It has been shown that in the presence of a long chain fatty acid soap ZnS is soluble in rubber. Such is not the case, however, when a short chain fatty acid soap is used. To determine if ZnS solubility might explain the negative x-ray results, we have carried out diffraction studies on stocks compounded from acetone extracted rubber and activated with zinc acetate, zinc benzoate, or zinc propionate. In all three cases we have obtained the characteristic diffraction pattern of β-ZnS from the cured stocks, thus proving that ZnS is formed and that the final step above is a possible one. Studies are continuing on the mechanism whereby ZnS can be made soluble in rubber.

14. Formation of Radioactive Zinc Dimethyl Dithiocarbamate in the Vulcanization of Rubber. I. G. GEIB, *The B. F. Goodrich Research Center.*—When a stock containing rubber, zinc oxide, tetramethylthiuram monosulfide (TMTM) and sulfur is cured, zinc dimethyldithiocarbamate (ZnDMDC) is formed.[1] If radiosulfur is employed, the ZnDMDC is found to be radioactive. Mechanisms for the formation of ZnDMDC are discussed. That rubber is not necessary was confirmed by forming radio ZnDMDC by heating TMTM, radiosulfur, and zinc oxide. The observed activity of the ZnDMDC is higher than that predicted for a mechanism in which zinc and sulfur add directly to the TMTM molecule. ZnDMDC, which is quite stable thermally, is one of the most active accelerators for the vulcanization of rubber. Radio ZnDMDC should be valuable in future tracer studies on the mechanism of acceleration and vulcanization.

[1] Clark, Le Tourneau, and Ball, Ind. Eng. Chem. **35**, 198 (1943).

MINUTES OF THE MEETING OF THE SOUTHEASTERN SECTION AT OAK RIDGE, TENNESSEE, ON APRIL 9–10, 1948

THE fourteenth annual meeting of the Southeastern Section of the American Physical Society was held at Oak Ridge, Tennessee, on Friday and Saturday, April 9–10, 1948. A record number of 442 registered, and the total attendance was estimated to be 525. There were 410 people at the annual dinner on Friday night.

The regular program consisted of seventy-two papers, abstracts for sixty-four of which are printed below. Abstracts of the other papers will be printed in the *American Journal of Physics.*

The Program Committee, with Dr. C. K. Beck as Chairman, arranged an excellent program of invited papers. These consisted of the following: words of welcome by R. C. Cook of the Atomic Energy Commission; "University Scientists and Government Research Laboratories" by Frank P. Graham, President of the University of North Carolina; "Nuclear Magnetic Resonance" by K. K. Darrow of Bell Telephone Laboratories, Secretary of the American Physical Society; "Reflections of Low Speed Electrons from Polycrystalline Platinum" by C. J. Davisson of the University of Virginia; "Interim Report on Stroboscopic X-Ray Diffraction in Vibrating Crystals" by R. Pepinsky of the Alabama Polytechnic Institute; and "Low Temperature Experiments with Liquid Helium" by J. G. Daunt of Ohio State University. On Saturday afternoon, the visitors were taken on a conducted tour of the Oak Ridge area.

At the business meeting, the election of the following officers for the Section was announced: *Chairman*, E. S. Barr; *Vice Chairman*, Philip Rudnick; *Secretary*, Eric Rodgers; *Treasurer*, H. F. Henry; *Member of the Executive Committee*, C. K. Beck. D. R. McMillan was elected to the Executive Committee to fill the unexpired term of E. S. Barr.

Eric Rodgers, *Secretary*

ABSTRACTS

1. An Improved Axial Magnetic Suspension.* J. F. DILLON AND J. W. BEAMS, *University of Virginia.*—Previous experiments[1] have shown that the axial magnetic suspension offers almost negligible resistance to rotation of symmetrical rotors. Consequently, rotors suspended in a good vacuum can be driven in synchronism with a piezoelectrically controlled circuit without "hunting."[2] As a result, a large number of investigations requiring extremely constant speed rotating mirrors or centrifuges of various weights are possible. In this paper a number of improvements in the axial magnetic suspension will be described. Details of an axial magnetic suspension will be given with which rotors weighing from about 0.1 g to roughly 10^4 grams have been stably suspended. It is possible to suspend smaller or larger rotors by changing the "pick up" or the supporting magnet respectively.

* This work was carried out under the Contract NOrd-7873 with the Bureau of Ordnance, U. S. Navy.

[1] Beams, Young and Moor, J. App. Phys. **17**, 886 (1946).

[2] Beams, Wash. Acad. Sci. **37**, 221 (1947).

2. A Coil System for Producing Longitudinal Magnetic Gradients. W. C. WINELAND, T. M. HAHN, JR.*, AND L. R. BOYD, *Naval Ordnance Laboratory.*—Several types of coil systems have been developed at the Naval Ordnance Laboratory for producing uniform magnetic gradients. One of these, the Gradhelm, which has been previously described,[1] produces uniform transverse and longitudinal gradients of the field components transverse to the major axis of the system. The present coil system, or "Solengrad," yields a uniform longitudinal gradient of the axial component of field. It consists essentially of a set of series-connected square coils of varying numbers of turns spaced uniformly along their common axis. The numbers of turns on the central coils form an arithmetic progression, and the turns on the outermost coils are chosen so as to cause the gradient at the center of the system to be equal to that on the axis at a considerable distance from the center. Details of the design, construction and calibration are given for one such system, 28 feet long, which produces a gradient uniform to within one percent over an axial distance of twelve feet.

* Now at the Massachusetts Institute of Technology.
[1] Shortley and May, J. App. Phys. **16**, 841 (1945).

3. Current Amplifiers for Use with Magnetic Generators. H. E. WOLF, H. SMALL, AND J. H. BUEHLER, *Naval Ordnance Laboratory.*—Two types of current amplifiers are employed to supply the current required for magnetic generators. Both circuits are characterized by linear operation and high stability. The first circuit is a single-ended amplifier of the cathode-follower type. A bank of parallel-connected Type 6L6 tubes controls the current through the load which is in the common cathode circuit. With eight tubes, this amplifier is capable of supplying a peak-to-peak output current of approximately 500 μa to a 100-ohm load. The d.c. component of output current makes this type of amplifier inconvenient when the device being investigated is affected by background field comparable in magnitude with signal fields. To eliminate the background current, a balanced current amplifier has been designed which uses Type 6A3 tubes connected in push-pull. The input voltage is supplied by means of a bridge network, and the maximum peak-to-peak current out put is approximately 200 μa. The applicability of this amplifier is limited in being unusable with single-ended inputs.

4. Controls for Generators of Influence Signals. B. P. RAMSAY, J. H. BUEHLER, AND C. E. MOLINEUX, *Naval Ordnance Laboratory.*—Controls for influence generators consist of a signal simulator, a transit-speed regulator, a power-supply, and an amplifier. Signal simulators differ in regard to the basic control element which is employed and the mechanism by which the signal pattern is impressed upon it. The potential-divider and the photoelectric cell are basic elements which have been found most practical. The transit-speed with which the signal pattern is impressed upon the simulator is regulated satisfactorily by a gear train. Variable-speed friction-drive motors, and field-controlled direct current motors with speed indicators are objectionable for routine measurements in which exact reproducibility of transit-speed is desirable, but are employed when it is necessary to vary the transit-speed by small increments. Several circuits have been found suitable for the power supply and amplifier in transmitting the simulator signal to the influence generator. The controls described here have been employed with generators of static influence-signals, such as magnetic ship-signatures, and for modulating monochromatic carrier waves. They are not suitable for low speed signals of complex frequencies, or for high speed signals of any type.

5. Note on the d.c. Characteristics of the String Galvanometer. II. G. W. CRAWFORD, *North Carolina State College* AND F. T. ROGERS, JR., *University of North Carolina.*—In an earlier analysis[1] of the d.c. performance of a practical commercial form the Einthoven galvanometer, it was assumed that the tension in a string would be given, in terms of the string's elongation $(L-l)$, by $T=t+\delta(L-l)+\Delta(L-l)^2$, a non-linear elastic relation. Measurements have now been made[2] on 0.0004-inch diameter string of gold-plated copper, about 30 mm long: tensions have been measured to ± 1 dyne on the average, from zero to about 400 dynes; extensions have been obtained to ± 0.01 mm on the average, from zero to about 4 mm. Typical of results is the set of values, $t \sim 150$ dynes, $\delta \sim 1.25 \times 10^4$ dynes/cm and $\Delta \sim 2 \times 10^6$ dynes/cm^2; these values are quite concordant with some assumed in reference 1, and to that extent they indicate the general adequacy of the equation.

