Proceedings of the American Physical Society

MINUTES OF THE BERKELEY MEETING, JUNE 18–23, 1934

THE 192nd regular meeting of the American Physical Society was held in Room 210, Le Conte Hall, University of California, Berkeley, over the period from Tuesday, June 19 to Saturday, June 23, 1934, in affiliation with Section B of the American Association for the Advancement of Science.

The program consisted of a symposium on spectroscopy in astrophysics in conjunction with the Astronomical Society of the Pacific, on Tuesday; a symposium on nuclear structure on Wednesday; and a symposium on fundamental physical constants on Thursday. This was followed on Friday and on Saturday morning by the regular program of ten-minute contributed papers. The program of the symposia and the ten-minute contributed papers are given on the following pages.

The meetings were exceptionally well attended, the maximum attendance being at the symposium on nuclear structure with an audience of close to 350. The meetings were presided over by Vice-President R. W. Wood of the American Physical Society, and some fifteen members from east of the Rockies were in attendance. The Physical Society met informally at luncheon on Tuesday, Wednesday, Thursday and Friday, the attendance of the luncheons varying between forty and sixty-five members. On Wednesday evening there was an informal dinner of the American Physical Society at which Vice-President Wood gave an informal talk which might have been entitled *The Physicist as a Detective.*

A short business meeting was held following the end of the sessions on Saturday, in which it was voted to hold the December meeting on the Pacific coast on Friday and Saturday, December 21 and 22, 1934, at the University of California at Los Angeles.

PROGRAM

Joint meeting with the Astronomical Society of the Pacific

Symposium on Spectroscopy in Astrophysics. Two sessions

1. TUESDAY, JUNE 19TH AT 10 A.M., ROOM 210 LE CONTE HALL

Paper I. Unidentified Interstellar Lines. DR. PAUL W. MERRIL, *Mount Wilson Solar Observatory*

II. Diffraction Gratings and Their Applications to Astronomical Problems. PROFESSOR R. W. WOOD, *Johns Hopkins University, Vice-President of American Physical Society*

2. TUESDAY, JUNE 19TH AT 2 P.M., ROOM 210 LE CONTE HALL

III. Light of the Night Sky. PROFESSOR JOSEPH KAPLAN, *University of California at Los Angeles*

IV. Spectroscopic Evidence of Galactic Absorption. DR. R. J. TRUMPLER, *Lick Observatory, Mount Hamilton, California*

V. Forbidden Lines in Astronomical Sources. PROFESSOR I. S. BOWEN, *California Institute of Technology*

Symposium on Nuclear Structure. Two sessions

1. WEDNESDAY, JUNE 20TH AT 9:30 A.M., ROOM 210 LE CONTE HALL

Paper I. The Production of High Voltage and its Application to Nuclear Research. PROFESSOR R. J. VAN DE GRAAF, *Massachusetts Institute of Technology*

II. Disintegration Experiments Using Protons and Deutons at 1200 Kilovolts. DR. MERLE A. TUVE, *Department of Terrestrial Magnetism, Carnegie Institution*

III. Recent Nuclear Investigations at the University of California. PROFESSOR E. O. LAWRENCE, *University of California*

2. WEDNESDAY, JUNE 20TH AT 2 P.M., ROOM 210 LE CONTE HALL

IV. The Emission of Neutrons and Gamma-Rays from Various Elements. PROFESSOR C. C. LAURITSEN, *California Institute of Technology*

V. Disintegrations with Positron Ejection. PROFESSOR CARL D. ANDERSON, *California Institute of Technology*

VI. The Nature of Cosmic Rays. DR. THOMAS H. JOHNSON, *Barthold Research Foundation*

Discussion of the theoretical aspects was led by Professor Felix Bloch.

Symposium on Fundamental Physical Constants. Two sessions

1. THURSDAY, JUNE 21 AT 10:00 A.M., ROOM 210, LE CONTE HALL

Paper I. The Value of the Electronic Charge. PROFESSOR R. A. MILLIKAN, *California Institute of Technology.*

II. Measurement of the Compton Shift. PROFESSOR P. A. ROSS, *Stanford University.*

III. Continuous X-Ray Spectra and the Value of $h/e^{4/3}$. DR. PAUL KIRKPATRICK, *Stanford University.*

IIIa. A Correction to the Theory of the Compton Shift.

IV. A Measurement of the Compton Shift and the Determination of the Constant h/me. DR. J. W. M. DUMOND, *California Institute of Technology.*

2. THURSDAY, JUNE 21 AT 2:00 P.M., ROOM 210 LE CONTE HALL

V. Spectroscopic Determinations of Atomic Constants. PROFESSOR W. V. HOUSTON, *California Institute of Technology*

Va. The Fine Structure of $H\alpha$ and the Determination of e/em and of the Fine Structure Constant. PROFESSOR C. D. SHANE, *University of California.*

VI. The Present Status of the Values of e, h and e/m. PROFESSOR R. T. BIRGE, *University of California*

ABSTRACTS

1. Ionization by Positive Alkali Ions in Noble Gases Using a Balanced Space-Charge Method. ROBERT N. VARNEY. *University of California.*—In recent years a number of investigations of the ionizing potentials produced by alkali ions moving in the inert gases have revealed the fact that using methods which detect the *electrons* liberated on impact, the ionization sets in at sharply defined potentials in the neighborhood of 100 volts for alkali ions whose electronic configuration is that of the inert gas. In view of the fact that by measuring the electrons liberated, sources of possible error are introduced, it seemed desirable to study these potentials using another method. To this end the balanced space charge method developed by Lawrence and Edlefsen for photoelectric studies was applied to the positive ions. Ions of potassium and sodium of varying velocity were shot into one chamber of the balanced space charge in argon and neon at pressures around 5×10^{-3} mm. The presence of positive ions of zero velocity is evidenced by a change in balance in the bridge and the nature of the arrangement makes the method exceedingly sensitive to the presence of low speed ions. Overlooking the initial disturbances created by the entrance of the very slow positive ions into the space charge chamber, virtually no change was observed above 40 volts up to 84 volts for K^+ ions in argon and 130 volts for Na^+ ions in neon. For K^+ ions in neon and Na^+ ions in argon, no de-

flection was observed below 225 volts. At the critical voltages in neon and argon, the current rose sharply and initially in an almost linear fashion. The values of these potentials are about 12 percent lower than the values obtained for ionization by Beeck. Inasmuch as any errors might lower the value of the potentials recorded some two or three volts, these results are notably different from those obtained by Beeck. In view of the fact that inelastic impacts were being detected in this case, while Beeck observed the liberation of electrons, these results need not be considered irreconcilable.

2. Further Studies on the Motion of Photoelectrons in a Gas. AUSTIN M. CRAVATH. *University of California.*—The problem and method of solution were outlined at the Stanford meeting (Phys. Rev. **45**, 138 (1934)). For fields so weak that the terminal energy does not appreciably exceed 1.5 kT, the thermal equilibrium value, the fraction of saturation of the photoelectric current is $i/i_0=1.88\,El/(1.5\,kT)=$(energy gained in 1.88, mean free path)/(mean thermal energy). Neither the energy of photoelectric emission, $V_e e$, nor the average fraction of the average energy lost per collision, f, enters. For moderate fields, i.e., terminal energy $\gg 1.5\,kT$ but $i/i_0 \ll 1$, $i/i_0=2.75 f^{\frac{1}{2}}((El)/(V_e e))^{\frac{1}{2}}$ approximately. The differential equations have been solved for a few cases of finite anode distance. These solutions show the limits of applicability of the previous solutions for infinite anode distance on the one hand, and of the Hertz solution for no energy loss on the other. Moreover, the extent to which electrons diffuse against the field, and hence the error in considering merely the average motion, are elucidated.

