about 2350 gauss ($\nu_n = 10$ Mc/sec) initially crossed the central conductor in slightly less than one cycle of the radiofrequency supply. Subsequently those protons which were, as a result, decelerated into a smaller radius orbit crossed the central conductor in an increasing fraction of one cycle and asymptotically approached an orbit of 4 cm radius, at which the transit time across the central conductor was one cycle, resulting in no net force on the protons.

In this apparatus the energy of the protons remains high and a larger number of revolutions can be observed than in the Jeffries type of inverted cyclotron. We obtained current peaks on a probe placed just outside the asymptotic orbit which had a full (base) width corresponding to a frequency resolution of 1 part in 16 000.

Great care has been exercised in ensuring that the protons moved in a region where the field was precisely known in terms of the spin precession frequency. All materials used in the construction of the apparatus within the magnet poles were tested, and rejected if their susceptibility was high enough to disturb the field by more than 1 part in 200 000. The magnet, which had optically flat polepieces 11 inches in diameter separated by 1 inch, gave a field which was uniform to ± 1 part in 60 000 over the working region and reproducible to ± 1 part in 200 000.

The result we obtain with this modified apparatus for the magnetic moment of the proton, corrected as above for diamagnetism in the water sample, is

$$\mu_p = 2.79281 \pm 0.00004 \text{ nuclear magnetons.}$$

The corresponding values obtained by the workers quoted are: Hipple *et al.*, 2.79276 ± 0.00006 nuclear magnetons; Jeffries, $2.7924_5 \pm 0.0002$ nuclear magnetons.

* Now at Epsom College, Surrey, England.
† Now at Atomic Energy Research Establishment, Harwell, Berkshire, England.

[1] C. D. Jeffries, Phys. Rev. **81**, 1040 (1951).
[2] Hipple, Sommer, and Thomas, Phys. Rev. **82**, 697 (1951).
[3] J. W. M. Dumond and E. R. Cohen, Revs. Modern Phys. **25**, 691 (1952).

PHYSICAL REVIEW VOLUME 99, NUMBER 5 SEPTEMBER 1, 1955

Proceedings of the American Physical Society

Minutes of the Southeastern Section at the University of Florida, Gainesville, Florida, April 7, 8, and 9, 1955

THE University of Florida in Gainesville was host to the Southeastern Section of the American Physical Society April 7, 8, and 9, 1955 on the occasion of the Section's twenty-first meeting. Two-hundred-thirty physicists from academic and research institutions in the Southeast participated in a program of fifty-five contributed and eight invited research papers arranged by M. S. McCay of the University of Chattanooga and his committee. The titles of the invited papers are listed here and the abstracts of the others appear below.

Ultra-High Vacuum Technique. Daniel Alpert, *Westinghouse Research Laboratories.*

Recent Spectroscopic Studies of Thermal Radiation in the Atmosphere. Dudley Williams, *Ohio State University.*

Nuclear Shell Structure. Ingram Bloch, *Vanderbilt University.*

Detection of the Neutrino—A Progress Report. Clyde L. Cowan, *Los Alamos Scientific Laboratory.*

The Solar Battery. Gerald L. Pearson, *Bell Telephone Laboratories.*

The Nuclear Power Reactor. Clarence E. Larson, *Oak Ridge National Laboratory.*

Current Experimental Work on the Bevatron. Robert W. Birge, *University of California.*

A Fixed-Frequency Billion-Volt Proton Cyclotron. Ted A. Welton, *Oak Ridge National Laboratory.*

During the dinner meeting the Section was welcomed to Florida by Dr. J. Wayne Reitz, president of the University, and was addressed by Dr. J. W. Buchta of the University of Minnesota and the National Science Foundation on the topic "Government-University Relations in Research and Education in Science."

A section of the meeting consisting of a forum, three invited, and five contributed papers all relating to the teaching of physics will be reported in the *American Journal of Physics.*

The Section has elected A. E. Ruark of the University of Alabama as its chairman for 1955–56. Other officers selected are Howard Carr, Alabama Polytechnic Institute, vice-chairman; Dixon Callihan, Oak Ridge National Laboratory, secretary; R. T. Lagemann, Vanderbilt University, treasurer, and K. Z. Morgan, Oak Ridge National Laboratory, member of the executive committee. W. M. Nielsen of Duke University is the retiring chairman. Thirty-three physicists were elected to the Section during the meeting bringing the membership to 538.

The 1956 meeting will be held at Fisk University, Nashville, Tennessee on March 29, 30, and 31.

Dixon Callihan, *Secretary*
The Southeastern Section
American Physical Society
Oak Ridge, Tennessee

1. The Infrared Spectrum of Hydrogen Fluoride.*† GEORGE A. KUIPERS, *K-25 Technical Division, Carbide and Carbon Chemicals Company* (introduced by A. H. Nielsen).—Earlier measurements by Talley, Kaylor, and Nielsen[1] on the fundamental vibration-rotation band of HF were limited to lines of low J-values because of the use of fluorothene windows and because of polymer absorption at high pressures. At 100°C CaF_2 windows are not etched as they are at lower temperatures and no polymer is present. Higher J-lines up to $R(11)$ and $P(11)$ were observed, permitting a more accurate evaluation of the molecular constants B_0, B_1, D_0, D_1, and ν $(1\leftarrow 0)$.

* Study being made in cooperation with the Physics Department, University of Tennessee.
† This work was done at the Oak Ridge Gaseous Diffusion Plant operated for the Government by Union Carbide and Carbon Corporation.
[1] Talley, Kaylor, and Nielsen, Phys. Rev. **77**, 529 (1950).

2. The Infrared Spectrum of SCl_2.* JOHN A. HERNDON, A. H. NIELSEN, W. H. FLETCHER, *The University of Tennessee.*—The infrared spectrum of SCl_2 has been scanned, at the University of Tennessee, from 300 to 4000 cm^{-1} in search of fundamental, overtone, and combination bands. A total of thirteen bands have been observed, two of which are of sufficient intensity to be fundamentals. These two bands are probably the ν_1 (symmetric) and ν_3 (antisymmetric) stretching vibrations. The region from 400 to 180 cm^{-1} has been investigated by Mills and Crawford[1] with a CsI prism at the University of Minnesota, who report that there are no SCl_2 bands in this region. Slides of the observed spectrum will be shown and an attempt at assignment of bands will be made.

* Supported by the Office of Ordnance Research.
[1] Private communication, February 17, 1955.

3. High-Dispersion Measurements on ν_2 of NO_2 at 200°C.* FRED L. KELLER AND ALVIN H. NIELSEN, *The University of Tennessee.*—The vibration-rotation band ν_2 of NO_2 observed prismatically by a number of investigators has been reexamined with a 1200-lines-per-inch grating. A 10 cm Monel cell equipped with silver-chloride windows was used at a pressure of 45 cm of mercury and a temperature of 200°C. The high temperature was necessary to eliminate N_2O_4 which exists in equilibrium with NO_2 at ordinary temperatures and completely obscures the central region of the band. The band has the appearance of a perpendicular band for a symmetric top except that the convergence of the lines is interrupted at the band center by the abnormal spacing of the four central lines. These central lines are also unsymmetrical in form and shade away from the band center. The use of asymmetric rotor functions does not seem to completely explain the appearance and positions of these central lines. A band analysis carried out with symmetric top assumptions and neglecting the central lines gives the band center as 749.83 cm^{-1}. The rotational constants are $\Delta(A-B)=0.327$ cm^{-1}, $(A''-B'')=7.607$ cm^{-1}, $(A'-B')=7.931$ cm^{-1}, $D_K'=2.77\times10^{-3}$ cm^{-1}, and $D_K''=2.65\times10^{-3}$ cm^{-1}.

* This work was supported by the Office of Ordnance Research, U. S. Army.

4. Vibrational Spectra, Structure, Force Constants, and Thermodynamic Properties of Arsenic Pentafluoride.* LAWRENCE K. AKERS† AND ERNEST A. JONES, *Vanderbilt University.*—The Raman spectrum of liquid AsF_5 and the infrared absorption spectrum of gaseous AsF_5 in the region 2–41 μ have been investigated. Using the observed vibrational spectra, AsF_5 has been assigned trigonal bipyramid structure with D_{3h} symmetry. The observed infrared spectrum is explained on the basis of this assignment. Force constants were calculated using the Wilson FG matrix method. The thermodynamic functions for AsF_5 were calculated for temperatures ranging from 219.96°K to 1500°K using the rigid rotator, harmonic oscillator approximations.