[1] Rogers, Rev. Sci. Inst. **12**, 351 (1941).
[2] G. W. Crawford, Phys. Rev. **74**, 119 (1948).

6. Sampling Specimens from an Ultra-Centrifuge by Quick Freezing. M. L. RANDOLPH, *Tulane University.*—Previous methods of pipetting or lifting off layers of solution after ultra-centrifugation in the quantity type rotor unavoidably cause some stirring on introducing the sampling devices.[1] Furthermore, incomplete removal of the top layers contaminates the lower layers. Therefore, a quick-freezing technique is suggested. After centrifugation, the sample tubes are put in metal tubes surrounded by a freezing mixture of "dry ice" and alcohol. These metal tubes are an eight inch shorter and a few mils greater in diameter than the sample tubes, with alcohol furnishing intimate contact. Cooling fins are provided. Within two minutes an entire sample is frozen solid and may be cut into sections in a lathe. Thermal insulation between the chuck jaws and sample tube is desirable. After cutting through the plastic wall and a few mils into the frozen solution, the section of sample is neatly broken off and allowed to melt at room temperature. Some changes in biological samples due to freezing and thawing may occur, but do not seem serious. Distinct layers, otherwise unnoticed, may appear following freezing and suggest points for cutting. Preliminary results with normal and pathologic human sera obtained with the cooperation of Dr. Roy H. Turner and associates of the Tulane Medical School will be presented.

[1] Hughes, Pickels and Horsfall, J. Exp. Med. **67**, 941 (1938). Chiles and Severinghaus, J. Exp. Med. **68**, 1 (1938).

7. A Knudsen Type Vacuum Gauge. J. T. MEERS AND L. A. PARDUO, *University of Kentucky.*—DuMond and Pickle[1] first investigated the usefulness of an all metal Knudsen type gauge for indicating continuously the pressure in systems where very low pressures are not maintained. Two gauges were constructed with some modification after the model of these investigators. They were calibrated by comparison with a McLeod gauge and an ion gauge. Curves obtained by plotting deflections of the Knudsen against the readings of the McLeod and the ion gauges showed very satisfactory reproducibility. The gauges were observed over a period of several months and their features noted. (1) The scale is nearly linear. (2) It gives a continuous reading of pressure and the time lag between pressure change and the response of the gauge is of the order of one second. (3) No auxiliary equipment is needed and there is no need for replacements of internal parts. One minor objection is that the gauge requires a solid support near the vacuum system.

[1] DuMond and Pickle, Rev. Sci. Inst. 6, 363 (1935).

8. New Data on Convection in Sands. H. L. MORRISON, *North Carolina State College.*—Since earlier work[1] has indicated the probable partial inadequacy of the only extant theory[2] of the minimum temperature gradient (β_c) required to produce thermal convection currents in liquids in porous media (possibly because the theory neglects the temperature-dependence of viscosity), a new series of measurements has been initiated for establishing the correct law for β_c by experiment. Using water in unconsolidated sands, the new data indicate in accord with the theory, that $\beta_c \propto 1/k$, where k is the sand permeability; they also indicate, again in accord with the theory, that β_c does not depend upon the horizontal extent of the sand. Present efforts are being directed toward determining the dependence of β_c on the depth (D) of the sand, for the theory indicates this to be a very strong dependence ($\beta_c \propto 1/D^2$). These measurements are being made under conditions where D and the horizontal extent are of the same order of magnitude, and where the vertical temperature gradient is a constant plus a cosine-of-distance.

[1] H. L. Morrison, J. App. Phys. 18, 849 (1947).
[2] C. W. Horton and F. T. Rogers, Jr., J. Appl. Phys. 16, 367 (1945).

9. A Mechanical Analysis of the Closure Movements of Venus' Fly Trap. OTTO STUHLMAN, JR., *University of North Carolina.*—The Venus' fly trap is a bivalve shaped structure formed at the end of the spatulated petiole of *Dionaea muscipula*, one of the "carnivorous" plants normally found near Wilmington, N. C. Closure (0.5 sec.) was analyzed with a moving picture camera. Angular closure was directly proportional to the square of the time. The basic movements simulate the motion of a rigid body rotating about a vertical axis under the action of constant normally directed forces. The forces maintaining the trap in its open position can be attributed to the action of an internal hydrostatic pressure localized in the layers of cells forming the inner epidermis. Speed and symmetry of closure can be controlled by the pattern of excitation, originating at the three spike-like organs located on the inner surfaces of the lobes. An excitatory wave-front in the form of an electrical transient, originating, at any one of the three excitatory organs, spreading over the lobes can account for the pattern and speeds of closure. Speed of wave-front about 5 cm/sec. A hydrostatic analogue, in the form of the response mechanism of the Bourdon gauge, is proposed as possessing the necessary and sufficient properties to account for all mechanical motions.

10. A Tensiometer for Elastic Properties of Very Small Wires. G. W. CRAWFORD, *North Carolina State College.*—In order to obtain direct measurements of increasing tension with elongation of small wires (0.0004-inch diameter), an apparatus has been constructed which consists of a vertical aluminum frame on each end of which are mounted micrometer calipers. A very light weight tensile spring, which can be calibrated, is fastened to the upper caliper; attached to its lower end is a light weight aluminum wire of U-shape, the coiled ends of which dip into two vessels containing a viscous fluid to damp out inevitable vibratory oscillations of the system. The very small test wire is fastened between the calibrated spring and the lower caliper. In use, the upper end of the test wire is adjusted always to a zero position as judged by a microscope; elongation is thus measured by the lower caliper, tension by the upper, to average precisions of 0.01 mm and 1 dyne, respectively. Provision is also made for mounting a magnetron magnet on the frame so as to immerse the test wire in a magnetic field, and for a mirror and micrometer microscope which allow observation of the behavior of the test wire when carrying a current in the magnetic field.

11. A Cathode-Follower Type of Dual-Coincidence Circuit. ARTHUR LINZ, JR., AND F. T. ROGERS, JR., *University of North Carolina,* AND G. W. CRAWFORD, *North Carolina State College.*—In a dual-triode gate-circuit[1] as used for detecting twofold coincidences, pulses P are applied to the two grids, and the resulting pulse V across the cathode resistor is used as an indication of grid-pulse coincidences. Let V_1 be the cathode resistor pulse when only one grid is pulsed, and let V_2 be the corresponding pulse caused by the simultaneous pulsing of both grids. Careful measurements have been made to demonstrate how V_2/V_1 depends upon $P<0$: for small values of P, this ratio is 2 or less as required by linear circuit theory; for large values of P, however, it rises to values as high as 8, indicating that the circuit is operating in a far from linear manner. The transition between these two limiting conditions is smooth and monotonic; and it seems possible to provide a graphical treatment of the nonlinear case which, merging into the linear at small P-values, should allow prediction of the V_2/V_1 ratio for a given circuit and known tube characteristics.

[1] Walter Jordan, invited paper read at Southeastern Section meeting on April 4, 1947.

12. Incremental Regulation by Carbon-Pile Type of Voltage-Regulator. V. E. SCHERRER AND F. W. ROGERS, JR., *University of North Carolina.*—In the simple d.c. voltage-regulator described elsewhere,[1] the output-voltage

is considered to be a function of the input-voltage and the equivalent load-resistance, and it is the purpose of the device to minimize $\partial E/\partial V$ and $\partial E/\partial Z$. In terms of the usual symbols, it can readily be shown that

$$\partial E/\partial V = Z_T/\phi, \quad (1)$$

$$\partial E/\partial Z = (V-E)/\phi, \quad (2)$$

where

$$\phi = Z_T + g + Eg'/Z_c. \quad (3)$$

It can also be shown from these equations that g or g' should be as large as practicable, but that perfect regulation is not practical. Tests have indicated that Eqs. (1)–(3) are quite valuable in predicting the incremental regulation for a regulator for which g and the constants are known.

[1] E. E. Caldwell and F. T. Rogers, Jr., Phys. Rev. **74**, 120 (1948).

13. Compensation of Circuits for Variations of Temperature. G. L. JENKINS AND F. T. ROGERS, JR., *University of North Carolina.*—The general features of the process of compensating a circuit of resistance $R_0[1+\alpha \times(T-T_0)]$ by means of a sintered oxide element which has resistance $r_0 \exp[-\beta(1/T-1/T_0)]$, are well known and have been published in various places. Because of the dissimilar characters of these T-functions, however, such compensation is generally not exact; instead, and as an example, if these two units are connected in series and then attached to an e.m.f. E, the current I which flows is temperature sensitive because

$$\partial I/\partial T = -I^2\{R_0\alpha - (\beta r_0/T^2)\exp[-\beta(1/T-1/T_0)]\}/E.$$

Hence the detailed behavior of the resulting "compensated" circuit is a matter which has to be adjusted through the above equation so as most nearly to satisfy applicable requirements, often a matter of compromise. The problem of compensation is further complicated because transients in heat flow (including the effects of self-heating in the elements themselves) may at times render the temperatures of the two units almost random variables.