3. Organic Liquids Suitable for Cloud Expansion Work. DONALD H. LOUGHRIDGE AND HAROLD C. TRUEBLOOD. *University of Washington.*—In an attempt to obtain a suitable liquid for use in the presence of gases highly soluble in water, a study of twenty-eight organic liquids has been carried out with reference to their minimum expansion ratio for condensation on alpha-particle tracks. The apparatus in use allowed a maximum expansion ratio of 1.30 and of the total number of liquids studied eleven were found to yield good results (several of these gave much sharper tracks than were obtained in water vapor) with ratios between 1.14 and 1.25. Four more gave a heavy general fog formation with expansion ratios between 1.008 and 1.20, but no ion condensation could be obtained. The remaining thirteen gave no general fog up to the maximum ratio obtainable, and no tracks could be seen. It is possible that in this latter group there are some which will allow ion condensation if a larger expansion ratio be used. All the liquids studied were chosen for their low surface tensions and a correlation with J. J. Thompson's theory was attempted, but the latter seems clearly to be unable to predict the experimental facts. Work is being continued on apparatus which will allow larger ratios.

4. The Energy of Detachment of Electrons from Negative Ions in Oxygen. LEONARD B. LOEB. *University of California.*—The *energy* of attachment of electrons to O_2 molecules to form negative ions has up to the present eluded evaluation. Cravath in 1929 and recently Bradbury (Phys. Rev. **44**, 883 (1933), have measured the probability of this attachment process. In the course of their experiments they observed what they believed to be a *detachment* of electrons from negative oxygen ions at about 0.6 volt energy. Using a high frequency arc of 10^5 cycles between Pt electrodes in O_2 as an ion source, the writer has investigated this process in detail. The mixture of electrons and ions from the arc passes through an electron filter consisting of a grid of fine copper wires 0.2 mm diameter spaced 2 mm apart between alternate wires of which an alternating potential of 3×10^6 cycles is established. This removes electrons and some few ions. The remaining ions then pass between the meshes of a similar grid of wires (3 mm in diameter 3 mm apart (ion smasher)) with an alternating potential of 3×10^6 cycles. By increasing this potential the last of the electrons begin to be removed and the current to the collector decreases to a minimum. Thereafter it *increases* slightly and then rapidly falls to zero. The increase ("hump effect" of Cravath) is explained as due to a sudden attachment of the residual electrons, which in the high field of the ion smasher suffer the inelastic impacts observed by Bradbury to lead to a fivefold increase of the electron attachment at 1.6 volts energy. Thus these electrons escape capture as the ions which they form are not captured. At about 400 volts per cm, peak value, at 2.69 mm pressure in the strong part of the field, the negative ions begin to break up to give electrons which are removed. Assuming that in these high fields the negative ions have free paths of molecular magnitudes, the ionizing energy for negative ions appears, as a preliminary result, to be 1.1 volts.

5. Some Improvements in the Technique of Kerr Cells. H. J. WHITE. *University of California.*—The quickness of cut-off of the electro-optical shutter tends to be destroyed by the presence of impurities in the liquid used in the Kerr cells. This is due to the polarization field set up in the cell by the ions of the impurities and hence the conductivity is a good indicator of a cell's usefulness. Experiments show that the conductivity of the liquid, nitrobenzene in the present experiments, should be at least as low as 10^{-11} mhos per cm^3. For use in the study of spark breakdown nitrobenzene has been purified by fractional distillation and freezing so that its conductivity is as low as 3×10^{-12} mhos per cm^3, which is to be compared with the lowest previously published value of 7×10^{-11} mhos per cm^3. The sealing of the windows onto a Kerr cell presents difficulty because nitrobenzene dissolves most waxes and cements. A search for a satisfactory substance has resulted in the use of ceresin wax which is practically insoluble in nitrobenzene. The corrosion of the plates of the cells is prevented by gold plating them. Cells constructed in this way have proved very satisfactory for studying the early stages of spark breakdown.

6. Changes in the Energy Distribution of Thermionically Emitted Electrons Produced by High Electrical Fields. R. K. DAHLSTROM AND JOS. E. HENDERSON. *University of Washington.*—Changes produced by high electrical fields

in the energy distribution of thermionically emitted electrons have been measured utilizing a method previously used by us for the measurement of the energy distribution of field current electrons. Although the apparatus is cylindrical, the distribution with zero applied field appears to be approximately Maxwellian in form. As the field is applied to the emitter, two major changes occur in the distribution. First, the curve as a whole shifts in the direction to be expected if the field does work on the whole body of emitted electrons. Second, a group of electrons of low energy appears which apparently would not have escaped had it not been for the applied field. The emitter was of tungsten having a composite surface such that the lack of saturation with increasing anode voltage was much pronounced.

7. Thermionic Pentode Controlled Constant-Voltage Rectifiers. ROBLEY D. EVANS. *National Research Fellow, University of California.*—Replacement of batteries by rectifiers for the reliable operation of ionization chambers, electrometers, tube- and point-counters, Pliotron amplifiers, etc., demands an efficient voltage-control unit to remove fluctuations in output caused by variations in the a.c. mains. The ingenious thermionic tetrode control circuits described by Street and Johnson omit consideration of the important fact that the cathode of the voltage controlling tube is usually heated from the same a.c. mains which supply the high voltage to the rectifier unit. It can be shown both theoretically and experimentally that cathode-heater voltage fluctuations materially affect the high voltage d.c. output from such units. A balanced circuit is described which employs a single thermionic pentode to eliminate these variations as well as variations in the high voltage input. The circuit employs one 45 v dry battery in the control grid, where the absence of a current drain permits long life and a constant voltage characteristic. Under average laboratory conditions the observed output voltage fluctuations from the a.c. operated rectifier and pentode voltage control unit are about 1 part in 5000. The type '47 tube has been found better qualified than the '57, '58, '59 or '77 for this control service.

8. The Production of High Velocity Lithium Ions. R. L. THORNTON AND B. B. KINSEY (*Introduced by E. O. Lawrence*). *University of California.*—A source has been developed capable of yielding an intense and stable beam of Li ions. The method used, which was first described by Kingdon, consists in directing a stream of Li atoms from a furnace (400–500°C) on a tungsten filament at a temperature of about 1100°C. By using a filament 1 inch wide by 2 inches long, a positive ion emission from the filament of 4 mA has been obtained. With suitable electrostatic focussing, a beam of over 1 mA of Li ions has been obtained through a tube $\frac{1}{2}$ inch in diameter at a distance of about 12 inches from the filament. The maintenance of an oxygen layer on the filament by means of an adjustable oxygen leak has been found essential for the satisfactory operation of the source. The ions thus produced are accelerated in a linear multiple accelerator of the type devised by Sloan and Lawrence. Using a ten stage accelerator, a current of 1.5 μA has been obtained at 500,000 volts. It is expected that higher voltages, of the order of one million, will be reached in the near future. It is proposed to use this apparatus for the investigation of possible nuclear disintegrations under Li bombardment, for the study of the range-energy relation, etc.