* Supported by the U. S. Atomic Energy Commission.
† Present address: Special Training Division, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee.

5. Infrared Intensity Measurements in Halogenated Methanes. TOM T. TRUE, NAND LAL SINGH, AND JOSEPH W. STRALEY, *The University of North Carolina.*—The measurements of the intensities of infrared absorption bands in CH_2Cl_2, CH_2Br_2, and CF_2Cl_2 have enabled us to determine values of bond moments and bond derivatives. On the basis of our work with these molecules together with the experience of others as reported in the literature we believe that one can safely conclude: (1) The magnitude of the bond moment of a particular type of bond may be strongly influenced by neighboring bonds, even to the extent in some cases of determining its sign. (2) The CH bond moment in CH_2X_2 is positive; the CX bond moment is negative. (3) The bond derivative does not in every case manifest the same sign as the bond moment. (4) The bond moment model is not adequate to explain in detail the infrared absorption intensities in the more complex molecules.

6. Emission Bands in Cu_2. N. L. SINGH, *University of North Carolina* (introduced by J. W. Straley).—A study of the emission spectrum of copper salts[1] has revealed the existence of the Cu_2 molecule in the flames. The molecule emits a continuous spectrum in the region from 5740 A to 5120 A broken by discrete bands which impart a yellow-green color to all copper-salt flames. The discrete bands form two systems involving transitions from two excited states $A^1\Pi u$ and $B^1\Pi u$ to the ground state $^1\Sigma g+$. The constants obtained from the analysis are:

State	T_e	ω_e	$\omega_e x_e$	$Do°$ (Dissociation energy)
$B^1\Pi u$	19464	100	1.5	
$A^1\Pi u$	17713	90	0.5	0.17 ev
$X^1\Sigma g$	0	150	5	

The continuum may be explained as due to a transition from a repulsive state $^3\pi g$ arising from two copper atoms in a ^2D-state to another repulsive state $^3\pi u^+$ arising from two normal atoms.

It is suggested that the two groups of bands reported by Ruamps[2] may be due to CuO or CuC. Whether the Cu_2 molecule can exist at the temperature of 2500°C can be decided by magnetic deflection experiments[3] or by absorption experiments.

[1] N. L. Singh, Proc. Indian Acad. Sci. **25**, 1–21 (1947).
[2] M. J. Ruamps, Compt. rend. **238**, 1489 (1954).
[3] A. Leu and R. G. Frazer, Z. Physik **49**, 498 (1928).

7. The Pure Rotational Spectrum of Hydrogen Fluoride.* D. F. SMITH, *Carbide and Carbon Chemicals Company,* AND A. H. NEILSEN, *University of Tennessee.*—The pure rotation spectrum of monomeric hydrogen fluoride has been observed in the region 16–23μ both in absorption and emission. Wave numbers of the absorption lines were measured on the University of Tennessee infrared grating spectrometer, while the emission spectrum was observed with Perkin-Elmer spectrometers models 21 and 12C (modified for double pass of the prism). The sample cell used for all measurements was of Monel closed with silver chloride windows and filled to one-half to one atmosphere pressure. The cell was heated to 120°C to observe lines emanating from rotational levels with $J=10$, 11, 12, and at about 300°C for $J=14$ and 15. At these temperatures polymerization of HF does not occur. The wave numbers of the lines observed were $J=10$, 441.21 cm^{-1}; $J=11$, 479.00 cm^{-1}; $J=12$, 516.27 cm^{-1}; $J=13^1$; $J=14$, 588.90 cm^{-1}; $J=15$, 624.13 cm^{-1}. These wave numbers were fitted to the formula $\nu=2(J+1)B_0-4D_0(J+1)^3$ which yielded

the rotational constant $B_0=h/8\pi^2cI_0=20.545_8$ cm^{-1} and the centrifugal stretching constant $D_0=0.00203_5$ cm^{-1} as compared with 20.555 cm^{-1} and 0.0022 cm^{-1} given previously by Talley, Kaylor, and Nielsen.[2]

* This work was done at the Oak Ridge Gaseous Diffusion Plant operated for the Government by Union Carbide and Carbon Corporation.
[1] $J=13$ was inadvertently overlooked during the measurement.
[2] Talley, Kaylor and Nielsen, Phys. Rev. **77**, 529 (1950).

8. The Effect of Sample Preparation Upon the Infrared Spectra of Polynuclear Hydrocarbons.* NELSON FUSON, MARIE-LOUISE JOSIEN AND JAMES R. LAWSON, *Fisk University and Tennessee A & I State University.*—The effect of change of state upon the spectra of the methyl-1,2-benzanthracene isomers has been made in the course of a study of the infrared spectra of polynuclear hydrocarbons which are carcinogenic. The spectra of solid samples, made by the potassium bromide pellet technique as well as in Nujol mulls, are compared to the spectra of solution samples in nonpolar solvents. Differences in band positions and intensities will be discussed. Sample preparation techniques will be described.

* This research has been supported by Grant No. 1520 from the National Cancer Institute, U. S. Public Health Service.

9. Charge Spectrum of Cl^{37} Recoils from Neutrino Emission in the Electron-Capture Decay of A^{37}. ARTHUR H. SNELL AND FRANCES PLEASONTON, *Oak Ridge National Laboratory.*—Magnetic deflection spectrometry of the 9.7 ev Cl^{37} ions which result from neutrino emission accompanying the electron-capture decay of A^{37} has shown that Auger processes leave the recoils in various states of ionization. The analyzing magnet separates the various peaks completely, and the charge distribution is found to be as follows:

Cl^{37} ionic charge	Percent abundance
1	6.2±0.1
2	15.7±0.4
3	39.2±0.5
4	26.7±0.4
5	10.0±0.2
6	1.8±0.1
7	0.4±0.1

(The neutrals are not measured in this experiment.) With predeflection acceleration amounting to 500 volts, the natural widths of the lines were small compared with the transmission width of the analyzer, and the data were obtained simply by setting on the individual lines and measuring counting rates. The only correction needed concerned the efficiency of the detector (electron multiplier) which varied slightly with the energy and charge of the impinging ions; this correction was obtained from integral bias curves obtained by using the recoil peaks themselves for charges 2, 3, and 4, and employing an ion source for the singly charged chlorine ions. An experiment at doubled pressure (1.6×10^{-5} mm Hg) indicated that the effect of collisions in the residual gas is to "degrade" the charge spectrum, but at these pressures the effect is small.

10. Neutron Resonances in the Kilovolt Region: F^{19} and P^{31}.† J. R. PATTERSON* AND H. W. NEWSON, *Duke University,* AND E. MERZBACHER, *University of North Carolina.*—Total neutron cross sections have been measured by the transmission method. The cross-section curve of F^{19} shows resonances at 99, 50, and 28 kev. The apparent peak cross sections are too high for a total angular momentum $J=O$. Assuming that $J=1$, the area method gives average widths 0.4, 1.5, and 10 kev, respectively. If these resonances are due to S-wave neutrons there should be sharp minima at 83, 47, and 27 kev. In spite of the fact that the resolving power is equal to or less than the displacements between maxima and minima, no such minima are found and the cross sections in these regions are 3 to 5 barns greater than should be expected on the S-wave assumption. It seems very unlikely that the resonances are due to S-waves. If the resonances are due to P-waves the possibility that $J=2$ must be investigated. However, measurements of the two higher energy peaks with several sample thicknesses yielded much less consistent results for the assumption $J=2$ than for $J=1$; $J=1$ is slightly more likely than $J=2$ for the 27-kev resonance. The reduced widths are 0.09, 0.13, and 0.34 kev on the assumption that $J=1$ and $l=1$ for all three resonances. Since only three resonances occur below 220 kev, the strength function may be estimated to be of the order of 25×10^{-4}. The cross-section curve of P^{31} is remarkable in that no resonances of appreciable strength occur below 140 kev. The width of the resonance at 147 kev is about 1 kev assuming that $J=1$.

