

PHYSICS

Chairman: A. R. THOMAS, Valparaiso University

D. Roller, Wabash College, was elected chairman for 1950.

ABSTRACTS

An Electronic Hydrogen Detector. L. W. AUCKERMAN, Purdue University.—In designing the Purdue cryogenic laboratory one room was reserved for experiments using liquid hydrogen. Though every feasible safety precaution was taken, it was considered desirable to construct a dependable device for giving a continuous indication of the air hydrogen content and which would set off an alarm if the concentration should rise above a certain predetermined level.

For this purpose a wheatstone bridge in conjunction with suitable electronic circuits is utilized in such a way as to detect an increase in thermal conductivity of the air. An increase of hydrogen content will increase the thermal conductivity of the air and will consequently produce an unbalance of the bridge. The output of the bridge is amplified, rectified, and, if above the critical value, is used to trigger an electronic circuit which in turn excites a relay. This relay then turns on a warning device.

The circuit also employs a meter which is calibrated directly in percentage of hydrogen. The point at which the triggering mechanism excites the relay is adjustable: two per cent hydrogen by volume is considered a satisfactory setting since four per cent is the explosive limit. This particular circuit is capable of detecting as low as one per cent hydrogen; however, it is quite probable that with greater design precautions one could go as low as 0.1 per cent.

Beta Spectrum of Pr^{143} . J. A. BRUNER, L. M. LANGER, D. MOFFAT, Indiana University.—The beta spectrum of Pr^{143} (13.8 d) has been studied in the 40 cm. radius of curvature shaped magnetic field spectrometer and also in a smaller version employing a 15 cm. radius of curvature. Although the comparative half life ($ft \sim 4.5 \times 10^7$) indicates that the transition is once forbidden, the spectrum was found to have the allowed shape. This suggests that the spin change must be less than 2. In order to satisfy these conditions it is necessary that, in this case, the $2d_{5/2}$ and $1g_{7/2}$ states be inverted in the nuclear shell model of M. G. Mayer.¹ The end point was found to be 0.922 ± 0.003 Mev.

¹ M. G. Mayer, Phys. Rev. **75**, 1969, 1949.

Shape of the interference fringes obtained with the Michelson-Williams reflection echelon. DELMAR O. DAVIS and K. W. MEISSNER, Purdue University.—The shape of the interference patterns which one has to expect when a Michelson-Williams reflection echelon is equipped with a long collimator slit, has previously been derived and discussed by K. W. Meissner. In order to check these results the reflection echelon of Purdue University was set up in an autocollimation arrangement. By employing a long slit, illuminated with the green krypton line 5570A, several photographs were obtained which exhibit the special features to be expected according to the calculations mentioned above.

A method for determining short time stress-rupture characteristics of various steels. W. E. FONTAINE, J. E. BROCK, and SAMUEL TARSON, Purdue University.—A method is described by which small specimens of steel may be stressed in an atmosphere of steam at 1200°F until rupture occurs. Stresses are chosen so that rupture occurs in less than 100 hours. Short time stress-rupture curves are shown for three different types of steel.

The Photoelectric Light Curve of the Eclipsing Star YY Canis Minoris. H. HAROLD HARTZLER, Goshen College.—Two hundred and forty one photometric observations were made of this star at the Steward Observatory of the University of Arizona from February 21, 1949, to April 24, 1949. Each observation consisted of a two minute observation on a comparison star, then a four minute observation on the star being measured and a final two minute observation on the comparison star. The light from the star was concentrated by a thirty six inch telescope on a photoelectric cell and then, after suitable amplification, automatically recorded by a Leeds and Northrup micrimax recorder. Five times of primary minimum were observed and a new period of 1.0940232 days was computed. The magnitude of this star changes from 8.5 to 9.4 in a periodic manner. Its spectral type is F5. The light curve of the star will be shown.