9. An Amplifier and Recording Apparatus for Alpha-Particles, High Speed Protons and Neutrons. M. C. HENDERSON. *University of California.*—Improvements have been made in the Wynn-Williams type of amplifier that make it possible to record the most rapid protons, even though ions are collected from only 4 mm of track. The number of stages of amplification has been reduced to four and only commercial radio tubes are used: a 57 in the first stage and a 77, 39 and 77 in the remaining three. The variable amplification factor of the 39 is utilized to control the overall amplification. The voltage pulse produced in the output by a slow proton is 15 times as large as the R.M S fluctuation in the background noise. By placing the ionization chamber in a magnetic field it has proved possible to count some of the recoil electrons produced by gamma-rays. A "scale of eight" thyratron counter and cathode-ray oscillograph of the high luminosity type are used for recording and observing the particles. The oscillograph makes it possible to follow the performance of the amplifier at all times, and spurious effects are easily detected and allowed for. In addition, any radioactivity involving the emission of alpha-particles, protons, or neutrons with a half-life down to 0.005 sec. could be readily measured.

10. The Loss in Energy in the Disintegration of Nitrogen by Neutrons. FRANZ N. D. KURIE. *National Research Fellow, University of California.*—Thirty-four disintegration forks have been photographed in a Wilson cloud chamber placed close to the Lawrence and Livingston apparatus in which a beryllium target was being bombarded by 3 MV deutons. The cloud chamber contained nitrogen and oxygen saturated with ethyl alcohol vapor. Most of the forks were due to the break-up of nitrogen, but some were certainly due to oxygen. However, they were computed on the assumption that they were all nitrogen disintegrations. If E_n, E_α and E_β are the kinetic energies of the incident neutron, the light fragment ($_2He^4$) and the heavy fragment ($_5B^{11}$), respectively, eight examples show a gain in energy corresponding to $E_\alpha+E_\beta>E_n$. If E_n is plotted against $\Delta(=E_n-E_\alpha-E_\beta)$ a definite relation is exposed. The results of other experimenters support this relation. If we assume $\Delta(E_n)$ is a simple function then $\Delta(0)$ should be a constant and $=B^{11}+He^4-N^{14}-n^1=-1.5$ MV. This point falls on the experimental curve and seems to preclude the possibility of a mass of the neutron differing from Chadwick's by more than 2 MV. Possible explanations of this relation are being sought and will be discussed.

11. The Transmutation of Fluorine by Proton Bombardment and the Mass of Fluorine 19. E. O. LAWRENCE, M. C. HENDERSON AND M. S. LIVINGSTON. *University of California.*—Protons having energies between 0.675 and 1.63 million electron-volts have been used to bombard a target of calcium fluoride and the range and number of

alpha-particles emitted in the resulting transmutation have been measured. The range of the alpha-particles depends on the energy of the proton in the expected manner and lies between 6.0 and 7.5 cm. Particles of shorter range, observed both by us and by other workers, probably resulted from the presence of boron in the target. With the energy of these alpha-particles of longer range, the mass of the fluorine atom is calculated to be 19.0031, a value in agreement with the chemical data and with other transmutation work but not with Aston's value. Professor Oppenheimer has calculated, along the lines of the Gamow theory, the manner in which the probability of transmutation should vary with the energy of the bombarding proton. The measurements agree well with the theoretical prediction.

12. Radioactivity Induced by Neutron Bombardment. M. S. LIVINGSTON, M. C. HENDERSON AND E. O. LAWRENCE. *University of California.*—Using a beam of neutrons from a Be target bombarded by 1 microampere of 2.6 MV deutons we have investigated the type of induced radioactivity recently discovered by Fermi. The magnitude of the initial activity in several elements is surprisingly large: for example a thousand beta-particles per min. were observed from 1 sq. cm of a silver surface. Some of the results are given in Table I. Magnetic deflection experiments established that both groups of disintegration particles in Ag as well as those from Al consist of electrons. Some evidence of two groups in Cu was obtained and the half-life given is possibly a mean value.

TABLE I.

Element	Half-life (sec.)	Approximate range of disintegration particles (cm Al)	Nuclear cross section for activation cm^2 ($\times 10^{26}$)
Ag {two groups}	26±4	0.28	1.9
	154±10	0.1	4.2
Al	570±30	0.1	0.5
Cu	420±60	0.15	0.3
F	10±.5	—	3.5

13. The Emission of Secondary Electrons from Various Metal Targets. LEO H. LINFORD. *University of California.*—Using the Lawrence and Sloan apparatus for the multiple acceleration of ions, the secondary electron emission has been studied for various metal surfaces bombarded by mercury ions with energies up to 1,300,000 volts. The total emissions from nickel, molybdenum, aluminum, copper, tungsten, tin, mercury, silver, gold and carbon fall in the range 8 to 35 electrons per ion depending upon the condition of the metal surface. The secondary emission does not depend markedly on the target metal nor on the energy of the bombarding ions above 300,000 volts. The energies of secondary electrons are in the range 0 to 15 volts. The radiation produced by the impacting ions apparently causes photoelectric currents from the chamber surrounding the target as great as the current of high speed ions.

14. Energy-Loss and the Production of Secondaries by Cosmic-Ray Electrons. CARL D. ANDERSON AND SETH H. NEDDERMEYER. *California Institute of Technology.*—Measurements of the energies of secondary electrons produced in plates of lead and carbon by cosmic-ray electrons (the word electron is used in referring collectively to both positrons and negative electrons, or negatrons) have shown that the distribution in energy of secondary negatrons is, within experimental uncertainty, in agreement with the distribution calculated from the theoretical cross section given by Carlson and Oppenheimer. Three cases have been observed of pair formation by electrons in lead, and no such cases in carbon. Measurements on electrons traversing a lead plate have shown large fluctuations in specific energy-loss and have given in some cases values of the order of 100×10^6 e.v./cm, which is much too high to interpret on the basis of normal energy-loss, *viz.*, the loss by primary ionization and by the production of secondary negatrons by close encounters with extra-nuclear electrons. This effect seems best explained by the production in an encounter with a lead nucleus of one or more photons, which carry off the excess energy. The magnitude of the effect indicates that such radiative processes may account for an appreciable fraction of the energy-loss in lead by fast electrons.

15. Absorption Measurements of Hard Gamma-Rays from Fluorine Bombarded by Protons. EDWIN MCMILLAN. *University of California.*—By using a lead-shielded ionization chamber, the gamma-rays from various targets bombarded by 1.1 million volt protons and 2.2 million volt deutons have been investigated. Absorbers could be interposed between target and chamber; the measured absorption coefficients were found to be about 6 percent low, by calibration with filtered radium gamma-radiation. With proton bombardment boron, beryllium, lithium and fluorine give strong gamma-rays, in increasing order of intensity. Absorption measurements of the fluorine radiation show it to be homogeneous. There is no evidence indicating neutrons. The yield is about 30 quanta per long-range alpha-particle. The absorption coefficients per electron ($\times10^{25}$) are: Pb, 1.75; Sn, 1.3; Cu, 1.07; Al, 0.8. Plotted against atomic number, these indicate a linear rise from the Klein-Nishina value for 5.5 million volts at $Z=0$ to a value 2.5 times this at lead. The extra absorption in lead is 1.05×10^{-25} per electron; that calculated by Oppenheimer on the basis of pair production is 1.10×10^{-25} at 5.5 million volts. The linear dependence on Z is that expected for pair-production absorption. With deuton bombardment fluorine, carbon, boron, lithium and beryllium give very strong ionization. There is evidence that part of this is due to neutrons.

