Proceedings of the American Physical Society

MINUTES OF THE MEETING OF THE SOUTHEASTERN SECTION AT CLEMSON COLLEGE, APRIL 15–16, 1949

THE fifteenth annual meeting of the Southeastern Section of the American Physical Society was held at Clemson College, Clemson, South Carolina, on Friday and Saturday, April 15–16, 1949. Approximately 325 members and guests attended.

The program consisted of sixty-seven ten-minute contributed papers and five addresses by invited speakers. Abstracts of sixty-four of the contributed papers are printed below. The others will be printed in the *American Journal of Physics*. The invited papers were as follows:

Rocketborne Upper Atmospheric Experiments of the Air Materiel Command. MARCUS O'DAY, *Watson Laboratories.*

High Speed Rotors. J. W. BEAMS, *University of Virginia.*

New Developments in Infra-Red Spectrometry. EARLE K. PLYLER, *National Bureau of Standards.*

Search for Beta-Proton Coincidences Associated with Neutron Decay. A. H. SNELL, *Oak Ridge National Laboratory.*

The Oak Ridge National Laboratory. A. M. WEINBERG, *Oak Ridge National Laboratory.*

Officers for the next year are as follows: *Chairman*, J. H. Howey; *Vice Chairman*, W. G. Pollard; *Secretary*, A. D. Callihan; *Treasurer*, H. F. Henry. F. G. Slack was elected to the Executive Committee for a four-year term. The next meeting will be held at the University of Chattanooga, in Chattanooga, Tennessee.

Eric Rodgers, *Retiring Secretary*

ABSTRACTS

1. Neutron-Induced Short-Life Activities. EDWARD C. CAMPBELL AND WILFRED M. GOOD, *Oak Ridge National Laboratory.*—In order to study activities with half-lives in the fractional second range a pneumatic tube has been constructed and installed in the Oak Ridge pile. The tube is rectangular in cross section and allows the delivery in a few tenths of a second of an oriented thin foil sample from the center of the pile to a position at rest facing a shielded beta-counter outside the pile. The decay of the sample is recorded automatically. A new activity in tantalum having a half-life of 0.33 seconds has been found. The activity is unchanged when the tantalum is irradiated in cadmium. Absorption measurements show that conversion electrons from an isomeric level are being detected. The energies of these agree within experimental error with those observed following the beta-disintegration of Hf^{181} to an excited state of Ta^{181}. The activity is therefore tentatively assigned to an excited state of stable Ta^{181}. Results of an extensive search for other short-lived activities will be presented.

2. Electron-Neutrino Correlation in Heavy Elements.* M. E. ROSE, *Oak Ridge National Laboratory.*—The angular distribution of recoil nuclei with respect to the direction of emission of the electron (positron) in a radioactive decay provides a means of distinguishing between the various forms for the beta-interaction. In terms of the angular correlation of electrons and neutrinos the distribution for allowed transitions is of the form $1+A\cos\theta$ where θ is the angle between the directions of electron and neutrino,[1] $A=ncp/W$, p and W are the momentum and total energy of the electron. For the Fermi, (Gamow-Teller) interaction $n=1$, $(\frac{1}{3})$. The possibility has been investigated that the Coulomb field on the electron may influence the correlation coefficient A sufficiently as to lead to erroneous conclusions with regard to the interaction form. It has been found that n is changed by a factor which is the same for all five interaction forms. This factor departs from unity by an amount proportional to Z^2 and for $Z\approx 80$ the correction is only about 20 percent. Therefore, for the purpose of deciding between beta-interaction forms the influence of the Coulomb field may be neglected.

* This work was done under Atomic Energy Project No. W-7405, eng 26, Oak Ridge, Tennessee.

[1] D. R. Hamilton, Phys. Rev. **71**, 456 (1947).

3. Some Isotopic Neutron Absorption Cross Sections. H. S. POMERANCE, *Oak Ridge National Laboratory.*—The Oak Ridge pile oscillator[1] was designed to measure thermal neutron absorption cross sections of small samples. At present, macroscopic cross sections of 0.1 mm^2 can be detected and 1 mm^2 can be measured with 10 percent accuracy. Many enriched isotopes produced at the Oak Ridge electromagnetic plant (Y-12) are available in sufficient weight to be used. For four elements the isotopes have been measured and the weighted sum of the isotopic cross sections times their respective abundances have been compared with the cross sections for the normal element. The results are:

Cr^{50}—16.3b;	Cr^{52}— 0.73b;	Cr^{53}—17.5b;
Cr^{54}— 0.3b;	Ni^{58}— 4.17b;	Ni^{60}— 2.72b;
Ni^{61}— 1.8b;	Ni^{62}—14.8b;	Cu^{63}— 4.29b;
Cu^{65}— 2.11b;	Zr^{90}— 0.116b;	Zr^{91}— 1.54b;
Zr^{92}— 0.269b;	Zr^{94}— 0.116b;	Zr^{96}— 0.294b.

Estimated accuracies vary from 25 percent for the zirconium. to 5 percent for the copper.

[1] J. I. Hoover, *et al.*, Phys. Rev. **74**, 864 (1948).

4. Neutron Diffraction Studies of AgCl, $Ag^{107}Cl$, and $Ag^{109}Cl$ W. A. STRAUSER, C. G. SHULL, AND E. O. WOLLAN, *Oak Ridge National Laboratory.*—Samples of silver chloride containing either normal silver or enriched silver isotopes have been examined in the neutron diffraction powder spectrometer in use at Oak Ridge. The powder patterns which have been obtained show that Ag, Ag^{107}, and Ag^{109} all scatter neutrons with a positive scattering amplitude, the same as does chlorine. Measurements of the diffraction peak intensities permit evaluation of the coherent scattering cross sections for Ag, Ag^{107}, and Ag^{109} as 5.1, 8.7, and 2.3 barns respectively. Powder diffraction patterns for these materials will be shown and general details of the neutron spectrometer operation and cross section evaluation will be given.

5. Microwave Spectrum of Methyl Fluoride, Fluoroform, and Phosphorus Tri-Fluoride. O. R. GILLIAM, H. D. EDWARDS AND W. GORDY, *Duke University.**—From measurements on pure rotation transitions in the millimeter wave region the molecular dimensions have been determined as follows: for

CH_3F, $d_{CH}=1.109$A°, $d_{CF}=1.385$A, and $\angle HCH=110°0$; for HCF_3, $d_{CF}=1.326$A°, for PF_3, $d_{PF}=1.546$A° confirming evidence for nuclear spins of $\frac{1}{2}$ for P^{31} and F^{19} has been obtained

* This research was supported by Contract No. W-19-122-ac-35 with the Army Air Forces, Watson Laboratories, Air Materiel Command.

6. Microwave Spectrum of Methyl Alcohol and of Methyl Amine. H. D. EDWARDS, O. R. GILLIAM, AND W. GORDY, *Duke University.**—The $J=0$ to $J=1$ rotational transitions of methyl alcohol and of methyl amine have been observed in the millimeter wave region. Measurements of the line positions yield the moments of inertia, I_B, 34.4489×10^{-40} gm-cm² for $C^{12}H_3O^{16}H$ and 37.0206×10^{-40} gm-cm² for $C^{12}H_3N^{14}H_2$. The internuclear distance d_{CO} for methyl alcohol is evaluated as 1.428A and the d_{CN} distance is methyl amine as 1.469A.

* This research was supported by Contract No. W-19-122-ac-35 with the Army Air Forces, Watson Laboratories, Air Materiel Command.