The stopping of fast deuterons in semiconductors. Z. H. HELLER and D. J. TENDAM, Purdue University.—Measurements of the stopping power of Ge and Si, as proposed by K. Lark-Horovitz, have been made for use in evaluating experiments on the nuclear bombardment of semiconductors, and to obtain information about the stopping process in these materials.

The reduction in range, due to the absorber samples, of the deuteron beam from the cyclotron (9-10 MeV) was measured using a system of two ionization chambers, one fixed and one movable, and a suitable detecting circuit. Curves for the conversion of extrapolated ionization ranges (which were measured) to mean number ranges were computed for large straggling parameters.

The stopping powers found were:

2.18 mg/cm² Ge = 1 cm air

1.50 mg/cm² Si = 1 cm air

The stopping power of Ge showed negligible velocity dependence when the incident beam energy was reduced.

Curves of range reduction vs. absorber thickness were measured for Al, Ni, Cu, Zr, Rh, Ag, Sn, and Au in order to compare the semi-conductor stopping powers with those of the metals. No significant difference was found. The figures for the metals also showed that the stopping powers in Table XLIX of the Livingston and Bethe¹ article need modification, the velocity dependence being accurate but the values some 3-6% too low.

Electrical Behavior of Semi-conductors at Very Low Temperatures.

C. S. HUNG, P. H. KEESOM, and K. LARK-HOROVITZ, Purdue University.—Using special cryostats to measure the electrical resistivity and Hall effect through the temperature range from room temperature to liquid helium temperature, Germanium, Silicon and Tellurium semi-conductors have been investigated. For some Germanium and Silicon semi-conductors with a large number of impurity centers so as to give the degenerate behavior as predicted by the theory of Johnson and Lark-Horovitz, theory and experiment agree. Some Silicon samples show a behavior which indicates, as has already been found at higher temperatures, that the resistance is due in part only to impurity scattering and lattice scattering and is due in a large extent to grain-boundary scatterings. Purest Germanium single crystals show anomalous behavior in the low temperature range, indicating, perhaps, inhomogenieties which are not detectable at room temperature. For these samples the assumptions usually made in the derivation of the Hall effect are not fulfilled. A similar effect is also observed in Tellurium; whereas at ordinary temperature Tellurium does not show any measurable dependence of Hall effect on magnetic field, such a dependence can be observed in the low temperature range.

Crystallization of Rubber. HUBERT M. JAMES, Purdue University.—

The freezing of rubber is a relatively complex phenomenon. Rubber freezes slowly at temperatures between -50°C and $+15^{\circ}\text{C}$, most rapidly at about -25°C . The melting point is also variable, depending on the temperature of freezing and on the length of time the material has remained frozen. Rapid freezing can be brought about by stretching the rubber, even at temperatures above 100°C ; again the behavior of the frozen rubber depends on the conditions under which it was frozen. These peculiarities of rubber arise from its structure as a molecular network. The rate of freezing depends, as with any material, on the rate of formation and growth of crystal nuclei; in rubber, however, there is the added factor that growth of any single crystallite is limited by the network structure. The molecules in rubber crystals are not equivalent, as in ordinary crystals, but are subject to differing constraints due to

¹ M. S. Livingston and H. A. Bethe, *Rev. Mod. Phys.* **9**, 261 (1937).

their different positions in the network. The melting point of the crystals depends on the disruption forces exerted on them by the network; these are greater the more rapidly the crystals are formed. Stretching rubber favors crystallization by aligning the molecular segments and decreasing the entropy change on freezing; it also favors the formation of crystals which, in the unstretched material, will be subject to large disruptive forces.