† This work was supported by the U. S. Atomic Energy Commission.
* Now at Furman University.

11. Neutron Resonances in the Kilovolt Region: Na^{23} and Al^{27}.† A. L. TOLLER,* AND H. W. NEWSON, *Duke University,* AND E. MERZBACHER, *University of North Carolina.*—The cross-section curve of Na^{23} has a strong resonance at 50 kev which is wide enough (about 1 kev) to show an interference dip if it is excited by S-wave neutrons; like the F^{19} resonance in the previous paper, it appears to be due to a P-wave. On this basis its reduced width is about 0.1 kev and its strength function about 10×10^{-4}. The shape of the resonance at about 3 kev is highly unsymmetric, lacks the interference dip which should be associated with an S-wave, and has a very long high-energy tail of about the shape to be expected from a P-resonance at this low energy. This shape is being investigated further in the hope of making a more definite identification. The very strong P-resonances which appear to occur in sodium and fluorine correspond to a space resonance at about $A=20$; this is consistent with the theory of Feshbach, Porter, and Weisskopf.[1] The aluminum resonances at 35 and 90 kev appear to be S-resonances ($J=3$) with widths 1.2 and 7 kev respectively. Few of the higher energy peaks appear to be S-resonances so that the order of magnitude of the strength function is about 0.1×10^{-4}.

† This work was supported by the U. S. Atomic Energy Commission.
* Now at the University of Louisville.
[1] Feshbach, Porter, and Weisskopf, Phys. Rev. **96**, 448 (1954).

12. Elastic Scattering of Neutrons from Neon. HANS O. COHN AND J. L. FOWLER, *Oak Ridge National Laboratory.*—The technique of pulse-height analysis of nuclear recoils in a proportional counter has been used for a preliminary study of the scattering of neutrons from neon of natural abundance in the energy region 0.8 to 1.7 Mev. Monoenergetic neutrons of 10-kev energy resolution were produced by bombarding a zirconium tritide target with analyzed protons from the Oak Ridge National Laboratory 5.5-Mev electrostatic generator. The proportional counter[1] was filled to 2 atmos with purified neon gas to which was added 2% CO_2. With low-bias setting the intregal recoil counts show up prominent resonances at 0.91±0.01, 1.31±0.01, 1.38±0.01, 1.62±0.01, and 1.68±0.01 Mev neutron energy. The low energy portion of the recoil energy spectrum was very distorted; an approximate interpretation can only be made for larger angle neutron scattering (>90°). This upper portion of the recoil spectra indicated the three higher energy resonances are characterized by increased backward scattering of neutrons.

[1] Fowler, Johnson, and Risser, Phys. Rev. **91**, 441(A) (1953).

13. Stripping Theory and the $Be^9(p,d)Be^8$ Reaction.* M. M. GORDON, *University of Florida.*—The experimental data on the $Be^9(p,d)Be^8$ reaction have been analyzed in terms of the simple Butler-type stripping theory.[1] Data at 5–8 Mev and 22 Mev are available.[2] If the simple theory (in any of its various forms) is applicable, then it can be shown that the experimental values of $(k_p/k_d)\sigma(\theta)$ plotted as a function of

$|k_p - \frac{1}{2}k_d|$ must yield the same curve at all energies. Application of this criterion shows that the 5- to 8-Mev data are not consistent within themselves nor with the 22 Mev data. The data at 22 Mev have been analyzed in detail, assuming that the neutron is captured from a p-state. The experimental and theoretical angular distribution cannot be made to agree unless one assumes a radius (Be^8): $1.5-2.5\times10^{-13}$ cm, which is rather too small.

* This work was begun while the author was a Research Participant at the Oak Ridge National Laboratory.
[1] See, e.g., R. Huby, *Progress in Nuclear Physics* (Academic Press, Inc., New York, 1953), Vol. III, pp. 194–199, for references and notation.
[2] Cohen, Newman, Handley, and Timnick, Phys. Rev. **90**, 323 (1953).

14. Soil Moisture Determination by Neutron Measurements. C. H. M. VAN BAVEL, NEWTON UNDERWOOD, AND R. W. SWANSON, *North Carolina State College.*—The use of a portable instrument to determine soil moisture content by slow neutron density measurements is described. The results are compared with previous work. The method consists of placing in or on the soil a fast neutron source (Ra–Be 10 mc) and in its immediate vicinity a detector (B^{10} counter) which measures the slow neutron density. In this situation there is associated with the source a cloud of thermal neutrons, the density of which is determined by the moisture content of the soil. If the moisture content is high, the cloud is dense and fairly well defined (radius about 15 cm). With low moisture content, the cloud is tenuous and ill defined (radius about 50 cm). The calibration curve of the moisture content *versus* neutron density departs from linearity when the sensitive volume of the detector extends beyond the radius of the neutron cloud, but it is reproducible. Surface measurements have an accuracy of 0.5 to 1.0% moisture by volume and measurements in test holes (5 cm diameter) 1 to 2%. The sample size varies with moisture content and may be as great as 15 cm depth for surface measurements and 65 cm diameter in well-type measurements.

15. FM Multichannel Pulse-Height Analyzer. JAMES COUCHMAN* AND C. D. CURTIS, *Vanderbilt University.*—A multichannel pulse-height analyzer has been built which has good pulse-height resolution possibilities and good stability with respect to channel boundary drift. The tube inventory is moderate except in scalars for recording. The principle of operation is conversion of voltage pulse amplitude to frequency by modulation of a 15 mc per second oscillator. Frequency sweep at present is achieved by a biased, variable inductor which receives the amplified counter pulse. Frequency discrimination is made by a series of band-pass filters. There are ten channels covering a range of ten megacycles but the number can be greatly increased over a variable frequency range. The differential count is now obtained by manual substraction of integral scalar counts received from successive channels but addition of a simple gating circuit will permit automatic recording of this count. The instrument circuit and performance data will be discussed.

* Holder of a U. S. Atomic Energy Radiological Physics Fellowship.

16. Resolving Time of Geiger-Mueller Counters. D. V. P. WILLIAMS AND DIXON CALLIHAN, *Oak Ridge National Laboratory.*—An empirical over-all coincidence loss correction factor for GM counters over a wide range of counting rates can be conveniently obtained by observing the decay of some radioactive element. The resolving time is obtained from a comparison of the observed (high) counting rate with that expected from the known half-life. The time required in this method can be significantly reduced by giving the radioactive sample an "accelerated" decay rate by counting at each of several fixed distances from the detector.

17. The Performance of a Cathode-Ray Tube Coincidence Discriminator. R. H. ROHRER, J. B. BAILEY, A. K. FURR, *Emory University.*—An instrument has been constructed which utilizes a cathode-ray tube presentation of pulses from two scintillation counters for coincidence or single-channel pulse-height analysis. The use of a type-5 short-persistence phosphor and a well-focused optical system yields resolutions which compare favorably with the resolutions attainable using all-electronic systems. Preliminary scanning for coincidences can be accomplished by photographing the pattern on the C.R.T. screen. The performance of the instrument will be discussed.

18. Chronotron for Time of Flight Studies of Cosmic Rays.* G. G. SLAUGHTER, M. M. BLOCK,† AND E. M. HARTH, *Duke University.*—A fast coincidence circuit has been developed which allows the measurement of small differences in arrival time of a particle at two counters. Plastic scintillators viewed by 5819 photomultipliers provide the fast pulses. The pulses are limited, clipped, and then amplified. One of the signals is split into ten separate signals, each of which is delayed by 8×10^{-10} second with respect to its preceding neighbor, and applied to a ten-channel fast diode coincidence circuit in coincidence with the signal from the other counter. The ten coincidence outputs are separated from each other by 0.5 microsecond delays, amplified, and applied to an oscilloscope. The histogram of the ten pulses will peak, after proper equalization, at the pulse corresponding to the time delay between the original signals from the scintillation counters. The time resolution of the equipment is of the order of 4×10^{-10} second. This equipment is to be operated above a multiplate cloud chamber, allowing mass assignments for slow cosmic-ray particles on the basis of the simultaneous measurements of velocity and residual range. Mass and energy resolution of the arrangement will be discussed.

