PROCEEDINGS OF THE AMERICAN PHYSICAL SOCIETY

MINUTES OF THE BERKELEY MEETING, JUNE 21 AND 22, 1929.

The 158th regular meeting of the American Physical Society was held in Berkeley, California, in conjunction with the meetings of Section B of the Pacific Division of the American Association for the Advancement of Science, Friday and Saturday, June 21st and 22nd, 1929. The Friday morning session was held in Room 1, Students' Observatory of the University of California, and the afternoon session on Friday, and the Saturday session were held in Room 210, Le Conte Hall. The Friday morning session which consisted of a joint session with the Astronomical Society of the Pacific in which there were five papers by invitation, was presided over by Dr. Walter G. Adams, President of the Pacic Division of the American Association for the Advancement of Science. The Friday afternoon and Saturday morning sessions were presided over by Professor E. E. Hall, Chairman of the Physics Department of the University of California. The papers presented in the joint session with the Astronomical Society of the Pacific are as follows:

1. **The theoretical intensities of emission and absorption lines**—D. H. MENZEL, *Lick Observatory.*
2. **Probable values of the general physical constants**—R. T. BIRGE, *University of California.*
3. **A photographic study of the solar spectrum in the region 10,000-11,000A.**—H. D. BABCOCK, *Mount Wilson Solar Observatory.*
4. **The chemical composition of gaseous nebulae.**—I. S. BOWEN, *California Institute of Technology.*
5. **Elements not yet identified or questionable in the atmosphere of the sun.**—C. E. ST. JOHN, *Mount Wilson Solar Observatory.*

Following this session there was a joint luncheon for members of the Astronomical Society of the Pacific and the American Physical Society at the Women's Faculty Club, with forty members attending. Preceding the regular presentation of papers on Friday afternoon, a short business meeting was held in which the following matters were discussed:

Owing to difficulties in the reception of abstracts by the Secretary on Saturday afternoon, it was moved, seconded, and voted, that the time for the reception of the abstracts by the Pacific Coast Secretary of the Physical Society be changed to Friday, a month preceding the date of meeting, instead of Saturday a month preceding the meeting as heretofore.

It was moved, seconded, and voted, that the meeting of the Physical Society held in December on the Pacific Coast would not permit the Physical Society participating in the general session of the Pacific Division of the

American Association for the Advancement of Science in the event of a meeting held in the fall, winter or early spring. The summer meeting will as usual be held in affiliation with Section B of the Pacific Division of the American Association as heretofore. It was moved, seconded, and voted, to recommend to the executive committee of the Physical Society that the date of the 160th meeting of the American Physical Society which is to be held at Stanford University, be on Saturday, December 7, 1929, with the possible view to the necessity of extending the meeting from Friday, December 6, at 2:00 P.M., through Saturday, December 7, 1929, owing to the length of the progarm during the last meeting on the Pacific Coast. The regular program of the American Physical Society consisted of forty-two papers. Papers numbers 7, 14, 19, 22, 23, 24, 33, 34, and 36 being read by title.

The abstracts of the papers are given in the following pages. An **Author Index** will be found at the end.

L. B. LOEB,
Secretary for the Pacific Coast.

ABSTRACTS

1. A new titanium band system. ANDREW CHRISTY, *University of California.*—Using chiefly previously published data, the writer has found a new system of titanium monoxide containing 18 bands, whose lower level is the same as that of the known blue-green bands. This new system has apparently been found, independently, by F. Lowater. Both systems appear in absorption in stellar spectra, proving that the two are resonance systems. Five unassigned bands found by Shane in o Ceti are shown to belong to the new system. The frequency of the heads is given by

$$\nu = \left.\begin{matrix}14172.2\\14105.8\\14030.8\end{matrix}\right\} + (862.5n' - 3.84n'^2) - (1003.8n'' - 4.61n''^2)$$

with an average residual of one cm^{-1}. The mean separation of the heads is 70.7 cm^{-1}, a value obtained indirectly for the lower level of the blue-green system. The upper level of the new system is in all probability a ^3S. The bands of TiO persist in stellar spectra up to temperatures of about 3500°T. Applying the Sackur-Tetrode equation, and assuming—first, the heat of dissociation for the lower level is 6.74 volts; second, if the ratio of Ti to TiO is as 100 to 1, the bands will not be observable,—we find that in stellar atmospheres the partial pressure of oxygen is 10^{-5} atmosphere.

2. The vibration spectrum of the ammonia molecule. JOSEPH W. ELLIS, *University of California at Los Angeles.*—The infra-red absorption spectrum below 2.5μ of NH_3 in CCl_4 and aqueous solutions and the visible spectrum of the latter solution have been obtained. Bands, decreasing in intensity with increasing frequency, at 1.51, 1.035, 0.795, 0.652 and 0.556μ fit the formula $\nu_n = 97 + 3400n - 70n^2$, the variable portion of which is the equation of an anharmonic vibrator. Extrapolation of this series indicates the 2.916μ band of Robertson and Fox (Proc. Roy. Soc. **120,** 168 (1928)) as a fundamental. Evaluation of the dissociation energy of the oscillator yields 5.1 equivalent volts in sufficient agreement with the energy of a single N-H bond to identify the oscillator as an N-H pair of atoms. Other bands observed in CCl_4 solution were: 2.35, 2.29, 2.01, 1.655, 1.29 and 1.21μ; and in aqueous solution: 1.62, 1.29, 1.21 and 0.733μ. Comparison of these bands with those observed in gaseous NH_3 by Robertson and Fox indicates only slight wave-length shifts, if any, on account of solution. The whole vibration spectrum of the ammonia molecule can be correlated on the basis of three fundamental bands: 10.55, 6.132 and 2.916μ. The 3μ absorption region is really double, including the last named fundamental and the first overtone of the 6.132 band.