7. An Experiment in X-ray Scattering. ERIC RODGERS, *University of Alabama.*—A study has been made of the scattering by iron of polarized x-rays. The x-rays from a 200-kv machine were scattered twice at 90°; first by a block of carbon, and second by a strip of iron extending through a magnetizing coil. No change in the intensity of the scattered rays was observed when the iron was magnetized by a direct current, but a change has been observed when it was magnetized by 60-cycle alternating current. Increases in intensity varying from zero up to 6 percent have been observed when the alternating field was on. The increase was found to depend on the phase relationship between the magnetic flux through the iron and the portion of the cycle at which maximum x-ray output occurred. A pick-up coil around the iron and the output of an anthracene crystal photo-multiplier combination in the x-ray beam were connected to an oscilloscope to show these phase relationships. Greater changes were observed in a direction perpendicular to the primary beam than in a direction parallel to it. A further study of the effect is in progress.

8. Color Produced in Quartz by X-rays. GUY FORMAN, *Vanderbilt University.*—*Z*-cut sections of quartz were irradiated with x-rays from a berryllium window x-ray tube. Color produced in the quartz was studied by measuring, before and after irradiation with x-rays, the percentage of transmission of light of different wave-lengths in the visible region of the spectrum. Definite color saturations were obtained which could not be changed by further x-ray irradiation. The percent of transmission, at saturation, is different for different wavelengths of light. The color was removed from the quartz by heating the sections in a furnace at temperatures ranging from 250°C to 400°C. The irradiation processes were repeated and the color produced was again studied. From the data collected the maximum coloration appears to be a physical property of the particular quartz section.

9. Photo-Multiplier Detector for X-ray Spectrometer. J. S. BROWN, G. M. FARRIOR, AND ARTHUR WALTNER, *North Carolina State College.*—The photo-multiplier tube used in conjunction with a fluorescent screen has been used as an x-ray detector by various investigators.[1] We have built an x-ray spectrometer using such a detector. A student-type spectrometer was used as a foundation with a collimator and crystal mounted in the usual way. X-rays are detected by means of a type 931-A photo-multiplier tube used in conjunction with a fluorescent screen. Efficiencies of several fluorescent screens are compared and curves are presented showing the performance of this simplified spectrometer.

[1] Marshall, Coltman, and Hunter, Rev. Sci. Inst. **18**, 504 (1947).

10. On the Knock-On Secondaries of Penetrating Particles. E. D. PALMATIER,* W. W. BROWN, AND A. S. MCKAY, *Cornell University.*—The knock-on secondaries of penetrating particles emerging from Pb plates (15 gm-cm^{-2}) have been investigated by cloud-chamber and by counter telescope. The frequency of occurrence and the spatial distribution of the secondaries with respect to the primary penetrating particles have been measured and found to be in agreement for the two methods. Further data are presented on the backscattering of secondaries from Pb plates and on the emergence of secondaries from thin sections of material such as counter walls. The possible effect on counter experiments are considered.

* Now at the University of North Carolina.

11. Optimum Thickness for Alpha-Particles of Phosphor Surface in Scintillation Counters. J. M. WATKINS, JR. AND A. C. MENIUS, JR., *Clemson Agricultural College.*—An attempt is made to determine the "solid angle" as a function of the thickness of the silver activated zinc sulfide (wurtzite) used with the photo-multiplier tube[1] in conjunction with an amplitude discriminator[2] and a conventional scaling circuit. Associated apparatus utilized in this experiment will be discussed. Initial investigations show a maximum "solid angle" using 5.3-Mev alpha-particles from Po^{210}. Theoretical calculations suggest a means of determining the energy loss of the alpha-particle per centimeter of the phosphor due to scintillation as a function of the energy.

[1] R. Sherr, Rev. Sci. Inst. **18**, 767 (1947).
[2] Higinbotham, Gallagher, and Sands, Rev. Sci. Inst. **18**, 706 (1947).

12. An Improved Scintillation Counter. ARTHUR WALTNER, *North Carolina State College.*—Experiments are under way in which we attempt to suppress the dark current pulses of a scintillation counter by using two matched photo-multiplier tubes feeding their output into a coincidence circuit. The dark current pulses being of a random nature will in general not trigger the coincidence circuit, whereas a true count will produce simultaneous pulses in the two photo-multipliers and therefore appear in the output of the coincidence circuit. Photographs of the dark current pulses are shown indicating the performance of this type of counting circuit.

13. Three-Fold Coincidence Counter. W. H. JORDAN AND J. C. GUNDLACH, *Oak Ridge National Laboratory.*—A circuit for counting triple coincidences in two Geiger tubes and an electron multiplier has been constructed. Delays in the Geiger tube channels have been held to a minimum (~0.1-μ sec.) by triggering the associated multivibrators at the beginning of the Geiger discharge. The resolving time is kept constant by using delay-line controlled multivibrators. The random coincidence rate and the true coincidence rate are measured during the same time interval. This is done by splitting the pulse from the Geiger tube into two channels, delaying the pulse in one channel by ten microseconds, and then observing the coincidences in each channel with the undelayed pulse from the multiplier. Counts from the delayed channel are random coincidences; counts from the other channel are random plus true coincidences.

14. On the Rate of Energy Loss of Protons and Deuterons. W. A. BOWERS, *University of North Carolina.*—Recently Wilcox[1] has presented evidence showing that the rate of energy loss of slow protons and deuterons of the same velocity passing through gold may not be the same, as is predicted by current theories, but may differ slightly, with deuterons losing energy at a rate 5 or 10 percent greater than protons. Calculations have been carried out to see whether it is possible, as suggested by Wilcox, that this effect is due to the neglect in the usual theory of energy loss of the effect of elastic collision, which would give a slightly greater energy loss for deuterons than

for protons. It turns out, however, that this effect is much too small to explain Wilcox's results. One can see easily on a simple classical picture that the proposed mechanism will give an effect of the order of (electron mass/proton mass) times the usual energy loss, and quantum mechanical calculation confirms this result.*

[1] H. A. Wilcox, Phys. Rev. **74**, 1743 (1948).
* In a Letter to the Editor, Phys. Rev. **75**, 891 (1949), which appeared after this abstract had been submitted, Hall and Warshaw report that more accurate measurements with the same apparatus show the same rate of energy loss for deuterons and protons.

15. Composite Particles. H. M. MOSELEY, *University of North Carolina.*—A proposal that particles of spin 0 or 1 are "composite" particles, consisting of two elementary particles each of spin $\frac{1}{2}$ is treated, using a modified form of the equations discussed by Kemmer.[1,2] The Dirac δ-function occurring in Kemmer's equations is replaced, by application of Rosen's[3] statistical geometry theory, by a term of the form $\exp(-r^2/4a^2)$, where a is a fundamental constant $\sim 10^{-13}$ cm. Work directed toward obtaining stationary-state solutions will be discussed.

[1] Kemmer, Helv. Phys. Acta. **10**, 47 (1937).
[2] Rosen, Phys. Rev. **74**, 128(A) (1948).
[3] Rosen, Phys. Rev. **72**, 298 (1947).

16. Electric Field and Discharge Photographs. F. G. SLACK AND HSIEH YU-CHANG, *Vanderbilt University.*—In attempting to duplicate the "electric discharge figures" photographed by J. M. Kuehne[1] some interesting pictures have been obtained. Pictures have been made by condenser discharge and also by use of the photographic plate is dielectric between charged electrodes. In the latter case images of the electrode surface are obtained. This is true for non-metallic as well as for metallic electrodes. Satisfactory explanations are lacking. Further work is being done to determine the nature of the images and possible uses for them.