14. Output Voltage from Carbon-Pile Type of Voltage-Regulator. E. E. CALDWELL AND F. T. ROGERS, JR., *University of North Carolina.*—A simple type of d.c. voltage-regulator[1] consists of a passive non-linear quadripole circuit which, attached to an input-voltage V, delivers a nearly constant output-voltage E, to a load Z. The series element in this quadripole is a carbon-pile resistor R, which is operated magnetically by the current i_c in a solenoid which is a following shunting element of resistance Z_c; there may be a second shunting element as well, but this is combined in the equivalent circuit into Z. Taking $R=g(i_c)$ in the steady state and $i_c=E/Z_c$ and letting $Z_T=Z_cZ/(Z_c+Z)$, it can readily be shown that

$$E\cdot g(E/Z_c)+E\cdot Z_T = V\cdot Z_T. \quad (1)$$

Equation (1) is useful because, solved numerically for E for a given g-function, it predicts the performance of such a regulator using that g-function. It is not difficult to predict E to within average uncertainties of two or three percent in some instances, by Eq. (1).

[1] W. G. Neild, Trans. A.I.E.E. **63**, 839 (1944).

15. A Study of the Mean Radiant Temperature and the Air Temperature in a Panel Heated House. CLYDE B. CRAWLEY, *University of Kentucky.*—The mean radiant temperature of a room may of course be higher or lower than the air temperature. The two temperatures ought not to differ greatly except for sudden changes in outside temperature. Data are given for a panel heated house to substantiate this point. A method of estimating the mean radiant temperature from a simple temperature reading is also given. The air temperature is first obtained with a thermometer at rest. The thermometer is then whirled rapidly in the air and the temperature read a second time. It is found that the mean radiant temperature is approximately equal to the first temperature. A table is given showing the relation between the mean radiant temperature and these two air temperatures.

16. The Formation of Spiral Marks on Fractures. ARTHUR E. RUARK, *The Johns Hopkins University.*—Fractures of glass and plastics show spiral marks called *ripples* (not to be confused with ribs, which are halting points of fracture, according to Poncelet and Murgatroyd). Wallner's explanation of ripples is, that when a fracture-front ruptures a serious flaw, an elastic wave is produced, which interacts with the spreading fracture, changing its characteristics at points on the locus of their intersection. This locus is a ripple. The ripple shape should depend only on the ratio of the elastic-wave speed and the fracture speed. There is evidence that the latter is nearly constant, so that ripple shapes can be used to measure the wave-speed. This varies from one case to another. I have made observations which suggest two modifications. (1) The speed of the finite, complex elastic disturbance is not equal to that of an infinitesimal disturbance, in analogy to plastic waves in metals. (2) As in metals, a flaw may rupture *before* the main fracture strikes it. These factors provide the flexibility needed for full elucidation of the behavior of these finite waves in brittle materials. Specimens will be shown.

17. Speed of Propagation of Fractures in Glass Plates.* V. E. SCHERRER AND ARTHUR LINZ, JR., *University of North Carolina.*—Measurements have been made of the progress of cracks across glass plates, with the object of obtaining information which bears upon the relation of fracture dynamics to initial applied stresses. Each crack was made to break a number of electric circuits (colloidal graphite) on the surface of a plate; and the circuit-breaks were recorded by means of a spark chronograph. Plate dimensions of 30 cm by 60 cm with a thickness of 0.3 cm have been studied to date; fracture along a surface scratch has been initiated in most instances by bending, although attempts have been made to cause fracture largely by tension. The data indicate that the velocity of fracture-head starts at a low value, accelerates, and then levels off at a value somewhat less than the velocity of sound. Similar tests are also under way using steel plates in tension.

* This research is being done under contract with the Office of Naval Research.

18. Failure of Metals Subjected to Repeated Plastic Strains.* J. P. PARKER, T. E. PARDUE, AND J. L. MELCHOR, *University of North Carolina.*—A research program has been initiated to determine the behavior of metals when subjected to repeated plastic strains. The experimental procedure consists of rotating a specimen in an R. R. Moore testing machine modified so as to permit the application of loads which stress the material at the outer surfaces of the metal plastically, in cyclic tension and compression. Measurements are made of the torques, strains and number of cycles to failure; these data provide a basis for approximate calculation of total work and work per unit volume necessary to produce failure. Preliminary tests indicate fundamental differences in the performances of three representative materials, cold rolled steel, cast iron and cast aluminum; graphs are presented to illustrate these differences.

* This work was financed by the Office of Naval Research.

19. Possible Method for Measurement of Speed of Brittle Fracture in Steel.* ARTHUR LINZ, JR., AND V. E. SCHERRER, *University of North Carolina.*—Two points, A and B, are placed close together at the center of one edge of a thin rectangular conductor. It has been found by experiment that if the plate is cut in two, starting between A and B and proceeding perpendicularly to the opposite edge, the resistance between the points A and B varies almost linearly with the length, x, of cut, until near the end of the cut: $R=R_0+A\cdot x$, $0<x<0.95d$, where d is the width of the plate. It has been suggested by Dr. F. T. Rogers, Jr. that a voltage developed across such a resistance in the case of a thin plate of steel might be used to study the speed of a brittle fracture across the plate; the discussion will relate to work which has been done in accord with this suggestion.

* This research is being done under contract with the Office of Naval Research.

20. Conditions for Brittle Fracture of Mild Steel. VICTOR SCHERRER AND JOSEPH W. STRALEY, *University of North Carolina.*—Measurements are being conducted to ascertain the conditions under which brittle fracture of notched steel plates may be initiated. Plates 12 inches wide and notched on both sides have been placed in a large testing machine and broken under tension. All fractures seem to start in a ductile or fibrous fashion but a portion may have the cleavage appearance associated with brittle fracture whose width depends on the conditions of the test. The likelihood of brittle fracture is increased if the plates are sharply notched on both sides and if the plate is quite thick at the notch. The dependence on speed in the ductile zone is now being studied by means of a spark chronograph. Speeds in the ductile region vary widely from a few hundred feet per second to several thousand feet per second. Speeds in the brittle region seem in every case to exceed the speeds attained in the ductile region.

21. Creeping Cracks in Slow-Bend Fracturing of Mild Steels.* MARGUERITE M. ROGERS, *University of North Carolina.*—If a slow-bend test specimen[1,2] is halted immediately after precracking, is stained, and then is reloaded to a torque value *below* the maximum which is necessary to cause ductile failure to continue in the ordinary way, it is found[3] that the specimen will begin to yield. If the applied torque is held constant, the creep of the specimen seems to accelerate until the creeping crack so formed develops sufficient speed to cause brittle failure to occur. Data on these creeping cracks will be given.

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

[1] P. E. Shearin, Phys. Rev. **71**, 832 (1947).

[2] M. M. Rogers and P. E. Shearin, Phys. Rev. **73**, 656 (1948).

[3] This phenomenon was predicted for this particular type of specimen by Dr. G. R. Irwin.

22. The Maximum Normal Stresses in Mild Steel During Bending.* W. J. BYATT AND F. T. ROGERS, JR., *University of North Carolina.*—It is found in the series of tests which are presently under way,[1] that the maximum torque (T) supported by a four-notch type of mild-steel specimen, decreases roughly linearly with increasing depth (x) of the crack in the specimen. Considerable plastic working and deformation occur in these specimens during bending, leading not only to advancement of the crack but also to slight changes in lateral dimensions, to gradual closure of the "back notch," and so on. It does not seem possible to explain this relation of T to x by means of elastic-type maximum normal-stress functions, however non-linear, because they lead to a strongly quadratic relation. Instead it seems that non-linearities and drastic displacements of the neutral surface from the center of retained area, may have to be combined to produce a normal-stress function which satisfies present ideas as to maximum possible local stresses in tension and compression, and which still relates T to x according to the experimental data. The discussion will relate to what can be inferred as to the maximum normal-stress function from the necessary relations[2] involving integrals over the retained cross-sectional area.

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

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

[2] S. Timoshenko, *Strengths of Materials* (D. Van Nostrand and Company, Inc., New York, 1930), p. 234.