Theory of the Hall effect at very low temperatures. V. A. JOHNSON and K. LARK-HOROVITZ, Purdue University.—In the study of semi-conductors, one obtains information about n , the number of free electrons (or holes) per unit volume in a sample, by measuring the Hall coefficient R . As long as current carriers of only one sign are present in the sample, R and n are taken to be related by the equation: $R = 3\pi / (8ne)$. Recent studies at Purdue show that there is good basis for doubting the validity of this equation at very low temperatures, especially in the range 1°K – 40°K . One important source of error lies in an assumption made in deriving the equation, i.e., that the mean free path of a free electron does not depend upon the energy of an electron but only upon the temperature of the sample. It has been found that this assumption is not valid at low temperatures and produces a 10% error at 50°K , a 40% error at 15°K , and still greater errors at lower temperatures. A second source of error appears whenever the mean-free-path is comparable in magnitude with the radius of curvature of the electron path in the magnetic field. Since the mean-free-path increases at $1/T$ as the temperature drops, while the radius decreases as $T^{1/2}$, the two distances approach equality at very low temperatures instead of the radius being about 100 times larger, as is the case in near room temperature.

The performance of the Purdue linear electron accelerator. JOHN W. MACKAY, Purdue University.—The accelerator consists of a cylindrical resonant cavity 1 meter long, excited by a 1 megawatt 10 cm. pulsed magnetron. Pulses of electrons are injected with an initial energy of 300 Kev. The output of the accelerator is analyzed with a magnetic spectrograph. Pulse techniques are used to observe the output current. Numerical integration of the electron orbits through the accelerator indicates that the energy spectrum should contain three peaks between 1.0 and 1.4 Mev. According to theory the electrons making up one of these peaks should suffer large radial forces in the accelerator and be widely spread in cross section. A second peak should be somewhat defocussed and the third only slightly defocussed. Analysis of the emergent beam shows two of these peaks and their distribution in the cross section of the beam. The electrons forming the other peak are apparently too widely spread to be detected.

Influence of irradiation on the voltage-current characteristic of a glow discharge through rare gases. K. W. MEISSNER and R. M. PIERSON, Purdue University.—When the positive column of a gaseous discharge through a very pure rare gas is irradiated with light from another dis-

charge tube containing the same rare gas one observes a distinct change of the current and of the voltage across the irradiated discharge tube. Experiments were carried out with neon and helium discharge tubes at various pressures. These experiments establish the fact that the voltage-current characteristics of these discharges are raised by irradiation. This effect can be understood by considering the role of metastable atoms in discharges through rare gases and that their number can be appreciably decreased by irradiation of light of proper wave length.

Some characteristics of the scintillation counter. MAURICE M. MILLER, and WALDO RALL, Indiana University.—Two 1P28 photomultiplier tubes were used in coincidence as a scintillation counter with low noise background. The performance of this counter as a proportional beta counter was investigated. A commercial electron gun, mounted in a vacuum system, was used to accelerate electrons up to 5600 volts. The gun was operated to give a beam current ranging between 10^{-10} and 10^{-12} amperes. The phototubes were operated at -600 volts. Integral bias curves were obtained which are logarithmic over three orders of magnitude. Curves will be shown giving pulse height distribution and efficiencies from 500 to 5600 volts. The relative efficiency of the scintillation counter as a gamma detector is now being investigated by means of coincidence and absorption methods.

Low energy beta ray spectra: Pm^{147} , S^{35} . H. C. PRICE, JR., J. MOTZ and L. M. LANGER,¹ Indiana University.—The beta spectra of S^{35} and Pm^{147} have been measured in an attempt to study further the nature of the low energy deviation from the Fermi theory previously reported.^{2, 3} Measurements were made with thinner sources and improved techniques in both the 40. cm radius of curvature spectrometer and also in a small 180 degree focussing Helmholtz coil spectrometer designed specifically for low energy spectra. The excess of particles at low energies was found to be a function of source thickness. The thinnest sources used were less than 10 micrograms/cm². Both S^{35} which is allowed and Pm^{147} which is probably once forbidden were found to have spectra of the allowed shape. Using counter windows of 3 micrograms/cm² and also a windowless counter technique, Fermi plots were obtained which, for Pm^{147} , were straight down to 8. kev. The end point of Pm^{147} was found to be 223.2 ± 0.5 kev. On the basis of an improved calibration of the instrument, the present results for S^{35} yield an end point of 167.0 ± 0.5 kev.