[1] J. M. Kuehne, Science Illustrated **3**, No. 12, 11, (1948).

17. A Precision Method for Measuring Bioelectric Potentials. EDGAR B. DARDEN AND OTTO STUHLMAN, JR., *University of North Carolina.*—The circuit employed is a slight modification of the Wheatstone bridge arrangement designed by Burr, *et al.*,* for measuring slow changes in mammalian potentials. The two absolute 112-A filament-type triodes functioning as two arms of the bridge were replaced by two 6J5's. The high input impedance required in bioelectric potential measurements was secured by applying the voltage, to be measured, across a 10-megohm resistor in the grid circuit of the input tube. The other tube functioned as a diode. Precision plate and bias regulations are provided so that with proper balancing of the bridge, a high sensitivity galvanometer connected between the plates measured a current almost directly proportional to the magnitude of an input e.m.f. The galvanometer was a Leeds and Northrup type 2285-X with a sensitivity of 0.057 microvolts/mm. Contact potentials of the electrodes across which the bioelectrical potential was placed were minimized by using a pair of Ag-AgCl reversible electrodes in dilute KCl. A salt bridge leading from each reservoir terminated in a glass capillary containing a small, asbestos-fiber wick, served as the contact electrode on the surface of the plant, where the e.m.f. originated.

* Burr, Lane, and Nims, Yale Journal of Biology **9**, 65-76 (1936).

18. Bio-Electric Transients Accompanying the Closing Movements of the Lobes of Venus' Fly-Trap. OTTO STUHLMAN, JR. AND EDGAR B. DARDEN.—Closure of the trap-like structure at the end of the spatulated petiole of Venus' Fly-Trap normally follows when the three spike-like trigger hairs or the irritable inner epidermis is stimulated. The earlier work of the senior author showed that speed of closure depended on the pattern of excitation, which was hypothecated to originate as a localized destruction of the degree of polarization which progressively spread as an equipotential electrical wave front propagated over the surface of the lobe at about 3.0 cm per sec. The present experimental evidence shows that the hypothesis was justified. The wave front was found to be a negative potential of about 0.05 volt for summer growth or as low as about 0.01 volt for winter growth plants. It is measurable as a diphasic or monophasic impulse depending on the position of the non-polarizable electrodes. The exact shape, speed and origin of the electrical impulse is being explored with the aid of a vacuum tube microvoltmeter, electrometer and oscilloscope.

19. A Portable Vacuum Tube Electrometer of Wide Utility. E. E. BORTNER, *Oak Ridge National Laboratory.*—A simple electrometer employing a VX-32-B tube has been constructed and used in tests on various ionization chambers. It is a null-reading device and is used with apparatus, which is either inexpensive or generally available in established laboratories. The electrometer is well suited to experiments involving radioactivity in that it features a portable chamber, has good sensitivity, excellent stability and permits remote operation, so that the worker is not subject to over exposure.

20. Measurement of the Thompson Coefficient for Tungsten at High Temperatures.* C. C. SARTAIN, *University of Virginia.*—The distribution of temperature along a straight filament carrying an electric current can be used to determine the Thompson coefficient σ. The electron emission current is plotted as a function of length along the filament to indicate the temperature. Theory shows that σ is a function of the shape of this curve, the cross-section area, the thermal conductivity and the current through the filament. An experimental method for determination of σ for temperatures between 1400°K and 3000°K is described.

* This work was partially supported by Contract NOrd-7873 with the Bureau of Ordnance of the Navy.

21. The Conduction of Heat from a Long Circular Cylinder. R. H. RITCHIE AND C. B. CRAWLEY, *University of Kentucky.*—A previously known expression for the transient temperature variation in an infinite medium bounded internally by a long circular cylinder is discussed. It is evaluated over a certain range of time and of distance from the cylinder. Its practical application to heat pump operation is considered.

22. Macroscopic Space Charge in Electrolytes during Electrolysis. CHARLES ALBERT REED* AND WILLIAM SCHRIEVER, *University of Oklahoma.*—In a uniform column of electrolyte, the potential rise was found to be a non-linear function of distance from the cathode, and it was shown that the non-linearity could not have been due to concentration changes caused by the electrolysis but must have been due to macroscopic space charges in the electrolyte. Calculations showed the space charge to be positive very close to the cathode, negative in the next quarter of the column, positive in the next nearly three-quarters of the column and negative very close to the anode. The eight electrolytes studied were 0.0024N solutions of $CuSO_4$, $CuCl_2$, $ZnSO_4$, $ZnCl_2$, $Zn(C_2H_3O_2)_2$, $NiSO_4$, $NiCl_2$, and $Al_2(SO_4)_3$. Each column of electrolyte was 40-cm long, and the constant potential difference was 8.000 volts. The pure metal was used for the electrodes in each case. Although the space charges were very small, they had very appreciable effects on the potential gradients which were also calculated.

* Now Associate Professor of Physics at Clemson College, Clemson, South Carolina.

23. Critical Damping and Time of Return of a Galvanometer Coil. MARVIN S. COHEN AND CLYDE B. CRAWLEY, *University of Kentucky.*—Critical damping has been defined as the transition condition between over-damped and damped oscillatory motion. It is often erroneously assumed that the critically damped condition has the property of minimum time of return for a body that is initially displaced from its equilibrium position. The motion of a galvanometer coil is used as an illustration of damped motion. Various definitions of the time of return are proposed and these times are calculated for various values of damping. It is found that the minimum time of return depends upon the choice of the definition of the time of return. It is also found that the value of the damping necessary to obtain the minimum time of return is dependent upon the choice of definition and is slightly less than the critical damped value.

24. An Equivalent Electrical Circuit for a Galvanometer. R. C. KINNAMON, M. S. COHEN, AND C. B. CRAWLEY, *University of Kentucky.*—It is proved that a circuit consisting of a resistance in series with a parallel combination of a resistance, an inductance and a capacitance is equivalent electrically to a galvanometer. The method makes use of differential equations and does not specify the form of the applied voltage so that it is completely general. The values of the galvanometer constants as functions of the equivalent circuit parameters are obtained. These results as implied above are true for transient and steady state conditions and are independent of frequency.

25. Anode Spark Breakdown on Distilled Water Surfaces. R. L. YOUNG AND HUGH F. HENRY,* *University of Georgia.*—Factors affecting the maximum breakdown distance of anode sparks produced on a distilled water surface have been investigated. The liquid was contained in a paraffin impregnated wooden cell approximately 100×100 cm, filled to a depth of 5 cm with distilled water. A microfarad condenser was charged by a transformer-rectifier circuit, and the potential applied across the electrodes through a spark gap. The anode was a copper rod 0.26 cm in diameter which was suspended vertically with its tip in the liquid. The cathode was a copper plate 12.6×7.6×0.18 cm which was so suspended that its flat surface was perpendicular to the water surface and its contact with that surface was along its greatest dimension. The shape and vertical position of the cathode did not affect the breakdown distance, but as the anode tip was immersed beneath the surface from 0 to 4 mm, that distance decreased. The breakdown distance was found to be proportional to the applied potential in the range studied (6 to 14 kev), but no change was noted when the input capacitance was 2 mfd.

* Now with Carbide and Carbon Chemicals Corporation, Oak Ridge, Tennessee.