16. Hyperfine Structure in the Arc Spectrum of Lanthanum. O. E. ANDERSON. *University of California.*—The hyperfine-structure analysis previously reported for the arc spectrum of lanthanum has been extended to

include a number of new lines; and the values of overall splittings of the hyperfine energy levels have been modified. The absolute splitting in several levels has now been determined by measurements on etalon patterns in which the off-diagonal components are observed. Of particular interest in the measurements are the overall separations of the hyperfine terms arising from $5d^26s\ ^4F_{3/2,\ 5/2,\ 7/2,\ 9/2}$. Both the hyperfine and fine structures follow the Landé interval rule. It is found that the Goudsmit-Bacher equations, taking into account the interaction of the single s electron with the nucleus, are not sufficient to account for the observed splittings. However, by considering that part of the interaction is due to the $5d$ electrons, better agreement between the observed and calculated values is obtained. The hyperfine structure overall widths for the four members of $^4F_{3/2,\ 5/2,\ 7/2,\ 9/2}$ are -0.20, 0.18, 0.40 and 0.54 cm^{-1}, respectively. A liquid-air cooled Schüler tube and Fabry-Perot etalons were used in the investigation.

17. Anomalous Behavior of Diffraction Gratings Coated by Evaporation. JOHN STRONG. *California Institute of Technology.*—Diffraction gratings coated by evaporation with Mg, Ag or Al generally develop bright and dark bands in their continuous spectra of the order of 50A width. The number of these bands which appear decreases for the above coats in the order named. Au, Cu, Sn, Bi and Sb coats fail to develop such bands. Many bands are double, a dark band lying in juxtaposition to a bright band. All bands disappear for polarized light with the electric vector parallel to the ruling. From R. W. Wood's study (Phil. Mag. **4**, 396 (1902)) of these phenomena as exhibited by a bare speculum grating Rayleigh (Phil. Mag. **14**, 60 (1907)) suggested the following formula to explain the dependence of the wave-lengths of the bands on angle of incidence of the light $\lambda=\epsilon(1\pm\sin i)/C$. Here C represented a passing off order and was integral. The author's measurements made with coated gratings justify this formula if C is not required to be integral. A speculum grating coated with silver and measured at 8 angles of incidence varying from 40° to 75° showed 78 bands. 61 of these were classified in three groups characterized by values of C which varied between the following limits: 5.83 to 5.86, 6.69 to 6.85 and 7.58 to 7.74. An experiment in which i and r were interchanged generally showed that if one had a bright band before the interchange one obtained a dark band after the interchange and *vice versa*—the wave-lengths of the bands being the same in both cases.

18. The Use of Schmidt Cameras in Plane Grating Spectrographs. THEODORE DUNHAM, JR. *Mount Wilson Observatory.*—A correcting plate at the center of curvature of a spherical mirror, as used by Schmidt for telescopes, has been found useful for spectrograph cameras. Such a camera, of 780 mm focus and 110 mm aperture, has been constructed with the plateholder outside the incident beam so as not to obstruct light. 3000A of the first order can be photographed at once in excellent definition. With a collimating mirror the spectrograph will be nearly achromatic and any region may be photographed by merely rotating the grating. The correcting plate curve is approximately a fourth degree paraboloid, $y=x^4/4(n-1)R^3$, combined with a sphere, as used by Schmidt. It should ideally be divided between front and back of the plate in a 3 : 1 ratio. The negative slope at the edge should equal the maximum positive slope. Chromatic difficulties are less than those of obtaining a field in monochromatic light, so that quartz or fluorite is not necessary except in the ultraviolet. A camera of 60 mm focus and 105 mm aperture ($f/0.57$) is under construction. A faster camera could be made if the correcting plate were built up of several rings spaced at different distances from the mirror. The field has a curvature whose radius equals the focus, but may be flattened in some cases by a plano-convex lens near the photographic plate.

19. The Spectra of O_4 and Other Polyatomic Polarization Molecules. WOLFGANG FINKELNBURG. *California Institute of Technology.*—The absorption spectrum of compressed, liquid and the blue solid oxygen shows a number of continuous bands which do not appear in the spectrum of gaseous oxygen at low pressure. These spectra are attributed to an O_4-molecule formed from two O_2 molecules by binding forces of the second order (polarization binding). By using the results for diatomic polarization molecules like Hg_2 the observed spectra can be explained as transitions from the small potential minimum of the ground level (dissociation energy about 0.008 volt) to excited O_4-states with dissociation energies of some hundredths of a volt. The electronic levels correspond closely to O_2 electronic levels, combinations of which with the ground state are forbidden in the undisturbed O_2. It is shown that the ultraviolet O_4-bands are independent of a similar band sequence found by Herzberg in the O_2-spectrum, and that the triplet structure of these bands has to be explained as structure due to the O_2-O_2 vibrations. The existence of similar polyatomic polarization molecules of the types A_2-A_2, A_2-B_2 and A_2-B is theoretically expected. The study of their spectra will bring an experimental proof for the explanation of the O_4-spectra.

20. New Second-Positive Bands in Nitrogen. JOSEPH KAPLAN. *University of California at Los Angeles.*

TABLE I.

Observed	4747	4737	4732	4453	4440	4435	4190
Calculated			(8,14) 4719		(8,13) 4441		(8,12) 4189
4180	4174	3180	3164	3027	3010	2886	2863
		(9,7) 3171	(7,6) 3150	(9,6) 3025	(7,5) 3002	(9,5) 2888	(7,4) 2866

The second-positive group of nitrogen, as normally observed, does not include bands originating on levels higher than $v'=4$. In the nitrogen tube, in which many new features of the nitrogen band spectrum have been observed, the new bands listed in Table I have been found. These bands degrade to the red, and in one of the bands

in which the rotational structure was clearly developed the lines show the characteristic alternating intensities of nitrogen bands. Although the previously observed second-positive bands degrade to the violet, due to the abnormally rapid convergence of the vibrational levels of the $C^3\pi$ state, one would expect bands originating on high vibrational levels to degrade to the red. In Table I the observed wave-lengths of the band-heads are compared with the same values calculated by Vegard. When one considers that it is not possible to predict accurately the positions of these heads the agreement is surprisingly good in some cases. These bands are therefore tentatively identified as "tail-bands" in analogy with similar bands in CN and N_2^+. A more exact and detailed investigation of these bands is proposed.

21. Photographic Photometry of Iron Multiplets in Electric Furnace Spectra. ROBERT B. KING. *National Research Fellow, Mt. Wilson Observatory.*—Spectra of elements excited by the electric vacuum furnace have the property that the atoms are in thermal equilibrium. With the furnace as the source, intensity measurements are being made of lines within multiplets and of the relative intensities of multiplets in the spectrum of iron. Relative intensities of lines within a multiplet are measured at the temperature most suitable for the appearance of the multiplet and the relative intensities of multiplets are measured at several temperatures ranging from 1800°C to 2600°C. Intensities are calibrated by a lamp and step raster at the horizontal focus of the 15 ft. concave grating spectrograph, and plates are standardized by black-body radiation from a carbon plug inserted in the furnace and heated to the same temperature as that used for the iron spectrum. Calibrating exposure times are equal to those for the iron spectrum and three standard time exposures of different intensities are used for standardizing. Percentage reversals are derived from microphotometer tracings of narrow slit spectra and the corrections applied to intensities derived from very wide slit spectra. The behavior of important multiplets of different excitation potentials will be discussed.