* This work was supported by a grant from the National Science Foundation.
† On military leave of absence.

19. The Simultaneous Contrast Effect in Heterochromatic Brightness Comparisons. ANTONIOS ANTONAKOS, *University of North Carolina* (introduced by Paul E. Shearin).—An apparatus was designed and constructed for investigating the reliability of the simultaneous contrast effect in an indirect null method for making heterochromatic brightness comparisons. Each of the two juxtaposed simultaneous contrast patterns consisted of a square with a smaller square (called a target) centered within it. The luminances and chromaticities of the four areas were capable of continuous variation within limits. Physical methods were employed in the calibration of the apparatus. A fixed ratio of surround to target luminance was maintained for one pattern and any induced hue differences between the targets were neutralized. The surround of the adjacent pattern was given a sequence of preselected luminances. At each setting of the variable surround the observer equated the brightness of the variable target with that of the fixed target. A linear relationship was assumed to exist for the luminance coordinates of the variable pattern. The constants of the line were determined statistically. The hypothesis was made that if the known value of the fixed target were substituted in the equation of this line, it should give a value for the luminance of the fixed surround close to its true value. Thirty-six observations made by ten individuals are reported.

20. A Small Electromagnet for Low-Temperature Magnetic Measurements.* T. E. LEINHARDT AND J. M. REYNOLDS, *Louisiana State University* (introduced by Max Goodrich).—A small, water-cooled magnet powered by a 125-volt, 15-kilowatt dc generator, has been built for low-temperature

magnetic measurements. The yoke of this magnet was formerly part of an industrial impulse magnetizer. On each of its 5 in. ×5 in. cylindrical poles, four coils and three cooling plates are mounted. Each coil—5¼ in. i.d.×10½ in. o.d.—has 120 turns of 1 in.×0.015 in. high electrical conductivity copper strip. The eight coils are series connected and have a total resistance of 1.1 ohms at 25°C. The cooling plates consist of grooved and slotted annular disks—5¼ in. i.d.×11⅛ in. o.d.×¼ in. brass—over which are soldered 1/16 in. brass annular disks having the same diameters. Water enters through an intake fitting on the outer rim of each of the plates, is directed along a diameter toward the inner rim, and, then, is circulated back and forth through a series of concentric grooves to a discharge fitting on the outer rim. The coil windings are insulated with 0.005-in. "Peerless" Fish Paper. Fiber Glass Base Phenolite (Nat. G-5-813) in sheet form, 0.010 in. thick, electrically insulates the coils from the cooling plates. Pressure baking assures good thermal contact. The coils are wound on Phenolite Tubing (Nat. XX-24)—5 in. i.d.×5¼ in. o.d.×1 in. All of these insulating materials were obtained from the National Vulcanized Fibre Company. Preliminary tests show that in constant operation the magnet delivers about 13.5 kilogauss at 100 amperes and 130 volts over a 1 5/16 in. air gap.

* Supported by the National Science Foundation.

21. Atmospheric Turbulence. M. J. SAUNDERS AND A. G. SMITH, *University of Florida.*—As part of a program in long range photography, phase contrast methods are being used to study optical inhomogeneities in heated air masses. These methods are based on the techniques originally developed by Zernike for the testing of optical elements. The sensitivity of the method is such that changes in the index of refraction in the fifth-decimal place can easily be detected. It is intended to correlate these observations with the photographic resolution of targets at intermediate and long ranges.

22. Double Interpolation and Differentiation Formulas. KUO-CHU HO, *Department of Physics, University of Florida.*—For making interpolations at different parts of a table, double interpolation formulas for mixed forward, backward, and central differences have been derived. However, these formulas are rather cumbersome and time consuming in use. For interpolation with more than one variable, formulas in terms of the tabular entries f_{ij} directly instead of differences are much simpler to use. Salzer[1] has derived such a formula for double-forward interpolation in terms of f_{ij}. This formula works satisfactorily for interpolation near the head of a table. For the purpose of interpolating at other parts of a table, double interpolation formulas for other than double-forward interpolation formula have been derived. Expressions for partial derivatives of different orders in terms of both double differences and f_{ij} directly, including those needed in the numerical solution of partial differential equations, are also worked out.

[1] H. E. Salzer, J. Math. and Phys. **26**, 294 (1948).

23. On Focusing High-Current Electron Beams by the Aperture Effect. KUO-CHU HO, *University of Florida.*—A theoretical study has been made of the focusing of high-current electron beams by means of the aperture effect. The aperture effect is obtained by a triode electron optical system. An equation for describing the beam profile through a region of varying electric field, including the space-charge force, has been derived. Both the condition for obtaining the minimum radius of the beam and the condition for optimum focus have also been worked out. Two numerical examples are treated to illustrate the triode focusing of electron beams with two different total current magnitudes of 50 and 250 μ amp. It is found that by using this triode system the final energy of the electrons and the total current of the electron beam may be controlled separately.

24. Effect of Inclusion of Exchange in the Thomas-Fermi Treatment of Molecules. JAMES D. ALEXANDER AND WAYNE A. BOWERS, *University of North Carolina.*—In order to see whether the statistical theory can be made to yield useful results when applied to molecules, we have included the Dirac exchange term in approximate calculations on two types of molecular systems. For diatomic homonuclear molecules the Thomas-Fermi theory, which predicts a binding energy $\sim Z^{7/3}$ and equilibrium internuclear separation $\sim Z^{-1/3}$, in violent contradiction to experiment, is not appreciably improved by inclusion of exchange. For the "spherical" molecule used previously by March[1] and one of us[2] as a model for tetrahedral (XY_4) and octahedral (XY_6) molecules, inclusion of exchange considerably modifies the curve of equilibrium radius *vs* N/Z (N=total charge of Y nuclei, Z=charge of X); although the agreement with experiment is improved for some molecules it is worsened for others. In general, one may say that although the statistical theory can yield charge distributions which are roughly correct, it is not accurate enough, even with inclusion of exchange, to predict those molecular parameters depending on the total energy.

[1] N. H. March, Proc. Cambridge Phil. Soc. **48**, 665 (1952).
[2] W. A. Bowers, J. Chem. Phys. **21**, 1117 (1953).

25. Particle Binding Energies in the Diffuse Boundary IPM.* ALEX E. S. GREEN, *The Florida State University.*—The approximate eigenvalues for a spherical well with an exponentially diffuse boundary and with spin-orbit splitting are applied to the study of the particle binding energies. The introduction of the diffuse boundary affords the possibility of (a) positioning zero velocity *s*-wave maxima of the neutron cross-section suface at mass numbers where they are observed, (b) reducing the particle binding energies to within the observed range, and (c) reducing the discontinuities in particle binding energies to within the observed range. For a middle-weight element the $1/e$ length of the exponential region needed appears to be of the order of 0.3 of the radius of the inner region of uniform potential.

* Supported by a grant from the FSU Research Council and the U. S. Atomic Energy Commission.

26. The Diffuse Boundary IPM Mass Surface.* KIUCK LEE AND ALEX E. S. GREEN, *The Florida State University.*—The approximate eigenvalues for a spherical well with an exponentially diffuse boundary are applied to the study of the IPM mass surface. It is found that the use of a diffuse boundary improves considerably the mass surface obtainable from a strict IPM. Apparently, however, some additional forces such as, exchange forces, velocity dependent forces, or many body forces are still needed to derive a completely satisfactory mass surface but the demands upon such forces are much less for the case of the diffuse boundary than the case of the sharp boundary. This work suggests an explanation for the differences between the radii of the proton and neutron distributions which is more direct than that of Johnson and Teller.

* Supported by a grant from the U. S. Atomic Energy Commission.

27. The Mixed Wigner-IPM Mass Surface.* JULIUS SALACZ-DOHNANYI AND ALEX E. S. GREEN, *The Florida State University.*—The work of Green and Lee on the diffuse boundary IPM model suggest that the energy level structure is far more complicated than might have been inferred on the basis of the sharp boundary IPM model. Furthermore it seems that additional forces of the nature of those appearing in the Wigner-Uniform Mass model are needed to provide a really satisfactory mass surface. From these as well as other heuristic considerations one is led to investigate the effect of

introducing energy terms appearing in the uniform model in conjunction with the energy terms obtained from the strict IPM model. Results obtained from this mixed model are quite promising.