26. Apparatus for the Study of the Philips Gage-Discharge. TALBOT CHUBB, *University of North Carolina.*—A program has been initiated at the University of North Carolina to investigate the Philips gage type of electrical discharge. Because the Philips gage discharge requires high vacuum, a 17-in. diameter bell jar enclosing the apparatus and mounted on an aluminum face plate is to be exhausted by an oil diffusion pump backed by a megavac. To provide the required magnetic field an electro-magnet has been built with its pole pieces mounted inside the vacuum system. The initial investigation is to study the role of secondary emission in the discharge. An assembly has been constructed to permit changing cathode plates under vacuum, so that a direct comparison between cathodes of various materials and of various designs can be made. A description of the apparatus and the status of the study will be given.

27. An Electrostatic Analyzer. MARY JANE A. LINKER, *University of North Carolina.*—By the use of a radial inverse first power electrostatic field Hughes and Rojansky[1] showed that a bundle of charged particles of the same energy could be focused in a manner similar to that in a magnetic field. A number of such electrostatic analysers have been built—some with deflecting plates subtending 127°17′, others 90°. One of the former type has been constructed, similar to the model built by Backus[2] for low energy spectra. Operation of the instrument has been tested using S^{35} as a beta-ray source. Preliminary data show a close correlation with the S^{35} spectrum determined by means of a magnetic spectrometer by Cork, Langer, and Price.[3] Future plans for the instrument include in addition to the measurement of other low energy beta-ray spectra, investigation of the physics of the instrument itself and its use as a source of mono-energetic particles for cloud chamber studies.

[1] A. L. Hughes and V. Rojansky, Phys. Rev. **34**, 284 (1929).
[2] John Backus, Phys. Rev. **68**, 59 (1945).
[3] Cork, Langer, and Price, Phys. Rev. **74**, 548 (1948).

28. Pulse Degradation in the Transient Response of Stable Linear Systems. W. WHITTIER WRIGHT AND W. B. WRIGLEY, *Georgia Institute of Technology.*—The concept of pulse degradation in considerations of the transient response of linear stable electrical networks is presented by means of an elementary optical analog. The exact transient response of a single general network-aperture, as well as of several network apertures in tandem, is discussed with regard to the degradation of pulse signals passed by the system. The limitations of two widely used methods of transient analysis—the harmonic analysis-synthesis (superposition), and the Laplace-Fourier transform and inverse transform solution of network equations on the complex frequency plane—are pointed out. The need for a new degradation index to specify the effect on system transient response of varying an integral aperture is shown. Two possible approaches in obtaining this degradation index are suggested, and a general statement is made regarding the applications of the resultant mathematics to other (non-electrical) stable linear systems.

29. Detection Pattern of a Magnetic Gradiometer. W. C. WINELAND, *Naval Ordnance Laboratory.*—The detection pattern of a simple magnetic gradiometer consisting of two similar magnetometers having their axes parallel and separated by a finite distance is calculated and compared with observed patterns. This detection pattern (which is considered to be the locus of points at which the presence of a magnetic dipole of fixed orientation produces a given difference in the components of magnetic field as measured by the two magnetometers) is shown to be a figure of six lobes. The effects of gradiometer unbalance and dipole orientation on the detection pattern are discussed.

30. Magnetic Effect of Eddy Currents Induced in a Conducting Plane by the Approach of a Bar Magnet. STANLEY A. JASHEMSKI AND W. C. WINELAND, *Naval Ordnance Laboratory.*—The approach of a bar magnet with concentric search coil at constant velocity toward an infinite conducting plane is considered, and the voltage induced in the coil by eddy currents in the plane is determined. The flux distribution produced by the magnet in the plane of the sheet is first determined experimentally by use of a number of concentric search coils, and the eddy currents in the sheet are calculated. The magnetic field of these eddy currents is then approximated by means of a set of concentric current-carrying coils, and the flux change in the coil wound on the bar magnet is measured stepwise as the magnet approaches the simulated conducting

sheet. This semi-theoretical method permits a static determination of the eddy current effect without resorting to the high velocities required to produce appreciable eddy currents.

31. Generalized Theory for the String Galvanometer. G. W. CRAWFORD, *North Carolina State College*, F. T. ROGERS, JR., *Oak Ridge National Laboratory.*—Represent the magnetic field[1] by a cosine series (Fourier coefficients a_J, by integration over the half-length $\frac{1}{2}l$ of undeflected string). If

$$h=\tfrac{1}{2}a_0-(2/\pi^2)\sum_{J=1}(-1)^J a_J/j^2, \quad (1)$$

$$q=\tfrac{1}{4}a_0^2+(3/2\pi^2)\sum_{J=1}a_J^2/j^2-(3a_0/\pi^2)\sum_{J=1}(-1)^J a_J/j^2, \quad (2)$$

and if the tension is[2] $\sum_{n=0} d_n(L-l)^n$, L being the length of the deflected string, then the mid-point deflection (D) is related to the current (i) by

$$D\sum_{n=1} d_n(8qD^2/3lh^2)^n=ihl^2/8. \quad (3)$$

This new and compact form for D *vs.* i should be valuable in assessing modern demands on this instrument's performance.

[1] F. T. Rogers, Jr., Rev. Sci. Inst. **12**, 351 (1941).
[2] G. W. Crawford and F. T. Rogers, Jr., Phys. Rev. **74**, 118 (1948).

32. Ultraviolet Absorption Spectra of Some Pyridine Derivatives in Liquid Solution. HAROLD P. STEPHENSON (Introduced by H. Sponer), *Duke University.*—The absorption spectra of picolinic acid, nicotinic acid and isonicotinic acid and of α-picoline, β-picoline and γ-picoline have been measured in liquid solution using a Beckman spectrophotometer. Ethyl alcohol was used as solvent for the three pyridine carboxylic acids while the picolines were measured in iso-octane solutions. Extinction coefficients ξ were obtained through the absorption regions of the substances extending in general from 2900–2200°A. The spectra of the three acids show two absorption peaks in the studied region, while the three methyl derivatives exhibit only one broad band. Maximum extinction coefficients for the acids range from 3900–2500 for the longer wave-length band and from 8600–7300 for the shorter wave-length band. For the picolines the corresponding ξ_{max}-values range from 2500–1500 in the single band observed. This is of the same order of magnitude as the maximum extinction coefficient in the corresponding band of pyridine ($\xi_{max}\sim 2000$). From the plots of the extinction coefficients *versus* wave numbers, the absorption strengths (oscillator strengths f) of the electronic transition in the different substances have been calculated. Tables of the various results will be presented and discussed.

33. Overtones in the Absorption Spectra of Color Centers in Alkali Halide Crystals. ROBERT LAGEMANN, *Emory University.*—Several new absorption bands have been noted in crystalline NaCl and KBr exposed to 50-kv x-rays from a copper target tube. In NaCl, for example, the new bands were found at 2300, 2950, 3600, and 8250 angstroms by use of a Beckman spectrophotometer operated manually. The band at 2300A fades when the crystal is first exposed to light of the F band frequency (4600A) and new bands appear at 2950, 3600, and 8250A. Upon further exposure to light, the 3600A-band also disappears. It has also been found that the F band is apparently split into a partially resolved doublet or shifted in position when the crystal is exposed to light. The bands at the lower wave-lengths may be interpreted as arising from higher stationary states of the same absorbing centers which yield the familiar F, M, and R bands. Such an interpretation is supported by the knowledge that they occur at about twice the "fundamental" frequency, are much weaker than the previously known bands, and fade in the expected manner.

