA}\left[2V\left(\frac{d^2i}{dV^2}\right)_V+\left(\frac{di}{dV}\right)_V\right].$$

For a cosine angular distribution

$$N(V)=-\frac{1}{eA}V\left(\frac{d^2i}{dV^2}\right)_V.$$

The latter case is applicable to photoelectric and secondary emission experiments.

E3. Delta Modulation. ERICH PIERUSCHKA, *Ordnance Missile Laboratories* (introduced by T. A. Barr, Jr.).—A pulse code modulation system, termed delta modulation, which transmits only incremental signals representative of the deviation of the modulating signal from the previously transmitted signal will be discussed. By utilization of a binary pulse code of a single bit with delta modulation, a very simple transmission system is obtained. Alternatively, a significant improvement of signal-to-noise ratio is obtainable when a multiple bit pulse code is utilized. The simplification of both coding and decoding devices in the first system is obtained by use of an integrating feedback loop in the transmitter in which the input signal is approximated by a step function which is transmitted to the receiver by a pulse code of one unit. In this system a 50% greater band width is required than in PCM. The second method retains the principle of delta-modulation by use of n previously transmitted pulses for pulse generation in the receiver. The transmission system has a higher complexity than the normal PCM system. However, a smaller band width than that of PCM is required for an acceptable signal-to-noise ratio. The value of the noise reduction depends on band width and shape of the information spectrum, and may be between $4n$ and $10n$ decibels.

E4. Response of a Nonlinear System. J. P. HALLOWES, JR., *Ordnance Missile Laboratories* (introduced by T. A. Barr, Jr.).—The nonlinear phenomena engendered by a primitive form of a control system, the relay servomechanism,[1] are of interest. The dynamics of such a system are described by a second-order ordinary differential equation with a viscuous like damping term and a nonlinear restoring force. The nonlinear restoring force is zero for absolute values of the dependent variable less than a threshold value and a positive or negative constant for positive or negative values of the dependent variable respectively exceeding this threshold. Solutions for the autonomous equation are well known; solutions for the case when a sinusoidal forcing function is applied to the system are presented. The resonance curves found exhibit a deformation of the resonant peak in conformity with behavior expected in a nonlinear system with a "soft" restoring force. The multivalued regions of the resonance curve are shown to be regions where instability occurs by appealing to energy considerations for the system. The results of an experimental investigation of the system simulated on an analog computer are shown.

[1] H. K. Weiss, J. Aeronaut. Sci. **13**, 364 (1946).

E5. Hydromagnetic Surface Waves. E. G. HARRIS,* *The University of Tennessee.*—The properties of waves which propagate along the interface between a perfectly conducting gas and a magnetic field are studied theoretically. It is found that when the Alfvén velocity in the interior of the gas exceeds the sound velocity, normal mode solutions (free oscillations of the surface) do not exist. By formulating the problem as an initial value problem the reason for this behavior is analyzed.

* This work was supported by the U. S. Atomic Energy Commission.

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