* Supported by a grant from the U. S. Atomic Energy Commission.

28. Perturbations of the Semiempirical Mass Equation.* KENNETH L. ZANKEL AND ALEX E. S. GREEN, *The Florida State University.*—It has been shown that the well-known semiempirical equation provides a rather good account of the general trends of nuclear mass data. Accordingly it would appear that studies of various theoretical mass equations might well utilize the semiempirical equation as a starting point of a perturbation analysis. A least-squares procedure is set up for investigating the influence of various types of energy perturbations upon the fit of a mass equation to the mass data. For each perturbation the method leads to redeterminations of the values of the semiempirical constants, and in particular the Coulomb radius constant. The procedure is applied in detail, using the latest mass data, to the number of energy perturbation.

* Supported by a grant from the U. S. Atomic Energy Commission.

29. Interval Distribution of Cosmic-Ray Tracks in Extensive Air Showers. TRICIA REEVES AND E. D. PALMATIER, *University of North Carolina.*—A statistical study was made of the distribution of intervals between cosmic-ray tracks in 369 cloud-chamber photographs of extensive air showers, 127 of which were obtained at Chapel Hill, North Carolina (500 ft elevation) and 242 at White Mountain, California (10 500 ft elevation). Only photographs which contained between 10 and 75 tracks in the 2 ft×1 ft×1 ft volume of the cloud chamber and which were reasonably clear throughout the major portion of the chamber were used in this analysis. Separate studies were made for various density groups for both the Mountain and the Chapel Hill data. In addition, the Mountain data were recorded so that separate studies could be made for all the tracks, regardless of direction, and for only those tracks which deviated from the predominant direction of the shower by less than 10°. The experimental results will be compared with those expected from a purely random distribution and with those expected from a model shower.

30. Interaction of π^- Mesons with Light Nuclei. JOSEPH CALLAWAY, *University of Miami.*—Experiments on the energy level displacements in light π^- mesic atoms show a repulsion between the meson in the ls state and the nucleus.[1] Assuming a repulsive square barrier interaction, the energy level shift is given in perturbation theory as

$$\Delta E=\frac{4}{3}\left(\frac{Zr_0}{a_0}\right)^3 A\,V$$

where a_0 is the meson Bohr radius. A plot of ΔE against Z^3A for six elements (with $r_0=1.25\times10^{-13}$ cm) gives $V=6.6$ Mev. To reconcile this result with the scattering of π mesons by light nuclei, which yields an attractive optical potential, we assume the interaction between meson and nucleus is attractive in p-states but repulsive in s-states. The scattering data for carbon at 62 Mev seem to be consistent with this hypothesis but require a stronger repulsion (10 or 15 Mev) than is suggested by the mesic atom.

[1] Stearns, Stearns, DeBenedetti, and Leipuner, Phys. Rev. **97**, 240 (1955).

31. π^+-p Interactions at Approximately 500 Mev.* M. E. BLEVINS, M. M. BLOCK,† AND E. M. HARTH, *Duke University.*—The scattering of positive pions was studied in a 6 ft×1 ft diffusion cloud chamber filled with hydrogen gas at 18 atmospheres. The chamber was exposed to an external π^+ beam from the Brookhaven cosmotron.[1] A steering magnet was used to select momenta of 750 Mev/c. In a total of 3100 pictures scanned, 15 scatterings were observed in the gas. Elastic scatterings were identified on the basis of coplanarity and measurement of the polar angles. The pion flux was determined by observing the number of π-μ decays and correcting for the unobserved small angle decays. From the ratio of the number of π-μ decays to the number of scatterings, a total cross section for π^+-p interactions at this energy can be obtained. This work is preliminary to a more complete study.

* This work was supported jointly by the Office of Naval Research and the U. S. Atomic Energy Commission.
† On military leave of absence.
[1] The exposures were kindly supplied by Dr. R. P. Shutt of Brookhaven National Laboratory.

32. Unstable Combinations Which Can Simulate Neutral Mesons. ARTHUR E. RUARK AND WILLIAM B. GOOD, *University of Alabama.*—Now that unstable particles are observed in steadily increasing numbers, it is pertinent to consider the properties of combinations of positive and negative particles coming from stars. The chance is very small that two particles will be emitted at such angles that they can form an "atom"; but this possibility should not be overlooked. Such combinations have ionization potentials ranging from 1400 volts for mu-mu to 14 800 volts for a pair of charged V_1 particles. The Bohrean radii are of the order 10^{-10} cm; the rotation periods are "large." They would ionize gas atoms sparingly,—a fraction of an ion pair per cm, ordinarily. Up to the point of destruction, they would simulate neutral mesons. For example, a pi-pi combination could break up in flight or one of its members could undergo pi-mu decay. (In the latter case, interpretation of the events as neutral-meson decays would encourage the false assumption of a continuous mass spectrum of neutrals.) Observation of combinations would throw light on annihilation (or lack of annihilation) of pi-pi, in competition with pi-mu decay; or of mu-mu, presumably obeying the Dirac equations.

33. The Gauge Problem in Internal Conversion. M. E. ROSE, *Oak Ridge National Laboratory.*—The presumable lack of gauge invariance in internal conversion consists in the fact that, as the theory is usually formulated, the calculated transition probability is infinite for electrons in a Coulomb field if any gauge but the "conventional" (least singular) one is used. If electron wave functions appropriate for a finite size nucleus are used, the infinity disappears but the results are still gauge dependent. This difficulty arises because one deals here with a second-order process involving outgoing wave fields in the electron space, although the original (gauge invariant) Hamiltonian contains only standing wave fields. As this statement implies, the usual assumption of a point nucleus is made in the perturbation theory. The paradox is resolved by noting that for a nonpoint nucleus there are no gauge difficulties and that when one considers the limit of point nuclei the terms corresponding to the electron inside the nucleus lead to surface terms which can be rejected only for the conventional gauge.

34. Validity of the Current Practice of Using Single-Exposure Data to Calculate Maximum Permissible Concentrations in Air and Water for Continuous Exposure to Radioisotopes. M. J. COOK, K. Z. MORGAN, *Oak Ridge National Laboratory* AND A. G. BARKOW, *Marquette University.*—It has been common practice in determining maximum permissible concentrations, MPC, to use animal data obtained from a single-body uptake of radioisotopes to calculate the absorbed dose expected under equilibrium conditions of continuous exposure. The simplifying assumption is made that the radioactive elimination from each body organ follows a simple exponential decay, $e^{-\lambda t}$, in which λ is the sum of the

radioactive coefficient, λ_r, and the biological coefficient λ_b. An experiment to test the efficacy of this practice was conducted by administering Co^{60} in a single dose by stomach tube to a group of 196 mice and by maintaining Co^{60} contamination at a constant level for two months in the drinking water of another group of 179 mice. Animals from both groups were sacrificed at various time intervals and the Co^{60} present in the body organs measured. The MPC calculated from the single-exposure data checked within a factor of two with the MPC values determined from the continuous exposure data. Because of large uncertainties in biological data available for calculating MPC values, a calculation that does not introduce an error greater than a factor of two is satisfactory. Experiments are being continued with larger groups of animals and with other radio-nuclides.

35. Tungsten *L* X-rays from a Be-Window Tube.* RICHARD RARIDON† AND P. K. S. WANG, *Vanderbilt University.*—Measurements have been made using a 50 PKV x-ray tube with a thin beryllium window and a full wave rectifier. The detector was a NaI(Tl) crystal 2 mm thick with an extra thin (0.5 mil) Al window. A scintillation spectrometer gave the count rate as a function of pulse height, which was plotted automatically on a linear recorder. Relative intensities were found by measuring the areas under the curves and also by integrated counting. Without additional filter, a high-intensity peak appeared. This peak was superimposed on the long wavelength portion of the spectrum. Absorption measurements showed the energy to be comparable to the *L* x-rays of tungsten, the target material of the tube. However, when this peak was effectively filtered out, the absorption curve gave, by Laplace transform,[1] a spectrum which agreed with previous results[2,3] of the bremsstrahlung continuum.