34. Spectral Color Determination by the Human Eye. W. A. PRYOR* AND HUGH F. HENRY,* *University of Georgia.*—The wave-length boundaries of the colors of the continuous spectrum as viewed by the human eye have been measured with these results, in angstroms:

7097 ±9—Red—6226 ±16—Orange—5895 ±11—Yellow—5719 ±12—Green—5106 ±8—Blue—4339 ±12—Violet—4051 ±3.

The spectral source was a No. 2 Photoflood, and the wave-lengths were determined by a small B & L Constant Deviation Spectroscope. The observers were 110 students (13 girls and 97 boys) between the ages of 18 and 30 selected at random. All could distinguish the six colors, and each selected the color boundaries given above. The average person's interpretation of any color boundary was considered to be the mean of the different values for that wave-length. The deviation associated with each wave-length in the table is a measure of disagreement over the position of the boundary concerned. The limiting wave-length at the violet end of the spectrum is too high, as 14 observers stated they detected color below 4000A, the lowest reading on the spectroscope scale.

* Now with Carbide and Carbon Chemicals Corporation, Oak Ridge, Tennessee.

35. On the Beta-Spectrum of Tritium. W. J. BYATT, F. T. ROGERS,* AND A. W. WALTNER,** *University of North Carolina.*—Measurements of β-activity from H^3 have been made using a low-pressure cloud chamber and non-sterographic photography. From these measurements, we get the differential distribution of projected lengths. By solution of the related integral equation, we may get the distribution of actual lengths. From this point, it is a simple matter to get the energy distribution of the β-spectrum by application of an energy-range relation. The data show good agreement with the Fermi theory of β-decay in the 5–10 kev region. Agreement with results[1] obtained by Cockcroft and co-workers is also good.

* Now at China Lake, Inyokern, California.
** Now at N. C. State College of Agriculture and Engineering.
[1] Curran, Angus, and Cockcroft, "Beta-Spectrum of H^3," Nature **162**, 302 (1948).

36. The Infra-Red Absorption Spectrum of Hydrogen Telluride Vapor from 3.8μ–5.5μ. HERMAN JARRELL* AND JOSEPH W. STRALEY, *University of North Carolina.*—The infra-red spectrum of hydrogen telluride has been observed in the region from 3.8μ to 5.5μ. The fundamental frequencies ν_1 and ν_3 are expected to appear in this region. Considerable absorption was observed between 4.5μ and 5.2μ. The line spacing varied quite linearly from a value of 4.5 cm^{-1} to 7.0 cm^{-1} from one side of the absorption to the other with an interpolated value of 6.09 cm^{-1} at the center. The resolution is not adequate to unambiguously say that this absorption is not due to two overlapping bands.

* Now at Clemson College, Clemson, S. C.

37. The Infra-Red Spectrum of Chlorine Monofluoride.* T. F. PARKINSON, E. A. JONES, AND A. H. NIELSEN,** *Carbide and Carbon Chemicals Corporation.*—The infra-red spectrum of ClF has been examined in the 2–15μ region. The fundamental band has been found centered at 772 cm^{-1} and with well defined P and R branches. The P and R branches exhibit a doublet structure, the separation of which is about the isotopic shift to be expected in $Cl^{35}F$ and $Cl^{37}F$. The location of the 772 cm^{-1} fundamental is in agreement with its calculated position from the observed electronic spectrum of this molecule.[1,2] The first overtone has been detected at about 1538 cm^{-1}. However, this band lies in the strong atmospheric water vapor band at 6.26μ, and it will therefore be necessary to

eliminate the water vapor before an exact band center can be quoted.

* This document is based on work performed for the Atomic Energy Commission by Carbide and Carbon Chemicals Corporation, Oak Ridge, Tennessee.
** University of Tennessee, Knoxville, Tenn.
[1] A. L. Wahrhaftig, J. Chem. Phys. **10**, 248 (1948).
[2] H. Schmitz and H. J. Schumacher, Zeits. f. Naturforschg. **2A**, 359 (1947).

38. A High-Speed Spectrometer for Raman Studies. W. E. HAISLEY AND JOSEPH W. STRALEY, *University of North Carolina.*—As is well known, the faintness of Raman spectrum lines requires that any instrument designed for their study must have high speed without excessive sacrifice of dispersion.[1] An instrument designed for this purpose is being built here at a cost considerably below that of commercially available models. The instrument is of the autocollimating type using a Wadsworth mount on a motor-driven prism table. The lens is an f 3.5 343 mm Eastman EY132 Anastigmat. Any of the mercury lines in the blue-green region will be suitable for irradiation. A carbon disulphide prism, presenting an effective area 10 cm square normal to the beam, is being used in the preliminary tests. Detection will normally be photoelectric[2] but may be made photographic with one small adjustment. Calculations indicate an overall speed of f 4.5 or better (deducting reflection losses) and a dispersion of 26.5 A/mm.

[1] James H. Hibben, *The Raman Effect and Its Chemical Applications* (1939), p. 25.
[2] Rank, Pfister, and Coleman, J. Opt. Soc. Am. **32**, 390, 397 (1942).

39. The Infra-Red and Raman Spectra of Chlorine Trifluoride.* ERNEST A. JONES, T. F. PARKINSON, R. B. MURRAY, AND J. S. KIRBY-SMITH, *Carbide and Carbon Chemicals Corporation.*—The Raman spectrum of liquid chlorine trifluoride and the infra-red absorption spectrum of the gas in the 2 to 25μ region have been investigated. Samples were obtained by fractional distillation of commercially obtained material. The Raman spectrum of the liquid was photographed using Hg 5460 excitation. The infra-red bands are: 485 (m.s.), 540 (s.), 630 (m.s.), 702 (v.s.), 742 (s.), 760 (s.), 952 (v.w.), 1028 (w.), 1110 (w.), 1235 (m.s.), 1268 (m.s.), 1468 (w.). The Raman lines are 321 (v.w.), 424 (v.w.), 502 (v.s.), 514 (v.s.), 753 (s.). The presence of five Raman lines is surprising since the expected pyramidal or planar models should have four and three Raman frequencies respectively. These considerations suggest either an unsymmetrical form or more probably association in the liquid state.

* This document is based on work performed for the Atomic Energy Commission by Carbide and Carbon Chemicals Corporation, at Oak Ridge, Tennessee.

40. The Infra-Red and Raman Spectra of Carbonyl Fluoride.* P. J. H. WOLTZ, ERNEST A. JONES, AND A. H. NIELSEN, *Carbide and Carbon Chemicals Corporation.*—The infra-red spectrum of gaseous F_2CO has been recorded from 2 to 25μ. The infra-red bands are: 584* (m.s.), 626* (m.s.), 775* (s.), 965* (s.). 1249* (v.s.), 1941* (v.s.), 2472 (w.), 2682 (v.w.), 2887 (w.), 3163 (v.w.), 3403 (v.w.), 3696 (v.w.), 3882 (w.), 4120 (v.w.). The six bands marked with an asterisk were considerably more intense than the rest and have been named the fundamentals, though definite assignment of the normal modes has not yet been made. With the exception of the band at 626 cm^{-1}, the bands appear to have well defined *P*, *Q*, *R* branches. The Raman spectrum of liquid F_2CO has been obtained using Hg 4358 excitations with a Lane Wells Spectrograph. The Raman lines are 571 (w.), 620 (m.), 771 (v.w.), 965 (s.), 1238 (v.w.), 1909 (m.), and 1944 (v.w.).