23. Characteristics of Curved Tubes.* H. A. JARRELL, AND T. E. PARDUE, *University of North Carolina.*—The behavior of curved tubes, whose bend radius is large compared to the tube radius, has been given by von Karman[1] for loads applied in the plane of the bend and by Vigness[2] for loads applied transverse to the plane of the bend. These theoretical results are in good agreement with experimental data. The increased use of bends whose bend radius is comparable to the tube radius (used in high temperature high pressure steam systems) makes it imperative that an extension of the earlier work be carried out to include the effects of the short bend radius. Theoretical analyses have

been made[3-5] and an experimental verification is now being carried out. Reasonable agreement is observed between the theoretical and experimental data.

* This work was financed by U. S. Navy Contract N7onr-284, T. O. 4.
[1] Th. von Karman, "Ueber die Formanderung Dunnwandiger Rohre, insbesondere federnder Ausgleichrohre," Zeitschrift des V.D.I. **55**, 1889–95 (1911).
[2] Irwin Vigness, "Elastic Properties of Curved Tubes," Trans. A.S.M.E. **65**, 105 (1943).
[3] Discussion by H. E. Jenks of paper "Design of Steam Piping to Care for Expansion," by W. H. Shipman, Trans. A.S.M.E., paper FSP-51-52, 1929.
[4] P. S. Symonds and T. E. Pardue, "Characteristics of Short Radius Tube Bends," Second Partial Report (Theoretical), NRL Report No. 0-2761, Feb. 18, 1946.
[5] Leon Beskin, "Bending of Curved Thin Tubes," J. App. Mech. **12** (1945).

24. Effects of Relaxing Materials in Force-Transmitting Linkages.* EMILY JONES AND F. T. ROGERS, JR., *University of North Carolina.*—The problem is considered of relating the displacement $s(t)$ of the driving member in a mechanical system, to the yield $S(t)$ of the driven member, when the driving force $F(t)$ is transmitted between the two by means of a series linkage containing both elastic and time-dependent quasi-elastic members. A first-order differential equation can be set up to relate $F(t)$ and the correction $c(t)=S(t)-s(t)$, which involves various stiffness moduli and relaxation constants appropriate to the linkage. Using constants which apply to the North Carolina slow-bend test-gear,[1] it is possible to obtain c-values which agree favorably with values of $S-s$ which were observed directly at a later date. Apart from the actual numerical values for $c(t)$, it is significant that even well-designed linkages may exhibit relaxation phenomena (perhaps due to inevitable local imperfections of construction) which cannot be neglected if $S(t)$ is sought in terms of an observed $s(t)$.

* This work is being done under contract with the Office of Naval Research.
[1] F. T. Rogers, Jr., Phys. Rev. **74**, 122 (1948).

25. Strain-Aging Effects in the Slow-Bend Fracturing of Mild Steels.* MARGUERITE M. ROGERS, *University of North Carolina.*—The slow-bend fracturing apparatus and the method of staining specimens to correlate crack-depth with work-input, which are used in this series of tests, have been described elsewhere.[1,2] A series of specimens of mild steel was fractured at 120°F, with different time-intervals between the precracking and the succeeding stages of fracture. These time-intervals varied from 10 minutes to 3 days. The work required to fracture the specimen in a ductile fashion, as a function of crack-depth, decreased sharply with increased time of aging, although the torque required to advance the crack in the usual way increased (as would be expected); and both of these phenomena were strikingly evident on the autographic records of the test-data. Presumably the limiting case of this age-hardening would be brittle failure, corresponding to no absorption of energy; but this would require very long aging.

* This work is being done under contract with the Office of Naval Research.
[1] P. E. Shearin, Phys. Rev. **71**, 832 (1947).
[2] M. M. Rogers and P. E. Shearin, Phys. Rev. **73**, 656 (1948).

26. Quantitative Data from a Slow-Bend Test of Mild Steel.* F. T. ROGERS, JR., *University of North Carolina.*—The subject test and its notched design of mild-steel specimen have been described elsewhere;[1-4] both applied torque (T) and energy absorbed (W) are observed in terms of each specimen's deformation (s) and resulting crack-depth (x), under various conditions of temperature, etc. One major part of the problem of quantitative interpretation lies in relating x to s in accord with the experimental data. Another major part, the fact that W is found to be nearly linear in x, has been attributed[4] to the volume-extent of work-hardening. A third part involves the relation of T (roughly) linearly to x, as observed experimentally, and seems to require a non-linear normal-stress pattern.[5] Data are available on other not so obvious phenomena, such as relaxation, lateral deformation, stored elastic energy, crack creepage;[6] and these also require quantitative interpretations.

* This work is being done under contract with the Office of Naval Research.
[1] P. E. Shearin, paper read 18 October 1947 at ASM and Case Institute Seminar of Fracturing, Chicago.
[2] M. M. Rogers and P. E. Shearin, Phys. Rev. **73**, 656 (1948).
[3] M. M. Rogers and P. E. Shearin (to be published).
[4] P. E. Shearin, Phys. Rev. **71**, 832 (1947).
[5] W. J. Byatt and F. T. Rogers, Jr., Phys. Rev. **74**, 121 (1948).
[6] Marguerite M. Rogers, Phys. Rev. **74**, 122 (1948).

27. Reversal of Secondary Series. M. S. MCCAY, *Virginia Polytechnic Institute.*—The absorption spectra of secondary series have never been fully developed in terrestrial sources in a manner comparable to the reversed series obtained from stellar sources. Approximate simulation of stellar conditions under which reversal occurs is realized in various reported schemes. The shielded, field-free center of a HF discharge as a source of such absorptions will be discussed, as will the applicability of the method to the determination of band lines, exact intensity distributions and effective "rotation temperatures" of molecules.

28. Absorption Spectrum of Benzotrifluoride Vapor in the Near Ultraviolet.* H. SPONER AND D. S. LOWE, *Duke University.*—The absorption spectrum of benzotrifluoride vapor at 2740–2450A was photographed in a medium Hilger quartz spectrograph. The band system can be interpreted in terms of an electronic transition A_1-B_1. The 0,0 band appears strongly at 37819 cm^{-1} and happens to coincide with the location of the 0,0 band in fluorobenzene. Several progressions of totally symmetric vibrations occur involving particularly frequencies of 750, 928 and 961 cm^{-1}. The first of these is assigned to the C–CF_3 vibration. Other prominent bands result from vibrations which correspond to the degenerate ϵ_u^+ vibration in benzene responsible for the appearance of the spectrum of that molecule. Bands corresponding to the excitation of ground state frequencies up to 1336 cm^{-1} have been observed at higher pressures and found to coincide with Raman frequencies. As may be expected, the general appearance of the spectrum resembles that of toluene, although there are interesting differences in finer details.

* This work was supported by the Office of Naval Research.

29. Methods in Microwave Spectroscopy.* MYER KESSLER AND WALTER GORDY, *Duke University.*—A filtering circuit will be described that eliminates spurious signals caused by impedance mismatch in the microwave line while allowing amplification of a sharp signal caused by molecular absorption at low pressures. A method will also be discussed for increasing the sensitivity of the system by modulating the microwave source so that a tuned receiver can be employed. Absorption spectra of certain molecules will be given to illustrate the methods.

* The research described in this abstract was supported by a Frederick Gardner Cottrell grant-in-aid from the Research Corporation of New York.

30. Frequency Stabilization of Microwave Oscillators by Spectrum Lines.* JOSÉ L. GARCÍA QUEVEDO AND WILLIAM V. SMITH, *Duke University.*—A 2K50 microwave oscillator has been electronically coupled to the NH_3 3.3 rotational spectrum line at 23,870 megacycles in such a manner as to maintain the frequency of the oscillator at the spectrum line frequency. Details of its construction, operation and observed discriminator slope as a function of pressure and input power are discussed. The discriminator used with an amplifier of 2000 gain reduce drifts by factors of 250 to 1000 compared to an unstabilized tube. Saturation of the ammonia absorption line at high powers sets an upper limit to the attainable stability for a given discriminator.

* The research described in this abstract was supported by Contract No. W-28-099-ac125 with the Army Air Forces, Watson Laboratories, Air Material Command.