* This work was partially supported by a U. S. Atomic Energy Commission sponsored project.
† U. S. Atomic Energy Commission Radiological Physics Fellow.
[1] J. R. Greening, Proc. Phys. Soc. (London) **A63**, 1227 (1950).
[2] H. A. Kramers, Phil. Mag. **46**, 836 (1923).
[3] C. R. Emigh and L. R. Megill, Non-Destructive Testing **11**, 30 (1953).

36. The Energy Spectrum of a Low-Voltage X-Ray Tube.* MARVIN TIDWELL,† S. K. HAYNES,‡ AND P. K. S. WANG, *Vanderbilt University.*—The energy spectrum of a beryllium window x-ray tube operating at 50 PKV and a maximum intensity of about 2 million r/min was obtained using a NaI(Tl) scintillation spectrometer. Measurement was made at an air distance of 8 cm for several values of current and voltage. The measured spectrum was compared with fair agreement to the theoretical spectrum calculated by Jennings[1] for a similar tube operating under the same conditions. The comparison was made by applying to the theoretical spectrum the smearing effect of the spectrometer. Measurements as well as corrections will be presented.

* This work was partially supported by a U. S. Atomic Energy Commission sponsored project.
† Now at Tennessee Polytechnic Institute.
‡ On leave of absence, 1954–1955, at the University of Paris.
[1] W. A. Jennings, Brit. J. Radiol. **26**, 193 (1953).

37. *K*-Series Fluorescence Yield Measurements of A, Cu^{65}, and In^{113}.† G. R. HARRISON, R. C. CRAWFORD, AND J. I. HOPKINS, *Vanderbilt University.*—A versatile and stable proportional counter has been developed which offers merit for the solution of some radio-nuclear problems. It was constructed from a brass cylinder 17 in. long and 4 in. in diameter, utilizing a 2-mil coaxial central wire. It was found to have a wide range of voltage proportionality, a relatively low effective capacity, and a half-width resolution of 13% on the 8 kev Cu^{65} x-ray transition. The *K*-series fluorescence yield of argon has been measured by the method of Cu^{65} x-ray excitation and found to be (0.081 ± 0.006). The *K*-series fluorescence yield for Cu^{65} was measured to be (0.39 ± 0.02), and that for In^{113} to be (0.816 ± 0.020). In arriving at the computed values, corrections were made to compensate for the reduced intensity of the escape peak or the photopeak caused by reabsorption of the *K* x-rays of argon in the argon gas, and for the incident radiation absorbed in the *L*-, *M*-, *N*-shells. Errors in intensity determinations from other effects were taken into account. We believe a liberal allowance has been made in estimating the probable errors, and because of good agreement with theory and with values determined by other methods, the results are gratifying.

† Supported by the U. S. Atomic Energy Commission.

38. Proton Bremsstrahlung. DAVID COHEN, *University of Miami (Florida)* (introduced by Joseph Callaway).—Careful statistical analysis of the raw proton bremsstrahlung data,[1] recently re-evaluated at Berkeley,[2] yields more information about the high-energy end of the *Z*-dependence curves. This statistical evaluation produces results which does not allow one to definitely state the mechanism of nuclear interaction which produces the change of state of the proton. This is somewhat contrary to previous possible interpretations.[1] A case may be developed for pure proton-nucleon collisions, pure proton-nucleus collisions, or a combination of both. The latter appears to be the most probable interpretation. These *Z*-dependence curves will be presented again in the light of the full statistical development.

[1] Cohen, Moyer, Shaw, and Waddell, Phys. Rev. **95**, 664(A) (1954).
[2] Charles Waddell (private communication).

39. On the Relative Number of Gamma Rays from Po^{210}. ONOFRE ROJO, M. A. HAKEEM, AND MAX GOODRICH, *Louisiana State University.*—It has long been known that the alpha decay of Po^{210} is accompanied by a weak gamma ray of about 800 kev. The number of these gamma rays has been reported to be from 1.5×10^{-5} to 1.8×10^{-5} times the number of alpha rays. In the course of some work on Po^{210} the authors have redetermined this ratio using scintillation spectrometer techniques. The alpha-ray measurements were made with a plastic scintillator using a diaphragm, while the gamma-ray measurements were made with a large (3 in. diameter by 3 in. long) sodium iodide crystal. The resulting ratio of 1.2×10^{-5} for N_γ/N_α (estimated error 10%) is believed to be significantly below the published values.

40. A Monte Carlo Calculation of Gamma-Ray Reflection Coefficients of Concrete and Aluminum.*† J. F. PERKINS, *Convair.*—Number and energy gamma-ray reflection coefficients have been calculated for a material of $Z_{eff}=13$, corresponding to both concrete and aluminum. The Monte Carlo method was used, the calculations being performed on an IBM-701. The single- and multiple-scattered components were evaluated separately; the multiple-scattered component was considerably the larger of the two in most cases, being as much as three times as large as the single-scattered component. For moderately small incident angles the emergent photons are distributed approximately proportionally to the cosine of the normal angle of emergence. The spectra peak around 150 to 250 kev and in some cases have a second peak at higher energy; such secondary peaks move upward in energy and increase in importance as the angle of incidence increases. The average energy of the emergent photons varies from 0.33 to 1.4 m_0c^2. For the multiple-scattered component the average energy varies from 0.30 to 0.93 m_0c^2. Build-up factors have been calculated for 2 m_0c^2 gammas normally incident on aluminum of 2 and 4 mean free paths thickness.

* Work performed under contract with the Wright Air Development Center of the U. S. Air Force.
† Now at Lockheed Aircraft Corporation, Marietta, Georgia.

41. An Investigation of Alpha Resonances in Aluminum.* T. K. FOWLER AND J. I. HOPKINS, *Vanderbilt University.*—A simple scintillation counter arrangement was used suc-

cessfully to investigate resonances in the reaction $Al^{27}(\alpha,p)Si^{30}$. Use of polonium as a source restricted observation to alpha resonances below ~5 Mev. Both alpha resonances and proton groups were quantitatively observed to at least two significant figures with an estimated possible resolution of 200 kev. It was thought that the systematic deviation of observed Q-values from accepted values resulted from inaccurate calibration data for protons in anthracene. A new calibration of the instrument based upon known α,p reactions would solve that problem. A more prohibitive difficulty consisted of polonium gamma background, which obscured the proton peaks below 4.3 Mev. Within the limits stated above, the arrangement was found to be an adequate instrument for the rapid search for resonances in α,p reactions. Because of the present success, it is believed that the design of a similar arrangement for observation at ninety degrees to eliminate gamma background would be interesting.

* Supported in part by the U. S. Atomic Energy Commission.

42. A New Radioactivity Mn^{53}.† RAYMOND K. SHELINE AND JOSEPH R. WILKINSON, *Florida State University.*—Chromic oxide (92.1% Cr^{53}, 5.7% Cr^{52}, 1.7% Cr^{54}, and 0.5% Cr^{50}) was bombarded with 29.03 microampere hours of $9\frac{1}{2}$-Mev protons to produce a new radioactivity Mn^{53} by the reaction $Cr^{53}(p,n)Mn^{53}$. Decay and absorption measurements indicate that this nuclide is a K-capture activity without gamma rays or positrons. With the assumption that the cross section for the reaction $Cr^{53}(p,n)Mn^{53}$ and $Cr^{54}(p,n)Mn^{54}$ are the same, it is possible to calculate an approximate half-life of 140 years for this nuclide. These data, together with those from previous measurements on the energy levels of Cr^{53} indicate that Mn^{53} decays from a $F_{5/2}$ ground state to a $p_{3/2}Cr^{53}$ ground state in an l-forbidden transition with a relatively high logft value.