* This document is based on work performed for the Atomic Energy Commission by Carbide and Carbon Chemicals Corporation, at Oak Ridge, Tennessee.

41. The Raman Spectrum of Hydrogen Fluoride.* J. S. KIRBY-SMITH, AND E. A. JONES, *Carbide and Carbon Chemicals Corporation.*—The Raman spectrum of liquid hydrogen fluoride has been investigated at a temperature of approximately −40°C. A single extremely broad and diffuse band has been observed from both the Hg 4358 and Hg 4047 exciting lines. The band is without structure and is centered at about 3400 cm^{-1} with an approximate width of 1000 wave numbers. Long exposures under intense illumination have shown no other bands or discrete lines at lower frequencies. The large shift in the H-F fundamental frequency from 3960 cm^{-1} in the gas phase, to 3400 cm^{-1} in the liquid as well as the great width of the Raman band in the liquid state, is in quantitative agreement with the high degree of polymerization and association of the HF molecule in the liquid state.

* This document is based on work performed for the Atomic Energy Commission by Carbide and Carbon Chemicals Corporation at Oak Ridge, Tennessee.

42. The Infra-Red Spectrum and Molecular Constants of Deuterium Fluoride.* HOYT M. KAYLOR AND ALVIN H. NIELSEN, *The University of Tennessee.*—The infra-red spectrum of deuterium fluoride has been observed on an automatically recording spectrograph[1] utilizing a 7200 lines-per-inch replica grating. Ten lines in the *P* and *R* branches of the fundamental ($v=0\rightarrow1$) band were recorded in first order at 3.44μ using a 5 cm. absorption cell filled to about 15 cm pressure. For the first overtone ($v=0\rightarrow2$) band, a 22 cm cell filled to 70 cm pressure made it possible to record about ten lines in each branch. This band was observed in second order of the grating at 1.75μ. The cell and windows were of fluorothene which is not attacked by deuterium fluoride, and which transmits about 60 percent of the energy in the absorption regions. Combinations relations are being applied as a means of analyzing the rotational structure, and the molecular constants will be given. Comparison between the present data and the HF constants[2] will be made.

* The research discussed in this abstract was supported in part by a Frederick Gardner Cottrell grant-in-aid from the Research Corporation of New York.
[1] A. H. Nielsen, J. Tenn. Sci. **XXII**, 241 (1947).
[2] R. M. Talley and A. H. Nielsen, Phys. Rev. **74**, 123 (1948).

43. On the Freezing of Fresh Water Lakes. L. D. HUFF, *Clemson Agricultural College.*—This paper is a theoretical investigation of the rate of formation of ice on an exposed water surface. It is found that if the upper surface of the ice is kept at a constant temperature the thickness will vary with the square root of the time of freezing. This calculation neglects the insulating effect of the atmosphere and gives a rate of freezing which is too high. No solution in terms of the thermal conductivity of the air was attempted but a comparison of the equations for diffusion and heat conduction allows a comparison of the rates of freezing in winter and of evaporation in summer. For one set of conditions this ratio is approximately three.

44. The Electrical Energy of Seeds at Various Stages of Growth. R. ELLIOFF AND A. A. BLESS, *University of Florida.*—The electrical energy stored in seeds was measured as a function of the number of hours after immersion in a nutrient solution, by allowing the seed to discharge through a known resistance. The energy varies from 1.95×10^{-1} ergs (24 hrs. growth) to 1.242×10^{2} ergs (48 hrs. growth). The resistance of the seeds is also measured as a function of growth both before and after discharge. The resistance of the various seeds varies from 13,000 ohms to 195,000 ohms. During the discharge of the seeds the resistance increased, ranging from 1.1 to 2 times the resistance before discharge.

45. A Mathematical Method for Determining Points of Maximum and Minimum Intensity in the Fresnel Diffraction Pattern of a Single Slit. E. J. SCHEIBNER, *Georgia Institute of Technology.*—In most textbooks of physical optics, the simpler cases of Fresnel diffraction are explained by fairly direct mathematical and graphical methods. It is shown that the Cornu spiral constitutes the vibration curve for a cylindrical wave front and that the intensity is proportional to the sum of the squares of the Fresnel integrals.[1] In the Fresnel diffraction pattern of a single slit, the method used to obtain the variation of intensity along the screen is to slide a piece of the spiral of constant length to various positions and measure the lengths of the corresponding chords to obtain the amplitudes. This paper presents a means of shortening the graphical steps involved by determining some points of maximum and minimum intensity by the mathematical method of minimizing the square of the line segment representing the amplitude. A simple expression is obtained which gives the arc length on one portion of the spiral for points of maximum and minimum intensity in terms of the constant arc length.

[1] F. A. Jenkins and H. E. White, *Fundamentals of Physical Optics* (New York, 1937), p. 188.

46. On the Attenuation of Sunlight in Natural Bodies of Water.* W. D. BULLOCH, *University of North Carolina.*—Measurements were made of the relative intensity of light at various depths in salt and brackish water around Morehead City, N. C. The photometer used consisted of an RCA 931-A photoelectron multiplier tube encased in a water tight brass box which was lowered to the desired depths. The tube voltage was supplied by batteries and readings were made of the plate current with the tube at various depths. An additional 931-A and circuit was run from the same power supply and kept on the deck of the boat to record any changes in the surface intensity during the run. Curves of intensity *vs.* depth showed at least one distinct inversion occurring between four and eight feet below the surface. Many curves indicated a second inversion occurring between depths of twelve to twenty feet. The first inversion has been partially explained by considering the effect of the shadow of the boat. However this does not completely account for the apparent increase of intensity at a particular depth.

* Partially supported by the Institute of Fisheries Research, U.N.C.

47. The Field of a Gravitational Dipole. HANS FREISTADT AND NATHAN ROSEN, *University of North Carolina.*—To get the metric describing the gravitational field of a mass dipole according to general relativity theory, the method of Weyl[1] and Levi-Civita[2] is used. Starting with the Newtonian potential of two masses which are equal but opposite in sign, one obtains by this method the corresponding solution of the gravitational field equations. The calculation is largely carried out by a slight modification of that given by Silberstein.[3] By a conformal mapping one transforms the line joining the two masses into a sphere on which the metric has a singularity, thus giving the desired solution. It is interesting to note that the equations of general relativity lead to a solution for the field of a mass dipole, although such a dipole has not yet been observed in nature.

[1] H. Weyl, Ann. d. Physik **54**, 117 (1918).
[2] T. Levi-Civita, Rend. Acc. dei Linci, 1919.
[3] L. Silberstein, Phys. Rev. **49**, 268 (1936).

48. Calibration of an Engraved Circle by a Constant Angle Method.* R. M. TALLEY AND H. M. KAYLOR, *University of Tennessee.*—The accuracy of the engraved marks on a six-inch radius brass spectrograph circle was studied by a constant angle method. The angle between the central image of the grating and the R(5) line of the fundamental band of hydrogen fluoride was used as a constant. This angle, about 20 degrees, was measured in terms of the engraved marks in overlapping sectors of the circle. When these measurements were plotted as ordinates *versus* the sector midpoint as abscissae, a smooth curve resulted (except for a small discontinuity located in a particular 5 degree interval). The 1.0139976[1] mu line of Hg in third order falls in the portion of the circle whose calibration is desired. When the angle which is represented by this exact line is superposed on the graph, it fixes a definite frequency point. All unknown lines lying to greater or lower frequency from this point may be corrected from the curve variation.