31. Microwave Spectra of Cyanogen Halides.* A. G. SMITH, H. RING, W. V. SMITH, AND W. GORDY, *Duke University.*—The microwave absorption spectra of BrCN, ClCN, and ICN have been observed in the millimeter wave-length region. The rotational transitions studies were $J=3$ to $J=4$ for BrCN, $J=2$ to $J=3$ for ClCN, and $J=4$ to $J=5$ for ICN. In each case the fine structure caused by nuclear quadrupole interactions was observed and compared with the theory of Bardeen and Townes. Doubling due to the isotope effect was noted in the cases of BrCN and ClCN. From the measurements it is possible to evaluate the moments of inertia of the molecules, the nuclear spins of the halogens, and the quadrupole coupling factors.

* The research described in this abstract was supported by Contract No. W-28-099-ac125 with the Army Air Forces, Watson Laboratories, Air Materiel Command and a Frederick Gardner Cottrell grant-in-aid from the Research Corporation of New York.

32. Saturation Effect in the Microwave Absorption of Ammonia.* ROBERT L. CARTER AND WILLIAM V. SMITH, *Duke University.*—Attenuation and line width for the NH_3, 3,3 inversion spectrum line at 23,870 megacycles are measured over a power range of from 10 milliwatts per cm^2 to 10^{-3} milliwatts per cm^2, at several pressures below 10^{-3} mm Hg. The peak like attenuation exhibits saturation at high powers in good agreement with theory. Measurement of the increase in line width accompanying saturation leads to an estimate of the collision cross section somewhat smaller than that deduced from collision broadening data.

* The research described in this abstract was supported by Contract No. W-28-099-ac125 with the Army Air Forces, Watson Laboratories, Air Materiel Command.

33. Structure of the Inversion Spectrum of Ammonia.* JAMES W. SIMMONS AND WALTER GORDY, *Duke University.*—Measurements of the fine structure in the ammonia inversion spectrum have been extended into the millimeter-wave region to the 16,16 line at 39944 mc/sec. The relative intensities and positions of the lines are compared with calculated values. The hyperfine structures of 15 lines have been measured. A systematic disagreement is shown to exist between the theoretical and observed separations of the hyperfine components. There is good agreement between the observed and calculated intensities of the hyperfine structure.

* The research described in this report was supported by Contract No. W-28-099-ac125 with the Army Air Forces, Watson Laboratories, Air Materiel Command.

34. Some New Measurements on the Infra-Red Spectrum of HF.* ROBERT M. TALLEY AND ALVIN H. NIELSEN, *University of Tennessee.*—In 1919 Imes[1] observed the fundamental vibration-rotation band of HF at 2.52mμ. Serious overlapping of this band, particularly of the P branch, with the atmospheric water vapor absorption at 2.7mμ prevented accurate measurements of the frequencies of the lines. In 1923 the first overtone was detected at 1.27mμ by Schaefer and Thomas.[2] Kirkpatrick and Salant[3] photographed and resolved beautifully the second and third overtones. There are certain discrepancies between their constants and those computed from Imes' work. With a sample of HF furnished by the K-25 Laboratories of Carbide and Carbon Chemicals Corporation at Oak Ridge the fundamental has been remeasured with a 7200 line-per-inch grating on an automatically recording infra-red spectrograph.[4] It is proposed also to measure the first overtone with high dispersion. Facilities for drying the air in the spectrograph permit much better identification and frequency measurement of the lines in the present data. It is hoped that these measurements will resolve earlier discrepancies.

* The research discussed in this abstract was supported by a Frederick Gardner Cottrell grant-in-aid from the Research Corporation of New York.

[1] E. S. Imes, Astrophys. J. **50**, 251 (1919).
[2] Schaefer and Thomas, Zeits. f. Physik **12**, 330 (1923).
[3] D. E. Kirkpatrick and E. O. Salant, Phys. Rev. **48**, 945 (1935).
[4] A. H. Nielsen, J. Tenn. Sci. **XXII**, No. 4, 241 (Oct., 1947).

35. The Infra-Red Spectrum of HCl in Solution with Dioxane, Di-Ethyl Ether, and Ethyl Acetate. JACK L. PARNELL AND JOSEPH W. STRALEY, *University of North Carolina.*—A study has been made of the infrared spectrum of HCl when in solution in benzene with dioxane, di-ethyl ether, or ethyl acetate. Interest in this problem arose from the observation by Gordy and Martin[1] that subsidiary bands at longer wave-lengths seem to be present. These bands are in addition to those normally expected

to arise as a result of the known tendency of these materials to form weak bonds with protons. A reexamination of the spectrum confirms the existence of these bands shifted approximately 0.4 microns farther into the infrared. A tentative explanation of the cause of this phenomenon will be presented.

[1] Gordy and Martin, J. Chem. Phys. **7**, 99 (1939).

36. A Study of Short-Distance Propagation of 147-MC Radio Waves. ROBERT N. WHITEHURST, *University of Alabama.*—In an attempt to investigate the propagation of VHF radio waves over a path which is slightly below line of sight, a 147 mc. transmitter and a continuously-recording receiver have been set up at points approximately one and one-half miles apart. A hill higher than either of the two stations lies between them.

An introductory study of the effects of polarization and antenna height and orientation will be presented. Continuous recordings of field strength have now been obtained for periods up to five days duration in order to study the effects of meteorological factors. It is expected that results obtained from these recordings will also be presented.

37. Durable and Optically Improved Front Surfaced Mirrors Processed Exclusively by Thermal Evaporation. R. W. BOYDSTON, *Georgia School of Technology.*—During World War II, the writer analyzed existing front surfaced mirrors, evaluated their virtues and disadvantages for military use in precision Fire Control instruments. Such analyses revealed that no desirable mirror existed. Research to develop a truly desirable type was undertaken. This paper describes these situations, and culminates in the author's method of processing, and the properties of the evolved "standard" mirror adopted by Army Ordnance in specification FXS-670, and elsewhere, with reasons for the same. All Army Ordnance mirror-making facilities learned these techniques and complied. The durable and optically improved first surface mirrors demanded are described. The method applies to evaporated aluminum, silver, etc., reflectors and consists of a one-half wave-length thickness evaporated layer of durably processed magnesium fluoride overlaying, protecting and enhancing the optical properties of the resultant reflectors. Spectrophotometric curves and durability data are included. Overcoated hard and durable silver front surfaced mirrors, having reflections of 99.2 percent, and similarly treated aluminum mirrors, withstanding terrific abuse with reflections of 93 percent, are produceable.

38. Characteristics of an Acoustic Interferometer. NEWTON UNDERWOOD, *Carbide and Carbon Chemicals Corporation.*—A quartz crystal which sets up vibrations in the liquid is driven by the beat frequency between two other crystal controlled oscillators as devised by McMillan and Lagemann. A reflector is moved down through the liquid by means of a micrometer screw. Each time the reflector is at a nodal point, mechanical resonance occurs. This reacts on the crystal and results in a voltage drop of about 5 percent. Spurious nodal points sometimes appear. This may be remedied in three ways: (1) improve the stability of the acoustic coupling between the crystal and the liquid by driving through a wave plate (thickness equal to the sonic wave-length in the material), (2) keep the liquid surface non-parallel to the plane of the bottom, (3) slope the back surface of the reflector or make it a wave-length in thickness. One of the advantages of the oscillator drive of McMillan and Lagemann is its great stability and insensitiveness to changing experimental conditions. The pressure on the interferometer crystal was varied from 6 plus or minus 2 gmf to 6000 plus or minus 20 gmf, without changing the voltage dips in shape or absolute magnitude in a detectable manner.

39. Ultrasonic Velocity in Some Liquid Fluoro-Carbons.* R. T. LAGEMANN, JOHN EVANS, AND NEWTON UNDERWOOD, *Emory University.*—The velocity of compressional waves has been measured for some liquid fluorocarbons using a movable-reflector acoustic interferometer and a beat frequency oscillator. The frequency employed was 500,000 c.p.s., and, in most cases, the temperature was maintained at 60°C. Included in the compounds was a series of polymers of various molecular weights. It was found that the complete substitution of fluorine for hydrogen in the molecules studied results in remarkably low values of the ultrasonic velocity, approaching, in fact, the range of velocities found for gases. For example, in the completely fluorinated compound, hexadecafluoroheptane, the velocity was found to be only 444 m/sec. at 60°C. The study of a few of the compounds over the temperature range 20° to 70°C showed the velocity to be a linear function of the temperature. The variation of ultrasonic velocity with molecular structure will be discussed.

* Work done under contract with the Carbide and Carbon Chemicals Corporation, Oak Ridge, Tennessee.