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

43. On the Elastic Scattering of Slow Electrons by Atoms. WILLIAM J. BYATT, *University of Alabama* (introduced by Arthur E. Ruark).—For electrons of zero angular momentum, the radial wave equation with suitable boundary conditions has been transformed into an equivalent integral equation. By iteration, after the fashion of Liouville, the radial portion of the wave function is then developed in a power series. From this expression, one may extract the phase shift. The first and the second steps in the iteration process yield phase shifts more nearly in agreement with previous (exact) calculations than does the Born calculation. The second iteration, for example, gives results at 340 v correct within 4%, while the Born is 8% in error. Discussion of the method and comparison of phase shifts for He, Ne, and A will be given. The potentials used are analytical fits to Hartree curves; the voltage range discussed is 50 to 700 v. Comparisons are made with the work of McDougall[1] and Westin.[2]

[1] J. McDougall, Proc. Roy. Soc. (London) **A136**, 549 (1932).
[2] S. Westin, Kgl. Norske Videnskab. Selskab. Forhandl. No. 2 (1946).

44. Electron Capture Cross Section for Protons. P. M. STIER AND C. F. BARNETT, *Oak Ridge National Laboratory.*—Measurements of the electron capture cross sections have been extended to the energy range 3 to 30 kev.[1] The proton beam was deflected within the differentially pumped gas cell by a radial electrostatic field. Neutral atoms formed by electron capture collisions were undeflected and did not enter the detector. The cross section for electron capture was calculated from the attenuation as a function of pressure. Results will be presented for the capture cross section in hydrogen, helium, nitrogen, oxygen, neon, and argon. Good agreement was obtained with the values calculated from the previously measured[1] loss cross sections and the ratio of loss to capture cross sections. The results to be presented agree well with those of Whittier[2] for hydrogen as the target gas and with those of Hasted and Stedeford[3] for helium. The cross section is large for the more easily ionized gases (e.g. 14×10^{-16} at 4 kev in argon), but is small and approaches zero at low energies in gases of high ionization potential (e.g. helium).

[1] C. F. Barnett and P. M. Stier, Phys. Rev. **98**, 1537(A) (1955).
[2] A. Charles Whittier, Can. J. Phys. **32**, 275–290 (1954).
[3] Hasted and Stedeford, Proc. Phys. Soc. (London) **A67**, 1075 (1954).

45. On Crystalline Electric Field Splitting Effects in Antiferromagnetic Transitions. L. D. ROBERTS AND R. B. MURRAY,* *Oak Ridge National Laboratory.*—The Van Vleck molecular field theory for antiferromagnetism has been extended to include crystalline electric field splitting effects of a type which may occur in S-state ions such as Mn^{++}. In particular, we assume an effective spin Hamiltonian of the form $H=-2KZ\bar{S}_zS_z\pm DS_z^2$ where the first term is the usual molecular field term and the second term is that due to the electric field effects. Here K is the exchange integral, Z is the number of nearest neighbors, D is the electric field splitting coefficient, and S_z is the z-component of the electron spin angular momentum operator. Employing standard magnetic theory, we then calculate the magnetization of each of the sublattices, proportional to $\bar{S}_z$. The predictions of this model for all temperatures from absolute zero through the magnetic transition temperature and above will be discussed. In particular, we note that the value of the transition temperature is very sensitive to the D term in H, and further that at the absolute zero the model suggests a sensitive dependence of the saturation magnetization on this term. These calculations may apply to salts such as $MnCl_2$ or $MnSiF_6\cdot6H_2O$.

* Graduate Fellow of the Oak Ridge Institute of Nuclear Studies from the University of Tennessee.

46. Extension of Molecular Field Theory to a Hexagonal Lattice. R. B. MURRAY* AND L. D. ROBERTS, *Oak Ridge National Laboratory.*—In the course of an investigation of the cryomagnetic properties of $MnCl_2$,[1] it became of interest to extend the molecular field theory to the $MnCl_2$ lattice, a hexagonal layer structure. We assume a division of the magnetic lattice into six sublattices such that the first nearest neighbors of a given ion are disposed in a hexagonal arrangement in the same plane, while the second nearest neighbors are located in adjacent planes. All four combinations of ferromagnetic and antiferromagnetic first and second nearest neighbor interactions are considered. This model predicts three types of magnetic order, one ferromagnetic state and two possible antiferromagnetic states. The two types of predicted antiferromagnetic order are: (a) ferromagnetically ordered layers with adjacent layers oppositely oriented, and (b) an arrangement in which the vector sum of the moments of any three neighboring atoms in a layer is zero. This latter condition may be fulfilled by a triangular net arrangement of the spins within a layer. The dependence of the Weiss constants and transition temperatures on the interaction parameters will be presented for each of the above states.

* Graduate Fellow of the Oak Ridge Institute of Nuclear Studies from the University of Tennessee.
[1] R. B. Murray and L. D. Roberts, Phys. Rev. **98**, 1180(A) (1955).

47. The Effect of Elastic Strain upon Electrical Resistance When Lattice Imperfections Are Present. E. W. KAMMER, *Naval Research Laboratory.*—It is of interest to observe that the influence imperfections, created by plastic deformation, have on the change in resistance a wire conductor exhibits when small elastic strains are applied. This change in resistance as a function of small elastic strains was measured, first, for the annealed metal, and then at several stages of progressively greater permanent plastic elongation. The metals for which data are presented in this report include copper, silver, nickel,

and constantan, the last being studied because of its extensive use in bonded wire strain gauges. If the contributions to the total resistivity from imperfections is assumed to be simply additive (Matthiessen's Rule), an expression can be derived for the ratio of the resistance change to the elastic strain which takes into account the presence of imperfections. Thus

$$G=\frac{\Delta R}{R}\Big/\frac{\Delta L}{L}=(1+2\nu)+g_a+\Sigma\frac{P_i}{P_a}g_i$$

in which the term $(1+2\nu)$ containing Poisson's ratio ν allows for the change in form of the wire specimen, while g_a is the change in resistivity produced by the elastic strain in the initially annealed lattice. Each term in the summation assigns a strain sensitivity g_i to the ith type imperfection structure (vacancies, dislocations, etc.) which are generated by the cold working. The contributions of these imperfection structures to the composite strain sensitivity G are respectively modified by the ratio P_i/P_a where P_i is the increase in resistivity due to the presence of the ith type imperfection in the metal having resistivity P_a in the annealed state. Applications of this equation are made to the presently available data.

48. A Preliminary Investigation of the Crystal Structure Changes of Sulfur.* J. E. MILLER, N. S. KENDRICK, JR., AND G. W. CRAWFORD, *Clemson College.*—An attempt to obtain the x-ray diffraction of monoclinic sulphur was reported by S. R. Das of India in 1938. His negative results have been explained by the authors. A constant temperature oven was designed and adapted to a Norelco Geiger counter x-ray goniometer for the investigation of the crystal structure of sulphur at elevated temperatures. A diffraction pattern of monoclinic sulphur was obtained. The d spacings and principal grating spacings have been computed. The rate of change of S_β to S_α and of S_κ to S_β was also investigated and has been computed as a function of the original temperature. A comparison of several sets of lines was employed. The thermal coefficient of expansion of S_κ was also measured. The accuracy of this determination, however was considerably limited by the method used.

* Supported by the National Science Foundation and the Kress Foundation of Clemson College.

49. Radial Vibrations in Short Hollow Cylinders of Barium Titanate. C. V. STEPHENSON, *Sandia Corporation.*—The mathematics has been developed which allows the calculations of the radial coupling coefficient in hollow cylinders of barium titanate whose length is small compared to its outside diameter. This can be expressed by the equation $(k^2/1-k^2)=C(\Delta f/f_r)$ where k is the coupling coefficient, Δf is the difference in frequency between the resonant and antiresonant frequency, f_r is the resonant frequency, and C is a constant which depends on the ratio of outside to inside diameters.

50. Comparison of the Ultrasonic Velocities in a Series of Carbonates and Acetates. D. R. MCMILLAN AND ANDREW ROBESON, *Emory University.*—The ultrasonic velocities in two series of compounds consisting of seven normal acetates and five normal carbonates have been measured at 500 Kc/sec with a modified form of the ultrasonic interferometer reported previously.[1] Each compound was purified by distillation and measurements made at five temperatures ranging from 10°C to 50°C. Additional data were secured to permit calculation of temperature coefficient of velocity, adiabatic compressibility, and Rao's constant for each member of the series, and a comparison of these properties leads to some interesting similarities in the behavior of corresponding members of the two series of compounds.