22. Intensities in the 3400 Band of Phosphorous Hydride. PHILIP NOLAN AND F. A. JENKINS. *University of California.*—Line intensities in the rotational structure of the $^3\Pi$, $^3\Sigma$ band of PH have been measured by photographic photometry. The source was a discharge in hydrogen flowing at a pressure of 1 to 3 mm through a capillary of 2 mm diameter, phosphorous vapor being introduced into the stream just before the capillary. Plates taken in the second and third orders of the 21-foot grating were calibrated in a 3-meter quartz spectrograph by means of a step-slit. All lines of appreciable intensity in the 0,0 band, comprising 22 of the possible 27 branches, have been measured on 3 different plates. By summing the intensities from each upper level and dividing by the statistical weight, $2J'+1$, the excitation function, R, is found to correspond closely to a Boltzmann distribution at an effective temperature between 650 and 700°K, the temperature increasing for higher pressure or current density. By using this excitation function, the intensity factors, i, in the various branches are evaluated. For small quantum numbers these are found to agree with the qualitative predictions of Mulliken, for $^3\Pi$ (case a)$\rightarrow{}^3\Sigma$. At high quantum numbers, the satellite branches decrease in intensity, showing the tendency of the $^3\Pi$ state toward case b. Theoretical equations for the i factors have not yet been derived for this case.

23. Isotopic Abundance Ratios of C, N, A, Ne and He. ALFRED L. VAUGHAN, JOHN H. WILLIAMS AND JOHN T. TATE. *University of Minnesota.*—From the relative intensities of the peaks of mass-spectrograph curves as a measure of isotopic abundance ratios, numerous curves with CO, N_2, A, Ne and He gave the following abundance ratios with the indicated average deviations.

C^{12}/C^{13}	N^{14}/N^{15}	A^{40}/A^{36}	Ne^{20}/Ne^{21}	Ne^{20}/Ne^{22}	He^4/He^3
91.6 a.d. 2.2	265 a.d. 8	304 a.d. 12	337 a.d. 20	9.25 a.d. 0.08	<35,000

These are compared with the abundance ratios predicted by chemical atomic weight measurements using conversion factors based upon the oxygen isotopic abundance ratios of Mecke and Childs and of Smythe. There is no indication of any preference in the magnitude of the conversion factor that would yield better agreement between the predicted and observed ratios.

24. The Nuclear Mechanical Moment of Cobalt. KENNETH R. MORE. *University of California.*—The nuclear mechanical moment of cobalt ($Z=27$, $M=59$) has been reported by Grace (Phys. Rev. **43**, 762 (1933)) to be probably $(7/2)h/2\pi$. This value was based on a study of partially resolved hyperfine structure of the lines λ3454, $3d^84s\ {}^4F_{9/2}-3d^84p\ {}^4G_{11/2}$, λ3466, $3d^74s^2\ {}^4F_{9/2}-3d^74s4p\ {}^4G_{11/2}$ and λ3909, $3d^74s^2\ {}^4F_{9/2}-3d^74s4p\ {}^6G_{11/2}$. A value of $(5/2)h/2\pi$ was set as the lower limit for the mechanical moment while a value of $(9/2)h/2\pi$ was considered to be possible. The hyperfine structure of several lines in the visible portion of the Co I spectrum has been examined in an attempt to determine the nuclear moment more definitely. The lines λ4191, $3d^74s^2\ {}^4F_{9/2}-3d^74s4p\ {}^6F_{9/2}$, λ4234, $3d^74s^2\ {}^4F_{9/2}-3d^74s4p\ {}^6F_{11/2}$ and λ6450, $3d^74s^2\ {}^2G_{7/2}-3d^74s4p\ {}^2G_{7/2}$ all show a flag type pattern degrading toward the red. The presence of this type of pattern indicates that the upper levels have wider hyperfine splittings than the lower levels. Photometer curves of the hyperfine-structure pattern of λ4234 show definitely that there are more than six components and probably not more than eight components. The ratios of the hyperfine-structure intervals of the lines examined agree with the ratios given by the Landé interval rule for a nuclear moment of $(7/2)h/2\pi$.

25. The Nuclear Mechanical Moment of Columbium. STANLEY S. BALLARD. *University of California.*—In a preliminary report (N. S. Grace and S. S. Ballard, Phys. Rev. **44**, 128 (1933)) a value $I\geq(7/2)\cdot(h/2\pi)$ was reported for

the spin of the columbium nucleus. More detailed work has been done on the hyperfine structure of this element. Attention has been centered on a group of lines lying between λ4050 and λ4220, since these are the only classified lines in the visible region. These lines are transitions from $^6F^0$ and $^6P^0$ terms to a lower ^6D term, the configurations involved being, respectively, $4d^45p$ and $4d^45s$. Interpretation of hyperfine patterns is difficult since the splittings of the upper levels are too large to be neglected even in comparison to the very large splittings (as great as 1 cm^{-1}) due to the penetrating s-electron of the lower state. The relative intensities of the hyperfine components of λλ4117, 4137 and 4168 have been measured on plates carrying intensity calibration produced by a slit of varying aperture. These measurements favor a value $I=9/2$ for columbium, although values of 7/2 and 11/2 are not definitely excluded. Interval measurements are being carried on, and should fix the value of the spin unambiguously.

26. Investigations of the Polarization and the Spectrum of the Sky Light During the Total Solar Eclipses of August 31, 1932, at Gray, Me., and February 14, 1934, at Losap Islands, in the South Seas. WILLI M. COHN. *Berkeley, California.*—The polarization of a point in the sky was observed at a distance of 8 degrees from the sun at mid-totality. These measurements were carried out by means of polarimeters mounted rigidly. Curves were obtained during the eclipse days and two comparison days each. Both eclipses were observed under clear skies. Whereas the polarization of the 8 degree points shows smooth curves during the comparison days, a considerable increase of the polarization was observed during totality. The plane of polarization changed for all days according to the position of the sun. During totality, however, the plane of polarization was rotated by several degrees from the strictly radial polarization observed otherwise. In 1934, the spectrum of the sky light of the same 8° point was investigated by means of a Hilger grating spectrograph, dispersion 49.4A/mm. Spectra were taken on two backed Agfa Superpan plates before, during, and after the eclipse. Comparison spectra were obtained on two other days. A preliminary measurement of the spectra by means of a recording Zeiss microphotometer reveals that the sky spectrum shortly before totality shows a new maximum extending photographically from 6150 to 5910A. A further maximum seems to appear in the region from λ4700 to λ4610. The spectrum during totality is too faint for accurate measurement, but the new maximum around 6000A appears also faintly in the spectrum taken shortly after totality. These phenomena may be explained only partly by the Tyndall-Rayleigh or a similar law. An explanation is presented based on the assumption that the light of the sky contains two components: Scattered light of the sun, and self-luminescence excited by electron impact of gases in the atmosphere, such as shown in recent experiments of the author (Zeits. f. Physik **75**, 544 (1932)).