40. Temperature Coefficient of Ultrasonic Velocity. D. R. MCMILLAN, JR. AND W. E. WOOLF, *Emory University.*—The velocity of ultrasonic waves was measured in twenty single-component liquids at 10°C intervals over the range of temperatures from 0°C to 60°C. An acoustic interferometer of the movable reflector type was employed for all measurements. Compressional waves were produced in the liquid contained in the interferometer by an x-cut quartz crystal which was driven by a 500 Kc/sec. crystal-controlled oscillator. The ultrasonic velocity was found to vary linearly with temperature for all liquids included in this study. The average temperature coefficient of velocity, defined here as dV/dt, was calculated for each compound from the observed data. A general decrease in the absolute value of this coefficient with increasing molecular weight was obtained. The results are tabulated and illustrated by graphs.

41. A Device for Determining Particle Size Distribution in Smokes. J. E. RHODES, JR., *Georgia School of Technology.*—A practical device for determining the particle size distribution in a smoke has been developed. Its

operation depends upon the fact that the velocity of thermal diffusion of a smoke particle in a gas is a function of its size. The particle bearing gas is passed at a known rate between two parallel walls whose temperatures are each maintained constant, and different from each other so that a temperature gradient is established in the gas. Smoke particles diffuse to and deposit on the cold wall. An examination of the variation of density of particles (number of particles per unit area, irrespective of their sizes) along the wall will yield the particle size distribution in the smoke. Particle densities can be obtained from microscopic counts, and particles can be counted that are too small to be resolved. An operator with experience can determine approximate distributions without laborious microscopic counting. The relation between particle density as function of position on the cold wall and the particle size distribution has to be determined with homogeneous smokes of known particle sizes.

42. Hard and Durable Non-Absorbing Optical Beam Splitters Produceable by Evaporated Multilayer Thin Filming Methods. R. W. BOYDSTON, *Georgia School of Technology.*—Strictly non absorbing beam splitters, impossible with metallized films, fit for outside, exposed optical surfaces, are described. Any prescribed reflectance, zero to 100 percent, or reflectance *vs.* wave-length curves, may be obtained by simple evaporations of alternate low and high index films. The author's processing methods and products replaced all means previously used expensively in complex, long drawn-out, and unsatisfactory procedures. During World War II such evaporatable multilayer films were impossible, since only magnesium fluoride, $N_D = 1.38$, properly processed, was satisfactorily durable. Other films were little more than laboratory curiosities. No technique had evolved giving additional materials required durabilities. Notwithstanding potential optical properties, zinc sulphite ($N_D = 2.37$) films were universally reported hopelessly non-durable. This paper describes the author's processing of ZnS in single or multiple layers with MgF_2 to possess amazing tenacities, toughness, hardness, and chemical durabilities. This disadvantage of ZnS films solved, they were applicable singly or in multiple with MgF_2 to give durable beam splitters, filters, dichroic reflectors, etc., having predictable optical properties. Inside and outside vacuum procedures, products, scientific and engineering applications, are revealed. Uses to date are extensive but strictly military. Spectrophotometric curves, durability data, support presented facts.

43. A Current Integrator for Small Currents. H. G. FLANARY, F. B. PAULS, AND L. A. PARDUE, *University of Kentucky.*—To record accurately the total charge received by a target from an ion source in a high voltage machine such as a Van de Graaff generator an integrating device is needed. This is usually accomplished by measuring the charge received by a condenser.[1] The integrator being described here consists essentially of a 1000$\mu\mu$f mica condenser and a $\frac{1}{4}$-watt neon glow bulb connected in parallel. The charge given up by the condenser in falling from the breakdown potential of the neon bulb to the extinction potential flows to ground through a resistance. The potential drop across the resistance constitutes a pulse which is amplified, shaped and observed on a mechanical recorder. A scaling circuit is used to scale the number of pulses down to a rate acceptable to the recorder when large currents are observed. This integrator is suitable for measuring pulsating currents from 10^{-8} amperes to 5×10^{-5} ampere. The counting rate and current show good linearity. Measurements on an ion source usable in the high voltage terminal of a generator will be discussed.

[1] R. E. Watt, Rev. Sci. Inst. **17**, 334 (1946).

44. Supercooling of Water. R. HOWARD AND C. B. CRAWLEY, *University of Kentucky.*—It is reported that waters from different sources have in general different spontaneous freezing points which are reproducible within small limits, provided the samples have not been subjected between measurements to temperatures much above room temperature. The spontaneous freezing points of some samples are constant for a period of months. Other samples have spontaneous freezing points which are erratic in time. Over a range extending from room temperature to temperatures somewhat above 100°C, the higher temperature to which a sealed sample of water is raised, the lower the spontaneous freezing point thereafter. Water can be held below 0°C for days without freezing. Data are given on the spontaneous freezing points of mixtures of waters as a function of concentrations. It is planned to investigate the relation between x-ray diffraction patterns and spontaneous freezing points. Finally, it is also planned to investigate the effect of centrifuging on the spontaneous freezing point. These investigations follow N. Ernest Dorsey's work as reported in Research Paper RP1105 of the National Bureau of Standards.

45. Crystal "Growth" in the Electron Microscope. A. C. MENIUS, JR. AND T. J. TURNER, *Clemson Agricultural College.*—Recently several observers[1-3] have noticed that objects viewed in the electron microscope change in size and shape when left in the electron beam for short times. This "growth," which is apparently due to some contamination, is critical since observations are therefore limited to a few seconds for any one object. Due to the importance of this phenomenon, a series of measurements have been made using zinc oxide crystals, in an attempt to determine the source of this contamination. The following results were obtained: (a) the growth is a linear function of time up to at least twenty minutes; (b) in contradiction to most observers[2] the growth seems to be independent of the distance of the specimen from the grid; (c) the rate of growth instead of increasing with beam current[2] reaches a maximum at about 0.25 μa and then decreases with current; (d) in agreement with other observers[3] the contamination appears less dense than the zinc oxide crystals.

[1] Watson, J. App. Phys. **18**, 153 (1947).
[2] Cosslett, J. App. Phys. **18**, 844 (1947).
[3] Watson, J. App. Phys. **19**, 110 (1948).

46. The Correlation of the Bioelectric Potential of Corn Seeds with X-Ray Dosage. M. W. JONES, J. G. JONES AND A. A. BLESS, *University of Florida.*—The current theories explaning the origin of the bioelectric potential are outlined. A description of the equipment used in the potentials of corn seeds is given with a resume of the difficulties encountered in its operation. The x-ray equipment and the mode of radiation of the seeds is described. Data and corresponding curves showing the rise of the bioelectric potential with growth of the seeds for the first 48 hours are given. The results of the irradiation of the seeds are tabulated and curves are drawn showing the decrease of the potential with increase of dosage. A summary of the observed results is given and from these results a discussion of the correlation of x-ray dosage, the growth of the seeds and their potentials is given.

47. Production of Short X-Ray Pulses by a Resonant Cavity Electron Accelerator.* L. B. SNODDY AND J. W. BEAMS, *University of Virginia.*—A reentrant copper lined cavity resonator tuned to approximately 400 megacycles is driven by a Western Electric 7C22 pulse operated twin triode. Such a resonator is essentially two quarter wave transmission lines back to back. Consequently, when resonance occurs an alternating high potential exists across the two ends of the "lines" or "gap" inside the cavity.[1] The 7C22 tube is pulsed with about 18,000 volts for sufficient time to permit the oscillations in the unloaded resonant cavity to build up to maximum amplitude. At this point a short duration vacuum spark is produced on one of the electrodes of the "gap" inside the cavity by a special transmission line arrangement. This gives a large burst of electrons which are accelerated across the gap and impinge upon a target. This in turn produces a short intense pulse of x-rays. Measurement showed that about 1.2 Mev electrons were produced. The duration of the x-ray pulse can be controlled by the characteristics of the transmission line feeding the vacuum spark.[2]

* This work was carried out under Contract NOrd-7873 with the Bureau of Ordnance U. S. Navy.
[1] Hereford, J. App. Phys. **18**, 956 (1947).
[2] Beams, Kuhlthau, Lapsley, McQueen, Snoddy and Whitehead, J. Opt. Soc. **37**, 868, (1947).

48. Operation of Grid-Controlled Fine-Focus X-Ray Tube.* H. M. LONG, JR. AND R. PEPINSKY, *Alabama Polytechnic Institute.*—Constructional details and modifications are described of the fine-focus, grid-controlled x-ray tube reported earlier from this laboratory,[1] and operating characteristics gathered over a two-year period are presented. Using the fine focal spot and a single pinhole at a distance of 11 cm. from it to produce near-parallel collimation (divergence about 20 feet of arc) of the primary x-ray beam, a d.c. tube current of 0.2 μa produces a beam of approximately the same intensity as is available in a beam of similar divergence from a General Electric CA-6 diffraction tube, viewed at the same angle with respect to the target surfaces, when the latter tube is operated at the same d.c. high voltage as the fine-focus tube but at 20 μa tube current. Operation of the tube under periodic grid pulsing is described.