The disintegration energy of Al^{29} . L. SEIDLITZ, E. BLEULER, and D. J. TENDAM, Purdue University.—Shell structure models of the nucleus

¹ Assisted by a grant from the Frederick Gardner Cottrell Fund of the Research Corp. and by the joint program of the ONR and AEC.

² C. S. Cook, L. M. Langer and H. C. Price Jr., Phys. Rev. **74**, 548 (1948).

³ H. D. Albert and C. S. Wu, Phys. Rev. **74**, 847 (1948).

as proposed by Wigner¹, Feenberg and Hammack² and Nordheim³, provide for no shell closures between Ne²⁰ and Ca⁴⁰. The measured mass difference between Al²⁸ and Si²⁸, however, is higher than expected from calculations based upon the above hypothesis indicating an especially stable structure for Si²⁸. A strong spin-orbit coupling, as proposed by Haxel, Jensen and Suess⁴ and Mayer⁵, could lead to a closed shell at Z (or N) = 14. If the Al²⁸—Si²⁸ anomaly is due to such a closure, then a similar result might be expected for the transition Al²⁹—Si²⁹.

Al²⁹ was produced by bombarding Mg with the α -particles of the Purdue cyclotron. The half-life was found to be $6.56 \pm .06$ m. Absorption and coincidence measurements show a complex β -spectrum of two components, each decay leading to an excited state of the residual nucleus. The two β -components have upper limits of $2.5 \pm .1$ MeV (70%) and $1.4 \pm .2$ MeV (30%) while coupled γ -rays have energies of $1.25 \pm .20$ MeV and $2.35 \pm .10$ MeV respectively. The total disintegration energy of $3.75 \pm .25$ MeV is approximately 1.7 MeV too high when compared with neighboring nuclei of the same symmetry (Ne²³ 4.3, Na²⁵ 3.7, Mg²⁷ 2.64, Al²⁹ 3.75, Si³¹ 1.8, P³³, S³⁵ 0.167 MeV). This appears to confirm the evidence for a highly stable structure for Si²⁸.

On the design of iris-loaded waveguides. LEO M. SILBER, Purdue University.—The microwave linear electron accelerator utilizes a waveguide which will propagate a wave with a component of the electric field intensity in the direction of propagation, and a phase velocity less than the velocity of light. Ordinary waveguide is unsuitable because the phase velocity is greater than that of light. However, a circular waveguide loaded with circular irises can be designed to have the required properties. The present work is connected with the design of a standing-wave linear accelerator. An empirical relation was found between the geometry of the waveguide and the phase velocity of the wave. Using this relation an accelerator was designed to accelerate electrons from 300 KV to 1.2 MeV, or from a phase velocity of 0.77 c to 0.95 c. The experimental results have also been compared to the theory of electromagnetic waves in iris-loaded waveguides.

An experiment on the arrival angle of 3.2 cm microwaves. C. M. ZIEMAN, Wabash College.—To measure small variations in the arrival angle of microwaves, caused by changes in the vertical structure of the atmosphere, a transmitter, radiating at a frequency of 9520 megacycles, was placed on the observatory grounds at Mt. Wilson, California.

The radiated energy was focused by a metallic lens located at the California Institute of Technology about 7.2 miles away.

¹ E. Wigner, *Physical Review*, **51**, 947, (1937).

² E. Feenberg and K. C. Hammack, *Physical Review*, **75**, 1877 (1949).

³ L. W. Nordheim, *Physical Review*, **75**, 1894, (1949).

⁴ O. Haxel, J. H. D. Jensen and H. E. Suess, *Physical Review*, **75**, 1766 (1949).

⁵ M. G. Mayer, *Physical Review*, **75**, 1969, (1949).

The shift of the diffraction pattern, as measured in the focal plane of the lens, was taken as a measure of change in arrival angle.

Variations of the order of one tenth of a degree were noted. Such variations seem larger than can be accounted for by calculations based on ray theory.