27. Improved Technique for Determination of Radon and Radium in Liquids. ROBLEY D. EVANS. *National Research Fellow, University of California.*—Important modifications in the author's method for the removal of radon from liquids (Rev. Sci. Inst. **4**, 216 (1933)), by the use of sample flasks and reflux condensers employing dry ground joints to prevent loss of radon by sorption on small rubber, wax or grease surfaces, are described. The technique is applied to measurements of the radon and radium content of water specimens collected by the Scripps Institution of Oceanography from the Pacific Ocean 13 nautical miles off shore from Point Lomas, California. The radium content is about 3×10^{-17} g Ra per cm^3 of water at the surface, increasing to about 3×10^{-16} g Ra per cm^3 at a depth of 1300 meters. At this depth (bottom) there is also present in the water some 22×10^{-16} curie Rn per cm^3 which represents emanation from the bottom mud, whose radium content of 3.2×10^{-12} g Ra per g is about three times the average content of terrestrial rocks. These data are interpreted as indicating the continuous precipitation of radium in the sea, and support the observations of high radium content in deep sea clays as found by Joly, Pettersson and Piggot. The numerical results here given are preliminary, and indicate the practicability of a general survey of the radioactivity of part of the Pacific Ocean which is now being carried on jointly with the Scripps Institution of Oceanography.

28. Growing and Testing Large Single Crystals of Ice. WILLIAM LEWIS. *University of California at Los Angeles. (Introduced by J. M. Adams.)*—Single crystals of ice, of dimensions of the order of 10 cm, have been grown from seed crystals taken from commercial blocks (Barnes, Proc. Roy. Soc. **A125**, 670 (1929)). A method of testing both the seed and the growth has been developed on the basis of the orientation of artificially produced cavities of simple form. Photographic records of these tests have been made.

29. An Ultramicrometer. C. L. UTTERBACK AND HENRY WIRTH. *University of Washington.*—A circuit has been designed which will permit the measurement of changes in pressure of the order of 10^{-3} dyne per square centimeter. The particular feature of the circuit is that a heterodyne frequency is produced between two oscillators which employ tubes of marked Dynatron characteristics. This frequency is amplified and made audible by means of either head phones or a loudspeaker. A beat frequency is produced between the heterodyne frequency and that of an electrically driven fork. The circuit is found to be quite stable with very little change in frequency with change in potential. With a distance of about 0.05 cm between the plates of a condenser, one of which is a liquid surface, a change in the beat note between the fork frequency and the heterodyne frequency of one beat per second is equivalent to a change of $7\cdot10^{-3}$ dyne per square centimeter. Changes in pressure of approximately one-tenth of this amount have been measured.

30. A Variable Frequency Generator for Furnishing Odd Harmonics of 60 Cycle Current of Pure Sinusoidal Form. DAVID L. SOLTAU, DONALD H. LOUGHRIDGE AND LINDSAY M. APPLEGATE. *University of Washington.*—This paper describes the control circuit for synchronizing and filtering

the output of a commercial type motor-generator set by which alternating currents of 180, 300, 420 and 540 cycles are produced and maintained. The synchronizing current is a wave of the proper frequency selected by a resonating circuit from among the harmonics produced in a bank of delta-connected transformers, operating at about 175 percent overload. This wave form is applied to the generator side of the motor-generator set in such a manner as to synchronize the speed of rotation of the generator, thus causing a constant frequency output of the desired number of cycles, which is filtered to produce a practically pure sinusoidal wave form.

31. Crystal Structure of Nickelous Acetate Tetrahydrate. ROBERT B. HULL. (*Introduced by Arthur E. Ruark.*) *University of Pittsburgh.*—Rammelsberg reported the axial ratios $a:b:c=0.7216:1:0.4143$ and the axial angle $\beta=93°\ 25'$ for monoclinic prisms of $Ni(CH_3COO)_2\cdot 4H_2O$. These values have been verified goniometrically. The habit of our crystals was essentially the same as that reported by Rammelsberg. Angle β was verified by Laue photographs. The density is $1.714\pm.001$ g/cm³ at 20°C, and from rotation photographs obtained with a camera of 8.58 cm radius the lattice spacings are $a_0=8.49\pm0.03$A, $b_0=11.77\pm0.05$A and $c_0=4.87\pm0.03$A. The unit cell contains two molecules. The possible space groups are C_s^2, C_2^2, C_{2h}^2, C_{2h}^4 and C_{2h}^5. The external symmetry of the crystals strongly indicates that they belong to the monoclinic prismatic class. If this evidence is trusted, the possible space groups are C_{2h}^2, C_{2h}^4 and C_{2h}^5. The absence of 100 and 010 reflections in odd orders and the presence of 001 reflections in all orders indicates that the nickel atoms probably occupy positions 0, 0, 0 and $a_0/2$, $b_0/2$, 0.

32. On the Development of the Intermolecular and Intramolecular Chains in Oxidation of *n*-Hexan. W. M. ZAIKOWSKY. *California Institute of Technology.*—The data obtained by the gas analysis of the oxidized air-*n*-hexan mixture are discussed in an attempt to establish the relation between the character of the persistence of the oxidation of the same hexan molecule (intramolecular chain) following the interaction with the first molecule of O_2 (or other intermolecular chain carrier) and the fundamental restrictions imposed on the energy transfers by the principle of the conservation of momentum and the loss of energy by the spontaneous radiation. The conclusion is reached that the development of the intramolecular chain is controlled rather by the related physical factors than by the oxidation temperatures of the intermediate chemical compounds.

33. Electronic Functions for a Metallic Crystal. W. V. HOUSTON AND C. B. CRAWLEY. *California Institute of Technology.*—Variation methods have been fruitful in obtaining good approximations for the characteristic functions of atoms with many electrons. A similar method can be applied to crystals. It can be shown that the functions first introduced by Bloch are good approximations to the exact solution, even when the electronic interaction is included, if the proper atomic functions are used in them. These atomic functions can be determined by the variation method. This method has been applied to lithium. The atomic functions were taken as simple $2s$ functions of Slater's type with a single parameter. They were made orthogonal to the $1s$ function by the inclusion of a suitable amount of the $1s$. The best value of the parameter was determined to get the lowest value of the energy. The results show fair agreement with the lattice constant, the lattice energy, and the compressibility.

34. A General Interpretation of Cosmic-Ray Effects. ROBERT A. MILLIKAN. *California Institute of Technology.*—Cosmic-ray researches have apparently established:—(1) That practically all cosmic-ray ionization is due to the passage of electrons (+ and −) rather than protons, alpha-rays or heavier nuclei, through the atmosphere. (2) That more than 70 percent of this ionization, probably 80 or 90 percent, is due to secondary electron-rays produced within the atmosphere by incoming photons and electrons (+ and −). (3) That there is no evidence that anywhere on the earth more than 2 or 3 percent of the ionization found at sea level is due directly to incoming electrons; their number is therefore very small. They are responsible, however, for the latitude effect, the longitude effect and the east-west effect. (4) That photons in general interact only with electrons (+ or −) whether in the nucleus or out of it. A photon colliding with a nucleus detaches one or many free electrons (+ and −) from it but not protons. (5) That the earth's magnetic field separates the low energy incoming secondary electrons formed outside our atmosphere from the high energy, letting the former in near the poles but only the latter near the equator. These latter are predominantly positive since they necessarily come from the nuclei of atoms and these have an excess of *positive* electrons. (6) That the greater part of the ionization of our atmosphere is due to photons of energy of the order of 200 (±70) million electron-volts.