* Development supported by U. S. Army Signal Corps.
[1] R. Pepinsky, Phys. Rev. **69**, 546 (1946).

49. Some Observations on Geiger Counters for Periodically Pulsed X-Ray Photon Counting.* P. JARMOTZ AND R. PEPINSKY, *Alabama Polytechnic Institute.*—Carrying further the measurements recently described by Pepinsky, Jarmotz, Long and Sayre,[1] it has been possible directly to measure the time lag between the appearance of an x-ray photon in a Geiger counter and the arrival of the discharge at the central wire. The x-ray tube is pulsed as previously indicated, and an oscilloscope sweep synchronized to the pulses. The pulses to the x-ray tube grid are applied to one vertical oscilloscope plate, and the output of the Geiger tube circuits to the other. A lag of about 1.5 microseconds is observed in the counter pulse, in the case of the new commercial North American Philips "Norelco" mica-window counters radiated with CuKα along a path about 2 mm from the central wire. A coincidence circuit is used to reduce the counter background noise (due to cosmic rays and radioactive contamination). The counter tube amplifier is gated on only during the time when a discharge due to an x-ray pulse can occur. A hundred-fold reduction of background counts is readily achieved, and the detection of very weak diffracted intensities is consequently greatly facilitated.

* Development supported by U. S. Army Signal Corps.
[1] Pepinsky, Jarmotz, Long and Sayre, Rev. Sci. Inst. **19**, 51 (1948).

50. Extensional and Thickness Vibrations of Two-Dimensional Crystals.* NICHOLAS CHAKO, *Alabama Polytechnic Institute.*—An investigation has been initiated of the modes of vibration of crystals of various types of symmetry, and a comparison of the results is made with the isotropic plate. Plates of rectangular as well as circular shape have been studied. It is found that for crystals belonging to group VII one obtains independent vibrations along the two axis (radial motion of the particles). For large amplitudes the vibrations in the two directions are coupled and the frequencies are no longer simple harmonic. For crystals of lesser symmetry than quartz, such as rochelle salt, the higher harmonics are in general not integral multiples of the fundamental, although for higher order vibrations the frequencies approach a simple harmonic relationship. For circular plates of quartz one can apply Love's theory, since both the dilatation and rotation vectors satisfy an equation of the type of wave motion with different propagation constants. The results, as one would expect, give a transcendental equation (of the Bessel type) for the determination of frequencies.

* This development supported by U. S. Army Signal Corps.

51. Quantitative Determination of Electron Densities and Contour Line Delineation in the Auburn Electronic Fourier Synthesizer for Crystal Structure Analyses.* R. PEPINSKY AND D. SAYRE, *Alabama Polytechnic Institute.*—By means of a clamping pip voltage detector applied directly to the intensity-modulating cathode-ray tube grid

signal, it is possible to sample quantitatively (within 1 to 2 percent) the projected electron density at any point of the planar map presented by the Auburn Fourier synthesizer for crystal structure analyses.[1] The point of sampling is indicated as a bright or dark pip directly superposed on the CR tube pattern, and the density at the sampled point appears as a meter reading. The accuracy of the measurement is independent of the CR tube screen, and depends only on the oscillators, amplitude potentiometers and subsequent amplifiers. Using simple coincidence circuits set at predetermined voltage levels, it has also been possible to accurately delineate contour lines of electron density directly on the oscilloscope screen. Photographs of contour-line patterns so obtained are presented.

* Development supported by Mathematics Section, Office of Naval Research.
[1] R. Pepinsky, J. App. Phys. **18**, 601 (1947).

52. Photoelectric Two-Dimensional Fourier Analyzer.* D. SAYRE AND R. PEPINSKY, *Alabama Polytechnic Institute.*—The coefficients ΩH_1H_2 of a two-dimensional Fourier series representing a function $\Omega(s_1\bar{a}_1+s_2\bar{a}_2)$, periodic in s_1 and s_2 with periods 1, are calculable from the relation:

$$\Omega H_1H_2=\int_0^1\int_0^1\Omega\cos2\pi(H_1s_1+H_2s_2)ds_1ds_2 +i\int_0^1\int_0^1\Omega\sin2\pi(H_1s_1+H_2s_2)ds_1ds_2.$$

Several photoelectric methods are described for evaluating ΩH_1H_2. These depend upon the preparation of photographic transparencies corresponding to Ω, and the multiplication and integration of these over a unit of Ω with a "fringe" corresponding to $\cos2\pi(H_1s_1+H_2s_2)$ or the corresponding sine. In particular, the Fourier synthesizer for crystal structure analysis under construction at Alabama Polytechnic Institute[1] facilitates this evaluation for cells of any axial ratios and angles, and for H_1 and H_2 values between -20 and 20. The transparencies corresponding to Ω can be obtained radiographically, as will be described elsewhere.[2]

* Development supported by Office of Naval Research.
[1] R. Pepinsky, J. App. Phys. **18**, 601 (1947).
[2] R. Pepinsky (in press).

53. A Counter for Low Energy Ionizing Particles. H. C. THOMAS AND N. UNDERWOOD, *Vanderbilt University.*—A counter which combines large solid angle, low operating voltage, ease of changing source, and ability to detect particles of low energy is described. By means of a revolving plate a sample may be rotated to a position inside the counting chamber through which helium is slowly passing. A large solid angle with low operating voltage is achieved by placing side by side several semicylindrical cathodes whose central wires are electrically connected. Fe^{55} which has a half-life of about four years was used as a sample with which to examine the operational characteristics of the counter.

54. A Simplified Low Pressure Cloud Chamber. ARTHUR WALTNER, *University of North Carolina.*—Low pressure cloud chambers have been of somewhat complicated design.[1] Construction details are given for a simplified low pressure cloud chamber capable of operation at pressures of a few centimeters of Hg. Expansion is initiated by releasing a compressed coil spring held in the "set" position by an electromagnet. The region below the diaphragm is partially evacuated, making it possible to control the rapidity of the expansions by varying the pressure in this region. Electronic photo-flash tubes are used for illumination. Electronic timing circuits provide a variable interval between expansions and a variable delay between the expansion and the photography of tracks.

[1] J. Petrova, Zeits. f. Physik **55**, 621 (1929).

55. Investigation of the Fading of Latent Images of Neutron-Induced Proton Tracks in Special Fine Grain Particle Emulsions. J. S. CHEKA, *Oak Ridge National Laboratory.*—While latent images in ordinary photographic emulsions are very stable, those of nuclear particle tracks in "particle" emulsions are unstable and "fade," i.e., become undevelopable in comparatively short times. The present paper describes the results of investigation of this phenomenon as applied to monitoring of neutron exposures of personnel at Oak Ridge National Laboratory. Several Eastman emulsions of the type NTA and a few specimens of type NTB were tested. It was found that different emulsion batches showed different fading rates. Shorter tracks faded faster than long tracks, consequently, overall drop in density of developable tracks after periods of delay was a function of original distribution of track lengths. Assuming that sensitivity of individual grains was lost with a fixed half-life, decay rates of tracks of various lengths were calculated by Dr. W. S. Snyder of the University of Tennessee. Results showed good agreement with experimental data. Retention rate of recognizable tracks was increased by the use of longer development time. Stale developing solution was found to lose efficiency in bringing out latent tracks.

56. Tne Energy Dependence of Film Meters. L. J. DEAL, J. H. ROBERSON, *Oak Ridge National Laboratory,* AND F. H. DAY, *National Bureau of Standards.*—Since the earliest use of x-rays, photographic films have been used for detecting the stray radiation exposures of operating personnel. At the start of the Atomic Energy Project a film meter was devised to more accurately measure gamma-radiation. The meter contains a dental x-ray film packet, half of which is covered with a 1-mm cadmium shield to reduce the abnormally high absorption for wave-lengths near the K edge of silver. In order to study the wavelength dependence of the film meter, arrangements were made with the National Bureau of Standards to use their free air chamber and high voltage x-ray machine. Films were exposed to doses of 0.1*r*, 0.5*r*, and 1.0*r* over the range from 10 to 1400 kv. After developing the films under standard conditions, the films were read with an Ansco-Sweet densitometer. Plots were made of the density *versus* the voltage of the x-ray machine. These curves show the following results. The film meters seem to be independent of quantum energy above 350 kv. Between 150 and 300 kv

the shielded film meter reading shows a maximum at about 200 kv, which is roughly 30 percent higher than values in the high energy range. In the unshielded portion of the films the density for a given dosage is a maximum at 90 kv, some 600 percent higher than the density for tube voltages above 400 kv.