* The research discussed in this abstract was supported in part by a Frederick Gardner Cottrell grant-in-aid from the Research Corporation of New York.
[1] Hunt and Campbell, Phys. Rev. **50**, 397 (1936).

49. A Photomultiplier Trigger for Flash Photography. R. L. VARWIG, V. E. SHERRER, G. CARMICHAEL, AND A. LINZ, *University of North Carolina.*—The RCA 931-A photomultiplier tube was first used in an attempt to detect light emitted from a steel plate during brittle fracture. This experiment failed, but it suggested the use of the photomultiplier tube as a detector of a light beam scattered from the rough edges of the fracture. The plate is thoroughly blackened, and the beam from an auto headlight, after focusing by an appropriate cylindrical lens and slit system, is made incident upon it in the form of a narrow vertical line. When the plate starts to crack, the edges of the fracture scatter the incident light which is picked up by the photomultiplier tube. The resultant voltage pulse is used to trigger a flash tube circuit containing a Sylvania 1530 flash tube. It is expected that enough scattered light will be obtained from the fracture surface to secure fairly reliable triggering of the flash tube giving pictures of the crack. It is pointed out that it is not necessary to know accurately the time of triggering of the circuit since the picture locates the crack in the plate. The photomultiplier tube is a more sensitive detector of light than photographic emulsion.

50. A Universal Low Frequency Modulation Technique. VINTON A. BROWN AND F. L. YOST,* *Naval Ordnance Laboratory.*—For certain work in progress at the Naval Ordnance Laboratory it has been found necessary to modulate at subaudio frequencies the intensities of a wide variety of types of r-f radiation incident upon a receiving antenna. An important requirement in this work is that the transmitter frequency be undisturbed (except for the introduction of side bands attendant upon modulation). Although the frequencies of certain well stabilized transmitters may not be unduly affected by changes in power output, such is not generally the case. Since the problem at hand involves numerous and diverse transmitters, the modulation of received intensity must be effected without variation of power output. The technique developed involves control of the intensity of the field at a point by suitable variation of the orientation of a radiating dipole. This modulates *received* intensities without varying the *total* energy radiated. Problems which have been solved in connection with this work are the elimination of background intensity due to reflections, and the exact description of the electromagnetic field in the vicinity of the radiating dipole.

* Now at Illinois Institute of Technology, Chicago, Illinois.

51. A Measurement of the Velocity of a Flow of a Combustible Gas Mixture Just Prior to Ignition. P. RUDNICK* AND W. H. KRUSCHWITZ,** *Vanderbilt University.*—A mixture of propane and air of variable ratio was ignited immediately after it left the end of a $\frac{3}{8}''$ vertically mounted tube. A wire, centrally located, normal to the flow just above the end of the tube acted as the flame holder, and the flame thus produced was V-shaped. Fine aluminum particles were introduced into the gas before it entered the tube. These particles were illuminated by two consecutive flashes of a light source of high

intensity and very short duration just before the gas was ignited. Photographs were taken of the end-view of the flame and of the illuminated particles. Using one set of conditions, a flow velocity of 8–9 meters/second was computed. The angle between the direction of these particles and the flame surface was observed to be from 2.5° to 5.0°. This gave 0.56 meters/second as the normal component of the velocity. The angle between the sides of the V-shaped flame was observed to be 24°–24.5°.

* Now at Marine Research Laboratory, San Diego, California.
** Now at Cumberland University, Lebanon, Tennessee.

52. A Statistical Consideration of Collisions. J. ELMER RHODES, JR., *Georgia Institute of Technology.*—A collision between two masses is always subject to conservation of momentum and other conditions may further limit the resulting configuration of masses after collision. For an ensemble of identical collisions these conditions restrict the ensemble to a "surface" in phase space. Postulate that this allowed phase volume be uniformly populated by members of the ensemble. For elastic collisions this principle gives exactly the scattering pattern that classical mechanics gives for collisions of pairs of spheres. For the collision between two hydrogen molecules, in which the possibility of a rotational transition is allowed but not demanded, probabilities of rotational transitions are obtained that are comparable with values calculated from velocity of sound data in the frequency-to-pressure range where rotational degrees of freedom fail to follow the temperature changes in the sound wave. The rotational transition probability for any given collision is taken to be no greater than the ratio of the volume of phase space occupied by the part of the ensemble in which the transition occurs to the volume of phase space occupied by the whole ensemble.

53. Instrumentation for Studying Electric Resistance Changes of Fine Wires during Elastic and Plastic Strains. E. W. KAMMER AND T. E. PARDUE,* *Naval Research Laboratory.*—The construction and use of bonded-wire strain gages requires a knowledge of the manner in which resistance of the wire employed varies with strain. The apparatus used to obtain electric resistance changes during elastic and plastic straining is described.

* Now at the University of North Carolina, Chapel Hill, N. C.

54. Results of Electric Resistance Changes of Fine Wires during Elastic and Plastic Strains. E. W. KAMMER AND T. E. PARDUE,* *Naval Research Laboratory.*—This investigation covers the elements, iron, nickel, and platinum, as well as fifteen alloys readily available in the form of fine wires. The variation of resistance and stress with respect to strain are displayed graphically. The strain sensitivity in the plastic and elastic range has been ascertained from the slope of the resistance-strain curve. Several typical specimens were subjected to permanent elongation and the residual resistance was observed after removing the tension.

* Now at the University of North Carolina, Chapel Hill, N. C.

55. Instrumentation for Studying Energy Losses and Fracture of Some Metals Subjected to Large Repeated Strains.* J. P. PARKER AND T. E. PARDUE, *University of North Carolina.*—Greater knowledge of the behavior of metals subjected to large repeated strains, is required in order to establish criteria for selection of suitable materials to be used under such severe conditions. The instrumentation developed to study the behavior of some metals is described. A rotating beam type fatigue machine was used with loads sufficiently high to produce failure in the range below 10,000 repetitions of strain.

* This work was supported in part by ONR contract N7onr 284 T.O.4.

56. Energy Losses and Fracture of Some Metals Subjected to High Repeated Strains.* J. L. MELCHOR, W. B. GOOD, AND T. E. PARDUE, *University of North Carolina.*—The energy dissipated in some materials tested in a rotating beam type fatigue machine has been obtained for loads sufficiently high to produce failure in the range below 10,000 cycles of strain. The energy dissipated per cycle of strain was found to vary during the life of a specimen. Specimens tested at different stress amplitudes showed the total energy losses per specimen to increase as the stress amplitude was decreased.

* This work was supported in part by ONR contract N7onr 284 T.O.4.

57. Photographic Method of Detection of the Speed of Fracture in Steel Plates. V. E. SCHERRER, G. CARMICHAEL, R. VARWIG, AND A. LINZ, *University of North Carolina.*—Flash photography was adopted initially, in the study of the speed of brittle fracture in steel plates, as a check upon the accuracy of simple metallic detectors of fracture speeds then being used. The results of these first pictures were quite promising, and it was decided to use flash photography as a method of measuring fracture speeds by taking multiple exposures of a single fracture. This development consists principally in searching for suitable detectors to trigger flash circuits. The first such detector is a small coil in which an emf is induced by changing current in the plate caused by the crack. This is described in another paper.[1] The second detector is a photomultiplier type tube, triggering the circuit by receiving reflected light from the irregular fracture edge. This is described in a separate paper.[2] The signals obtained from the detectors are fed into trigger circuits with negligible time delay to initiate the flash of a Sylvania type 1530 flash tube.