35. Electrons and Positrons. C. H. DIX. *Rice Institute.*—It is shown that there is an essential ambiguity in the Dirac "hole" theory. Either (1) one may have a large finite number of energy levels so that *almost all* the negative levels may be filled and one must regard Dirac's equations as approximate since they give an infinitude of energy levels; *or* (2) one may regard the Dirac equations as exact and reinterpret the negative energy levels. We adopt the second alternative. Instead of a point electron at (x_1, x_2, x_3) we consider a composite electron formed of two point particles "located" at $(x_1+iy_1, x_2+iy_2, x_3+iy_3)$, $(x_1-iy_1, x_2-iy_2, x_3-iy_3)$. All electrons are assumed to be formed of two parts in this manner. The interaction energy of two electrons at relative rest is formed of the four Coulomb energies of the interactions of the four parts. This energy is $V_{1,2}=e^2/4[1/r+1/\bar{r}+1/r_1+1/\bar{r}_1]$ where r, $\bar{r}$ are conjugate. $V_{1,2}$ has an infinite value when the real and imaginary parts of r or r_1 are both zero. Such points of infinite energy lie on mutually perpendicular rings—two singular rings for each electron. $V_{1,2}$ is a double valued function in the sense that if the real coordinates of a "test electron" are carried over a closed path enlacing both singular rings of the electron producing the field, $V_{1,2}$ changes its algebraic sign at the end of

its path. This is interpreted as the production of a positron. If a closed path of the "test charge" enlaces only one singular ring the terminal mutual energy is very nearly zero. This latter process is interpreted as the formation of "neutrinos." The model of the electron proposed has the following properties: (1) it behaves as a classical electron should in classical fields; (2) it may be used as a basis for the derivation of the Dirac equations; (3) it furnishes a simple, direct picture of the processes involved in the formation of positrons, neutrinos, and the Gray and Tarrant radiation. The author wishes especially to point out the experiments of Skobeltzyn in which a high energy β-particle produced a positron-electron pair.

36. The Passage of Charged Particles through the Magnetic Field and the Atmosphere of the Earth. R. M. LANGER. *California Institute of Technology.*—Convenient and reasonable approximations make it possible to handle analytically the problem of the effect of the earth's magnetic field on charged particles which ionize uniformly along their path. The important parameter is the range in air of a particle of given energy, charge and mass. Given the ionization-altitude curve at some sufficiently northerly latitude an expression can be found in terms of this parameter for the ionization at any altitude in any latitude. If the primary radiation consists of a mixture of two or more types of particles the results are much less useful except in altitude ranges in which one type predominates strongly. The recent experimental results of Millikan and Neher or of Compton and Stephenson in the upper atmosphere are hard to interpret with plausible values of the fundamental energy-range parameter for electrons or protons. Moreover, it does not seem possible to interpret the results as due to a mixture of protons and electrons of various energies. The inclusion of heavier ions or of photons may resolve the difficulty, but the uncertainty of the constants to be associated with these forms of radiation makes it impossible to deal with them satisfactorily in the manner of the present theory.

37. The Production of High Voltage X-Rays for Medical Uses. M. STANLEY LIVINGSTON AND MILTON A. CHAFFEE. *University of California.*—Under the stimulus of Dr. Stone of the Medical School and Professor Lawrence of the Physics Department, and through the interest of Mr. W. H. Crocker of San Francisco a high voltage x-ray machine of the Sloan type has been installed and is now in use for medical treatments. A resonance transformer in the form of a water-cooled coil is mounted in a steel vacuum tank. The x-ray filament is placed opposite a tungsten target on the end of the coil. Radiofrequency power is applied through demountable power-oscillator tubes in a "push-pull" circuit. Lead shielding around the tank and on the walls of the room insures protection for the patients and operators. Four x-ray portals are adjustable for any desired treatment apertures. Lead absorption curves compared with those of Coolidge show peak voltages of 800,000 volts. With about 10 milliamperes emission, intensities as measured in an air ionization chamber of 50, 30 and 20 roentgens per minute are obtainable with lead filtration of 1, 2 and 3 mm, respectively, at 70 cm from the target.

38. Disintegration with the Emission of Protons Induced by Neutrons. FRANZ N. D. KURIE. *National Research Fellow, University of California.*—A type of disintegration caused by neutrons, in which a proton (or some other particle of charge about unity) is emitted instead of the usual alpha-particle, has been photographed several times in the Wilson chamber. The neutrons were generated by bombarding beryllium with 3 MV deutons in the large cyclotron. Sufficient intensity was obtained that 3–5 nuclear recoil tracks of lengths greater than several mm together with roughly a dozen with lengths around 1–2 mm were photographed on each expansion. A disintegration of the type discovered by Feather was observed on about every tenth exposure. The new type of disintegration is characterized by a short heavy spur joined to a thin proton track. In all cases the proton has a range greater than the confines of the chamber. Unfortunately measurements on the usual type of disintegration forks indicate that the neutrons are so badly scattered before they reach the chamber that no quantitative information can be got at present concerning these forks. The chamber contained oxygen predominantly but there was some nitrogen present so that we may imagine either of two reactions occurring: ${}_7N^{14}+{}_0n^1={}_6C^{14}+{}_1H^1$ or ${}_8O^{16}+{}_0n^1={}_7N^{16}+{}_1H^1$. A reaction of this type has been postulated by Fermi to explain the chemical processes necessary to entrain the β-ray activity induced in many elements by neutrons.

39. A Study of the Initial Stages of Spark Breakdown in Gases. H. J. WHITE. *University of California.*—The electro-optical shutter is used to study spark breakdown in nitrogen, hydrogen, oxygen, helium, argon and carbon dioxide at atmospheric pressure and for gap lengths up to 1 cm. Photographs of single sparks in early stages have been obtained for several of these gases, some of the exposures being as short as 5×10^{-9} sec. Four distinct types of breakdown, as characterized by the appearance and growth of the luminous streamers, are recognizable in these gases. The velocities of the cathode streamers in hydrogen and nitrogen have been measured and are found to be about 10^7 cm per sec., which is the order of magnitude of the calculated velocities of electrons in these gases under breakdown conditions. The experiments indicate that the major portion of the current passing during breakdown is carried by electrons, and that these, for the most part, come from the cathode rather than from ionization in the gas. The shortness of the spark lag and breakdown times of sparks show that the phenomenon is essentially due to the motion of electrons, and that the space charges which cause breakdown result from the large difference in the mobility velocities of electrons and positive ions.

40. Continuous Electron Radiation in Flames and Arcs. WOLFGANG FINKELNBURG. *California Institute of Technology.*—In some recent publications we have shown that continuous spectra observed in condensed discharges at

high electron density are due to continuous electron radiation, i.e., radiation of electrons in the field of ions formed in the discharge. In the same way we expect continuous electron radiation in gases, ionized due to high temperature, i.e., in flames and arcs. The few observations published on that subject seem to confirm our expectation. The faint continuous background in the spectrum of the Bunsen flame becomes considerably stronger by introduction of the easily ionizable alkali atoms, the intensity increasing with decreasing ionization potential of the alkali. The same applies for the hydrogen-oxygen flame, all continuous spectra being stronger due to the higher temperature. Though there are in some flames also continuous spectra due to reactions, there exists always a continuous background, the intensity of which increases with increasing temperature and pressure and with decreasing ionization potential of the gas. These properties of the continuous spectrum as well as its independence of lines and bands are exactly what we expect for electron radiation. The same applies for the continuous background in arcs, which in the confined arc at high electron density becomes a strong continuous spectrum.