57. Focusing Properties of the Electrostatic Analyzer. W. A. BOWERS, *University of North Carolina.*—Numerical integrations of the equations of motion of a relativistic charged particle in a radial electric field inversely proportional to the distance from a fixed axis have been carried out in order to check the validity of the first order focusing theory.[1] This theory predicts perfect focusing of a monoenergetic beam of particles emitted from a line source parallel to the axis, and travelling approximately in a circle about that axis. Results of the numerical integrations show that the focal line is smeared out into a region whose dimensions depend on beam energy, distance of the source from the analyzer, and angular width of beam subtended by the analyzer. In a typical case, with $\beta^2=0.5$, the source distance equal to the radius of the analyzer, and an angle of about 10° subtended by the analyzer at the source, the width of the focal line is about 3 percent of the radius of the analyzer.

[1] F. T. Rogers, Jr. and C. W. Horton, Rev. Sci Inst. **14**, 216 (1943).

58. The Use of Auger Electrons in Coincidence Experiments. S. K. HAYNES AND H. C. THOMAS, *Vanderbilt University.*—Since no energetic charged particle accompanies every disintegration of a nucleus which decays by orbital capture, the study of the decay schemes of such nuclei by coincidence methods is more difficult than the study of those of positve and negative beta-ray emitters. If a very thin source is placed inside a low pressure chamber containing two windowless counters and if both receive particles from the front side of the source, not only x-rays but also Auger electrons can be counted and coincidence experiments can be performed. Experiments on Fe^{55} are underway. The theory has been worked out assuming that only one excited state of Mn^{55} is involved in the decay scheme. Due to large differences in the absorbability of the four different radiations, namely Auger electrons, x-rays, conversion electrons, and gamma-rays, the effects of each can be separated by absorption. Solution of four single counting equations and three coincidence equations yields both the conversion coefficient for the gamma-ray transition and the branching ratio between disintegrations to the ground state and disintegrations which leave Mn^{55} in an excited state.

59. "Band Width" for Energy in the Electrostatic Analyzer. MARY JANE AULD AND F. T. ROGERS, JR., *University of North Carolina.*—Let particles of rest-mass m_0 and charge e traverse the field (average value X) of an electrostatic analyzer of small aperture and small optical power; let ξ be the kinetic energy of particles, in units of m_0c^2. Let $\sigma \ll D$ be the separation of plates, where D is the average length $(r_0\Phi)$ in X of paths which completely traverse the field; and let $\zeta = XeD/m_0c^2$. Then for such particles incident on the analyzer's field normally to x direction, approximate calculations indicate that only those particles which have energies in the band $W \leqq (2\sigma/\zeta D)\xi^2(2+\xi)^2/[1+(1+\xi)^2]$, centered at, will be able to pass through the analyzer; particles with other energies will collide with one of the plates. For particles entering in other directions, the band width is generally less than the equation indicates, because of the relatively great thickness (in the particle-optical sense) of the electrostatic lens.

60. Considerations on the Use of Field-Deflections for Determining the Mass of the Meson.* F. T. ROGERS, JR., *University of North Carolina.*—Since the electrostatic analyzer now seems capable of producing predictable focusing of particles of relativistic speeds,[1] it is worth while to examine the application of an earlier experiment[2] on the beta-particles of RaB, to the low energy particles of the cosmic radiation. Such an experiment would be quite large-scale, and would provide values N and n, respectively, for mv^2/e and mv/e, as

$$N = XR, \quad n = B\rho, \tag{1}$$

from which

$$v = N/n, \quad m/e = n^2/N. \tag{2}$$

The analyzer would largely eliminate uncertainties due to scattering in the entrance-slit window,[3] so that both N and n could be obtained for individual particles to within a fraction of one percent. Recent suggestions* relative to the enhancement of usable intensity of mesons for such an apparatus, make it appear possible to obtain intensities comparable to those in other present-day experiments.

* The basic parts of this paper were discussed on February 4, 1948 before the joint Duke-Carolina colloquium. The author is particularly indebted to Dr. L. W. Nordheim and to Dr. O. K. Rice in this connection.

[1] W. A. Bowers, Phys. Rev. **74**, 128 (1948).
[2] Marguerite M. Rogers, A. W. McReynolds, and F. T. Rogers, Jr., Phys. Rev. **57**, 379 (1940).
[3] F. T. Rogers, Jr., Phys. Rev. **73**, 656 (1948).

61. Composite Particles. NATHAN ROSEN, *University of North Carolina.*—In view of the large number of different particles that have been found in nature, one is led to consider the possibility that only a few of them are elementary particles, the others being built up from these. A reasonable assumption is that particles of spin 0 and 1 are formed by a combination of two particles each of spin $\frac{1}{2}$. In accordance with this idea, a system of two interacting particles of spin $\frac{1}{2}$ is treated relativistically. The starting point is similar to that of Kemmer,[1] except that the rest mass of each particle and the total momentum are taken to have arbitrary values. However, the sixteen-component wave function, instead of being expressed in terms of an irreducible representation, is expressed by means of a set of tensors of various ranks. The interaction between the particles can be treated relativistically by the use of the ideas of "statistical geometry."[2] The tensor equations are set up and some of the properties of the solutions are investigated.

[1] N. Kemmer, Helv. Phys. Acta **10**, 47 (1947).
[2] N. Rosen, Phys. Rev. **72**, 298 (1947).

62. A Densely Crowded Group of Galaxies in Serpens. C. K. SEYFERT, *Vanderbilt University.*—A new, unusually crowded group of six external galaxies has been found at the Vanderbilt Observatory on photographs taken at the Harvard Observatory. This sextet of galaxies is in the constellation Serpens and is contained within a volume of space two minutes of arc in diameter. If we assume for the average galaxy in the sextet a normal intrinsic luminosity of 10^8 times the luminosity of the sun and a mass of 2 times 10^9 solar masses for each of the members, the apparent luminosity leads to a distance of 40 million light years and to an average density of the material in the group 7×10^{-24} g/cc. If the individual galaxies are giants or dwarfs in luminosity and hence in mass, the computed distance will be correspondingly increased or decreased, but the computed density will remain essentially unchanged. A comparison of this group with other similar systems indicates that the density of material in the Serpens sextet is greater than that in any other known cluster or group of galaxies.

63. Effect of Rapidity of Expansion on Cloud-Chamber Operation. ARTHUR WALTNER, *University of North Carolina.*—The effect of the composition of the cloud-chamber liquid on the cloud and ion limits is well known.[1] For a given mixture these limits are, however, a function of the rapidity of the expansion. This effect has been studied by varying the rapidity of the expansion and recording the cloud limit, ion limit, and the optimum expansion ratio. It is observed that the cloud limit varies over a wide range whereas the ion limit remains essentially constant. Results are presented graphically and show the optimum expansion ratios for different expansion velocities. Expansion times are calculated from the forces acting and the mass of the moving system.

[1] N. N. Das Gupta and S. K. Ghosh, Rev Mod. Phys. **18**, 235 (1946).

64. Present Problems in the Use of the Electrostatic Analyzer. MARY JANE AULD, *University of North Carolina.*—Following the original calculations[1] which showed that a non-relativistically monoenergetic bundle of particle-rays could be focused by a radial inverse-first-power electrostatic field, first-order relationships of more generality were established[2] and were extended to relativistic energies.[3] In the meantime the electrostatic analyzer was widely used, for purposes which generally involved increasing particle-speeds and higher precisions. There are, therefore, present problems having to do with the physics of the instrument itself, such as: the effects of stray-fields,[4] and of "non-uniformities" of field resulting from inevitable constructional non-perfections or from methods[5] of minimizing scattering; scattering; second-order aberrations in general;[6] and ultimate limits to operations, resulting from cold-field emission. It is the purpose of this note to invite attention to the need for resolving such problems.

[1] Hughes and Rojansky, Phys. Rev. **34**, 284 (1929).
[2] Herzog, Zeits. f. Physik **97**, 596 (1935).
[3] Rogers and Horton, Rev. Sci. Inst. **14**, 216 (1943).
[4] Cf. the servo-operated automatic field-plotter under construction by the Department of Electrical Engineering of North Carolina State College, Raleigh, North Carolina.
[5] W. A. Backus, Phys. Rev. **68**, 59 (1945).
[6] W. A. Bowers, Phys. Rev. **74**, 128 (1948).