[1] A. Linz, The Inductive Method of Detection of Speed of Brittle Fracture in Steel Plates.
[2] R. L. Varwig, V. E. Scherrer, G. Carmichael, and A. Linz, A Photomultiplier Trigger for Flash Photography.

58. An Inductive Method of Detection of Speed of Brittle Fractures in Steel Plates.* A. LINZ, JR., V. E. SCHERRER, AND G. CARMICHAEL, *University of North Carolina.*—Small search coils are placed in a vertical plane perpendicular to a thin steel plate through which a current is passed. When a horizontal crack passes a search coil, the resulting induced voltage is amplified and recorded on an oscilloscope. Preliminary tests indicate the possible usefulness of the phenomena in measuring the velocity of propagation of brittle fracture in notched steel plates.

* This work being done under contract with Office of Naval Research.

59. Quantum Mechanics of a Particle on a String. NATHAN ROSEN, *The University of North Carolina.*—The transverse vibrations of a perfectly flexible string under tension between fixed supports, with a particle of finite mass attached to the string, are investigated from the standpoint of non-relativistic quantum mechanics. By introducing normal coordinates one can obtain exact solutions of the Schroedinger equation for this case. The mean zero-point kinetic energy of the particle turns out to be infinite. However, it is interesting to note that, while a first-order perturbation calculation leads to a quadratic divergence of this zero-point energy, the exact calculation gives only a logarithmic divergence. This may have a bearing on the general problem of the self-energy of a particle interacting with a field.

60. A Method for Microwave Propagation Study in the Lower Troposphere.* F. E. LOWANCE AND R. A. MARTIN, *Georgia Institute of Technology.*—An investigation has been made of the effects of atmospheric conditions, such as ducts, turbulence, and subsidence inversions, on the propagation characteristics of electromagnetic waves in the microwave region. Signal strength measurements were made on 3, 10,

and 25 centimeters over a common propagation path. Simultaneous meteorological measurements were made along the transmission path using aircraft and captive balloons to transport meteorological instruments. Signal strength records and the meteorological data were compared to determine the effects of various atmospheric conditions on the propagation. The experimental procedure employed transmitters located on the Physics Building at Georgia Tech and mobile receiving units located at a point approximately 48 miles distant from the transmitter site. Provision was made for measurement of transmitted power and recording and calibration of the receiver outputs. Meteorological sounding instruments recorded at frequent intervals, the wet- and dry-bulb temperatures and absolute pressure. The meteorological data obtained were used for plotting modified index of refraction curves for later study and correlation with received signal strength data. Sample data are presented.

* This work is supported by the Watson Laboratories, Air Materiel Command, Contract No. W28-099-ac-175.

61. Effects of Meteorological Conditions on Microwave Propagation at 3, 10, and 25 cm.* J. E. BOYD AND CATHERINE YOE, *Georgia Institute of Technology.*—A preliminary analysis has been made of the signal strength records and associated meteorological data collected in the Georgia Tech propagation studies at 3, 10, and 25 cm. The analysis includes studies of data for both optical and non-optical paths approximately 50 miles in length. Propagation was over hilly and mountainous terrain, from transmitters at a height of 1050 feet above sea level to receivers at heights of 1800 feet or greater. For the non-optical paths (receivers below horizon) large increases in signal strength occurred under ground-based superrefracting conditions resulting from temperature inversions and negative humidity gradients. For the optical path, interference-type fading occurred under similar atmospheric conditions. Statistical methods of analysis show definite correlations between signal characteristics and particular types of atmospheric stratification. Results are summarized and compared with the Rayleigh probability distribution for the resultant of a large number of vibrations with random phases.

* This work is supported by the Watson Laboratories, Air Materiel Command, Contract No. W28-099-ac-175.

62. Relations in Quasi-Isothermal Slow Fracture. I. General Considerations. F. T. ROGERS, JR.,* *Oakridge National Laboratory.*—In the experimental slow fracturing of a specimen of solid, as by torque,[1] dynamic load f is applied in some member of a loading device through a distance ds, leading to deformation and fracture. Energy $u=\int f\,ds$ is thus supplied to the specimen, and the speed at which the process takes place is governed by $ds/dt=\rho$, ρ being a known function of t or s. If e represents the elastic energy stored in the specimen, then $w=u-e$ is the energy "absorbed" by the specimen. The element of advance of the fracture is $dx=dw/R$, R being a suitable function chiefly of x; x now being identified, the static load supportable by the solid can be written as $F=F(x)$; also $e=e(f,x)$. Finally, a macroscopic rate-relation, $dw/dt=\phi(f, f-F, \cdots)$, must apply. Since there are thus seven equations relating the eight variables u, f, s, t, e, w, x, and F, these equations suffice to determine any seven variables in terms of the eighth (often t).

* Present address: U. S. Naval Ordnance Test Station, Inyokern, California.

[1] F. T. Rogers, Jr., Phys. Rev. **74**, 120–122 (1948).

63. Relations in Quasi-Isothermal Slow Fracture. II. The Problem of Brittleness. MARGUERITE M. ROGERS* AND F. T. ROGERS, JR.,* *Oak Ridge National Laboratory.*—The general equations, solved for a constant drive-rate (ds/dt=small constant$=r$), yield

$$f-F=(r/a)/(1+de/dw) \tag{1}$$

and

$$s=s_0+\int_0^x (1+de/dw)[R(x)/f(x)]dx, \tag{2}$$

if $\phi=af(f-F)$. Clearly $(f-F)$ should show anomalous behavior, and x should increase independently of s, as in uncontrolled or "brittle" fracture, when[1] $(1+de/dw)=0$. In measurements upon four-notch mild-steel bars, $(1+de/dw)$ became quite small (certainly 0.2, perhaps less) just before brittle failure; it remained near unity for specimens which did undergo uncontrolled failure.

* Present address: U. S. Naval Ordnance Test Station, Inyokern, California.

[1] This possibility has been discussed by G. R. Irwin, Fracture of Metals (Am. Soc. for Metals, 1948), pp. 147–166.

64. Dependence of Convective Process on Thickness of Porous Medium. H. L. MORRISON, *North Carolina State College,* F. T. ROGERS, JR., *Oak Ridge National Laboratory.*—Typical data are given in the first four columns of the table, relative to the onset of thermal convection of water in unconsolidated sands. D is the thickness (or depth of layer) of sand in cm; μ_{Av} is the average viscosity of water in centipoises; k is the flow-permeability of sand in c.g.s. units; and β_{obs} is the observed mean (over D) thermal gradient in °C per cm. These and additional data indicate a strong dependence of β_{obs} on $(\mu_{Av}/k)^p$, where $p\cong\frac{1}{2}$; theory[2] indicates $\beta_{obs}aD^{-2}$. Clearly the tabulations in the last column cannot justify a different dependence upon D.

D	μ_{Av}	$10^8\,k$	β_{obs}	$10^4\,k^{\frac{1}{2}}D^2\beta_{obs}/\mu_{Av}^{\frac{1}{2}}$
8.0	0.59	125	6.87	0.64
8.0	0.60	125	5.69	0.53
10.0	0.76	125	3.8	0.49
10.0	0.53	70	6.0	0.69
10.0	0.75	88	5.4	0.59
14.0	0.77	125	2.21	0.55

[1] Preliminary data indicated that $p=1$; see H. L. Morrison, Phys. Rev. **74**, 119 (1948).

[2] C. W. Horton and F. T. Rogers, Jr., J. App. Phys. **16**, 367 (1945).