41. New Members of the Lyman-Birge-Hopfield System. JOSEPH KAPLAN AND LEO D. LEVANAS. *University of California at Los Angeles.*—New members of the Lyman-Birge-Hopfield system of N_2 have been photographed and identified as the bands (5,15), (6,16), (7,17), (8,18), (9,19), (10,20), (11,21), (8,17), (9,18), (10,19), (11,20), (9,20), (10,21) and (11,22). The wave-length measurements, while exact enough to identify these bands, are to be redetermined at higher dispersion, and hence they are not listed here. The band (11,22) is at 2425A, and between this and 2800 there are more bands that are probably members of this system. It was impossible with a Hilger E31 to resolve them sufficiently for identification. Their photography on a higher dispersion should yield data for vibrational levels above $v''=22$. Even with the low dispersion used in this work it was possible to notice a sudden drop in intensity and an increase in diffuseness for the bands originating above $v'=8$ in the $v'-v''=9$ sequence. This suggests predissociation, and since the energy of $v'=8$ is 10.06 volts, it must correspond to dissociation into ^4S and ^2D. This yields a maximum value of 7.7 volts for $D(N_2)$, a value lower than the 7.9 volt value of Lozier and in good agreement with the 7.4 volt value suggested by the recent discovery of the system $A^3\Sigma \rightarrow X'\Sigma$.

42. Interpolation Equation for Photo-Densitometer Charts of X-Ray Diffraction Patterns. WALTER SOLLER. *University of Arizona.*—This paper shows that a simple interpolation equation can be applied to charts produced from diffraction patterns by a photo-densitometer in which a photoelectric cell and a galvanometer are used, and the intensities obtained are of an accuracy comparable with those obtained by ionization chamber methods. The equation was first derived theoretically. Then a graphical method was developed by which the equation could be rapidly applied to the chart. A number of diffraction patterns of NaCl was taken. From these, photo-densitometer charts were made, and the intensities of the first fourteen lines determined by the graphical application of the interpolation equation. These intensities were compared with the calculated intensities from Bearden's theoretical equation.

It was found that these intensities agreed as well with the theoretical values as those determined by ionization chamber methods. These results indicated that this method of obtaining intensities increased the accuracy of ordinary diffraction pattern data, so that they now could be used for structure factor and atomic arrangement determinations, thereby allowing the advantages of applicability to all substances, correct intensities, and simple technique inherent in the powder method to be realized.

43. The Establishment of a Precision High Frequency Standard Capable of Delivering Considerable Power. FRANK G. DUNNINGTON. *California Institute of Technology.*—In the precision determination of e/m being made by a new deflection method (Phys. Rev. **43**, 404 (1933)) a source of high frequency in the region of 3 to 6×10^7 cycles (5 to 10 meters) is necessary. The requirements include: power up to at least 500 watts, peak voltage known to about $\frac{1}{2}$ percent, good frequency stability and frequency known to at least 1 part in 10^5. The means of accomplishing these objectives will be outlined including the obtaining of the government standard of frequency through the use of a broadcast carrier wave as a connecting link between the government standard and the laboratory. Tests indicate that over periods as long as an hour the frequency drift averages about 1 part in 10^7 per minute.

44. The Existence of a Sharp Temperature Threshold for Catalytic Decomposition of Molecules on a Hot Platinum Surface, and the Nature of This Decomposition. OTTO BEECK. *Shell Development Company.*—By using true molecular beams of various hydrocarbons such as ethane, ethylene, etc., projected onto a platinum strip filament 4 mm² area of known and controllable temperature, the decompositions were studied instantaneously by pressure variations in a chamber large compared to the filament as indicated by a Pirani gauge. In the case of ethane, C_2H_6, decomposition set in at about 800°, gradually rose in amount as strip temperature increased yielding dehydrogenation of *all* impinging molecules at 1200°C, in the form of ethylene, C_2H_4 and H_2. This *appears* to represent a reaction proceeding according to Arrhenius' equation with a heat of activation. Ethylene, C_2H_4, shows *no* decomposition below about 830°C but within 20° (i.e., at 850°) *every molecule impinging on the surface is dehydrogenated* yielding C_2H_2 and H_2. In this case both H_2 and C_2H_2 fly off the surface after dissociation with no lingering. Below 1200° the H_2 gas produced by decomposition would be sufficient to produce an equilibrium layer partially covering the surface. In C_2H_4 about one percent of the C_2H_4 molecules incident go to remove this layer giving C_2H_6 and leaving a clean Pt surface to dehydrogenate the C_2H_4. In the case of C_2H_6 the H_2 is not removed and the partial H_2 covering reduces the efficiency of the surface. As the temperature increases up to 1200° the covering is progres-

sively removed from the surface and dissociation of impacting molecules is more complete. Control experiments with outgassing and using O_2 confirm these interpretations.

45. Terminal Energy Distribution of Electrons Driven through a Gas by an Electric Field. A. M. CRAVATH. *University of California.*—Didlaukis (Zeits. f. Physik **82**, 709 (1933)) found that the energy distribution was less than 1/20 as wide as Maxwell's unless the free path increased rapidly with speed. Didlaukis' term $D+E$ should have contained the *mean square* of the component of velocity in the direction of the field instead of the *square of the mean* component. With this correction a number of distributions have been calculated. Let $W\,dE$=fraction of electrons having energy E in dE, and fE=energy lost in a collision. If $f=0$ when $E<E_r$, and $f=1$ when $E>E_r$, $W=2.25E_r^{-3/2}E^{1/2}\ln(E_r/E)$ and $\overline{E}$, the average energy, is $(9/25)E_r$. If $|f|\ll 1$ for all collisions (not merely for the average) and $\overline{E}\gg$average energy of molecules, $W=a\,E^{1/2}\exp(-3X^{-2}e^{-2}\int q^2(1-P)fE\,dE)$, a=a constant, X=field, q=collisions per cm, P=average cosine of angle of scattering, all for electrons of energy E. If $q^2(1-P)f=q_0^2f_0E^h$, $q_0^3f_0$ being constant, $W=aE^{1/2}\exp(-3q_0^3f_0E^{2h+2}(2h+2)^{-1}X^{-2}e^{-2})$. Unless $h>-1$ there is no terminal state. If mean free path is proportional to velocity, and P and f are constant, $h=-\frac{1}{2}$ and the distribution is Maxwellian. If mean free path, P, and f are all constant, $h=0$ and $W=1.038\overline{E}^{-3/2}E^{1/2}\exp(-0.547(E/\overline{E})^2)$, $\overline{E}=0.604Xeq^{-1}(1-P)^{-1/2}f^{-1/2}$. For elastic spheres $P=0$, $f=2m/M$, and the above becomes Druyvesteyn's distribution (Physica **10**, 61 (1930)).

AUTHOR INDEX TO ABSTRACTS OF THE BERKELEY MEETING