[1] D. R. McMillan and R. T. Lagemann, J. Acoust. Soc. Am. **19**, 956 (1947).

51. The Design of an Oven for Obtaining the X-Ray Diffraction Patterns of Materials with a Low-Thermal Conductivity. N. S. KENDRICK, JR., J. E. MILLER, AND G. W. CRAWFORD, *Clemson College.*—Preliminary investigation into the crystal structure changes in solid sulfur by x-ray analysis revealed the inadequacies of the methods previously used. An oven was designed which was adapted to both a Debye-Sherrer camera used with a G.E. XRD1 and to a Norelco Gieger counter x-ray goniometer. The oven design incorporates two highly desirable features: (1) Both the sample holder and the ambient air are heated and controlled independently, thus assuring the absence of a temperature gradient in the sample. (2) The temperature is controlled to within ±0.1°C. The first feature is important in obtaining the x-ray diffraction patterns of substances with low-thermal conductivities. The latter feature is especially desirable in locating transition temperatures. The temperature may be stabilized at any arbitrary value for extended periods of time. The oven was used with a Debye-Sherrer camera to obtain the x-ray diffraction pattern of monoclinic sulfur. The intensities of the diffraction lines were obtained by adapting the oven to a Norelco Geiger counter x-ray goniometer.

52. Secondary Emissions from Negative-Ion Bombardment of Metal Surfaces. HOWARD SKELTON BARRINGER AND WILLIAM HENRY BANCROFT, JR., *Alabama Polytechnic Institute.*—A Nier type 60-degree sector spectrometer with a Winn-Nier ion source and a newly designed ion collector is being used to study the secondary emission from certain metal targets under negative-ion bombardment. Preliminary results obtained when singly charged Cl^- and Br^- ions impinge on a Ni surface will be given. Ions having energies from 300 to 2000 ev were employed in the study. A comparison of the secondary emission coefficients for Br^+ and Br^- ions will also be shown.

53. The Calculation of Diffusion Coefficients for Polystyrenes from Measured Values of Osmotic Pressure. T. A. BARR AND H. B. JENKINS, *University of Georgia.*—The calculations of diffusion coefficients for polyethylene glycols have been reported previously.[1] These calculations were made from measured values of osmotic pressures in a metal membrane osmometer. The polyethylene glycols ranged in molecular weight from 285 to 6600 M.W. units. Similar measurements have now been made of the osmotic pressures of several polystyrene molecules ranging in molecular weights from 100 000 to over 500 000 M.W. units. Calculations show that the observed osmotic pressures are almost equal to the theoretical values for the heavier polymers, and that the calculated diffusion coefficients are markedly lower than the free diffusion coefficients for these polymers. A brief outline of the measurement and calculation techniques used will be given.

[1] T. A. Barr, Southeastern Section, American Physical Society, April, 1953, Durham, North Carolina.

54. Diffusion of Uranyl Nitrate Activity through Porous Media. F. L. LANGFORD, R. A. WEBB, AND F. T. ROGERS, JR., *University of South Carolina* (to be read by title).—We have repeated the experiment[1] of A. Gemant with slight modifications and extensions. Experiments were made with Fiberglas (97% porosity) as solvent holder, and with glass beads of 0.0526 cm diameter (36.4% porosity). These latter were corrected for a small net migration of activity observed with contaminated beads when $0<x>l$ was filled with pure solvent and $x>l$ was void of all fluid. The rate of increase of counting rate was much greater for diffusion through Fiberglas than through glass beads: $R_F/R_B=4.1+1$. Expected rates of increase were calculated in the usual way,[1] with allowance for differing absorptions of Fiberglas and beads for beta

radiation. When plotted against kt for $l=0.215$, these calculated curves had initial slopes in the ratio of $S_F/S_B=1.52$. For our experiments ($l_F=l_B=0.215$) this suggests that the ratio of apparent coefficients of diffusion through the two solvent holders was $k_F/k_B=(4.1)/1.52=2.7\pm0.7$. Since the ratio of porosities was also 2.7, this technique for apparent coefficients of diffusion may turn out to be of value in certain measurements of porosities.

[1] A. Gemant, J. Appl. Phys. **19**, 1160 (1948).

55. On Some Special Stopping-Power Laws. MARGUERITE M. ROGERS,* *Columbia College*, AND F. T. ROGERS, JR.,*† *University of South Carolina* (to be read by title).—Several readily integrable special cases of the expression,

$$-dT/ds=k_0+k_{-1}/T+k_1T+k_2s, \quad (1)$$

have been investigated. For $(k_0, k_{-1}, k_1, k_2)=$ (constant, 0, constant, 0), Eq. (1) yields Poncelet's[1] well-known formula for range in terms of kinetic energy; for $k_0=k_0(\sigma)$, $k_1=k_1(\sigma)$, and $d\sigma/ds$ simply related to dT/ds, generalizations of Poncelet's formula are obtained depending upon the functional dependencies in k_0, k_1. The cases (constant, constant, 0, 0) and (constant, 0, 0, constant) yield monotonic range-energy relations as do the two preceding ones; in the latter instance, however, range is severly limited by the values of k_0, k_2. These several special cases have been encountered in attempts to provide phenomenological explanations for selected data in terminal ballistics; in many instances the data are found not to be of meaningful precision or completeness.

* Assisted by the Quartermaster Research and Development Laboratories, U. S. Army.
† Assisted by the Office of Ordnance Research, U. S. Army.
[1] Poncelet, Mem. Acad. d'Sciences, **15**, 55 (1829).

PHYSICAL REVIEW VOLUME 99, NUMBER 5 SEPTEMBER 1, 1955

Proceedings of the American Physical Society

MINUTES OF THE 1955 JUNE MEETING AT TORONTO, CANADA

(Corresponding to *Bulletin of the American Physical Society*, Vol. 30, No. 4)

THE summer of 1955 will be remembered in the American Physical Society as the summer in which we twice crossed the frontier. On the first of these two occasions we traversed the northern border, and assembled in Toronto on Wednesday, Thursday, and Friday, June 21–23. Some of us of course did not cross the frontier, for our Canadian members were on that side already. The invitation to meet in the halls of the University of Toronto had been extended to us by President Sidney Smith and by Professor W. H. Watson. The general manager of the meeting was Professor H. J. C. Ireton. He was aided by a great number of people at the registration desk, at the lanterns, and elsewhere—and we must not forget the ladies of the Department of Physics who took the visiting ladies on excursions. Their names have not been listed, but we are grateful to all. We met in three buildings of the University: the McLennan Laboratory, the Mechanical Building, and the Wallberg Building. Nowhere were the halls too small, and yet the meeting was not inconsiderable in size.

This was a joint meeting (and our first) with the Canadian Association of Physicists, celebrating this year its ninth anniversay and tenth annual meeting. Their ten-minute papers were distributed through our programme. Their invited papers had been given on the two previous days; our members were cordially invited, but regrettably few seemed able to come. The registration for the five days of the entire double meeting amounted to about four hundred. With especial pleasure we noted that many physicists from as far away as Saskatoon and Vancouver, and some from Nova Scotia, had made the formidable journey.

Our Division of Electron Physics (R. L. Sproull, *Chairman*; H. D. Hagstrum, *Secretary*) made a notable contribution to the meeting, both by inviting speakers and by stimulating its members to provide ten-minute papers. On the general programme, most of the invitations were issued to Canadian physicists and to physicists of universities in the United States near to the border.

The banquet was held Thursday evening in the Sheraton Room of the King Edward Hotel, R. T. Birge presiding and having beside him the President of the Canadian Association, Larkin Kerwin, who greeted our members in the name of the Association. D. A. Keys gave an account of the recent development of physics in Canada which had no fault other than that of being too brief. The attendance at the dinner was 147. This was not the only festive occasion on the programme. The University of Toronto gave us an unprecedented reception Wednesday afternoon in the hall of a large gymnasium. The President and the Chancellor of the University and their wives received us, and liquid and solid refreshments were served. A crowd of several hundred responded warmly to this amiable invitation.