3. Intensities in super-multiplets of titanium. GEORGE R. HARRISON, *Stanford University.*—Quantitative measurements have been made on the quintet pentadtriad super-multiplet of Ti I, which contains 10 multiplets arising from the transition $[(3d)^24s]\,4d-4p$. The 35 sets of spectrograms reduced show very good agreement, although most of the lines are very weak. A large majority of the lines are of anomalous intensity, and the sum rule does not hold within the individual multiplets, and only slightly better for the super-multiplet as a whole. Four relatively strong ^5FH lines appear to have obtained their energy, in part, by robbing ^5GH lines having the same upper states. When all known inter-system combinations are added in, and when the J values corresponding to given L values are added together, Kronig's formulas and the sum rule are approximately obeyed. This super-multiplet appears to furnish the most anomalous set of intensities yet observed; its intervals are also anomalous, and the lines are nebulous in sources at moderate pressures. No self-reversal affected the results, as was shown by simultaneously photographing the triad super-multiplet $^5F'-{}^5G'FD'$ $[(3d)^24s]\,5s-4p$, which has the same lower states as the other. These multiplets are practically normal, and their intensities came out within 5 percent of the theoretical 9:7:5, no excitation correction being necessary.

4. Characteristics of the electric furnace spectra of europium, gadolinium, terbium, dysprosium and holmium, λ3900–λ4700. ARTHUR S. KING, *Mount Wilson Observatory.*—Two objects in a preliminary study of these spectra were the separation of the lines arising respectively from the neutral and ionized atoms, and the temperature classification of both groups. The first was carried out by the usual comparison of arc and spark spectra, but the selection was confirmed and many critical cases decided by the method of mixture in the tube-furnace with a substance of low ionization potential such as caesium, which by contributing a large supply of free electrons promotes recombination and quenches the ionized lines. The temperature classification was based on spectra for three furnace temperatures between 2000° and 2800°C and a comparison with the arc spectrum. Groups of very strong low-temperature lines were noted, especially for europium, dysprosium and holmium, and as in previous studies of rare earths the furnace was found to emit strongly many lines which are faint in the arc and hitherto unidentified. Hyperfine structure, previously noted for lanthanum and praseodymium, was found for many lines, usually ionized, in the spectra of europium, terbium and holmium. In graduated spacing of components these often resemble the lines of ionized praseodymium.

5. Low energy states in C_{II} and N_{II}. I. S. BOWEN, *California Institute of Technology.*—Several of the strong lines of C_{II} have been identified as combinations of the ^4P term of the sp^2 configuration with the quartet terms observed by Fowler and Selwyn (Proc. Roy. Soc. **120,** 212). This fixes the term values $^4P_1=206810.7$, $^4P_2=206789.2$, $^4P_3=206760.6$. In N_{II}, the term value of the ^1S term of the s^2p^2 configuration, has been fixed at 206159, and of the ^1P term of the sp^3 configuration at 72084. relative to the term values given by Fowler and Freeman (Proc. Roy. Soc. **114,** 662). The ^1S term combines with the ^1D term of the same configuration to give the nebular line at 5754.8A. A large number of terms including those which Fowler and Freeman designated by "a" have been shown to belong to the quintet system. These have the following relative term values: sp^2s, $^5P_1=90000$, $^5P_2=89943.8$, $^5P_3=89873.1$; $sp^2\cdot p$, $^5S=65759.0$, $^5P_1=69994.6$, $^5P_2=69970.7$, $^5P_3=69926.9$, $^5D_0=71955.0$, $^5D_1=71939.8$, $^5D_2=71909.6$, $^5D_3=71866.5$, $^5D_4=71812.6$; $sp^2\cdot d$, $^5D_1=50658.5$, $^5D_2=50650.6$, $^5D_3=50639.3$ $^5D_4=50624.9$, $^5F_2=52611.4$, $^5F_3=52585.3$, $^5F_4=52551.6$, $^5F_5=52511.1$; sp^3, $^5S=248812(?)$.

6. Relative abundance of the isotopes of oxygen. HAROLD D. BABCOCK, *Mount Wilson Observatory.*—Improved agreement is found between observed positions of lines of the A' band and those calculated for the isotopic molecule $O^{16}-O^{18}$, the average residual being -0.02 cm^{-1}. The existence of O^{18} is further confirmed by the occurrence in A' of 34 lines corresponding to odd numbered rotational levels not recognized in the original description of the band, and also by another new faint band, B', likewise showing both sets of levels and displaced 30 to 40 cm^{-1} from the B band. A third exceedingly weak band, A'', is described, which Giauque and Johnston have attributed to another molecule, $O^{16}-O^{17}$. Their conclusion is confirmed and from the intensities of the lines it is estimated that O^{16} is roughly 10000 times as abundant as

O^{17}. On photographing the A and A' bands with air paths of a few meters and of several kilometers respectively they were made to appear of equal intensity. The actual ratio of intensities thus found is 1250:1. This would make the relative abundance of atoms O^{16} and O^{18} 2500:1, but since the A' band has twice as many rotational states as the A band the ratio remains 1250:1.

7. The Raman effect in water. E. L. KINSEY, *University of California at Los Angeles.*—The light of a glass mercury arc scattered by distilled water at room temperature was photographed on astronomical green sensitive plates. Exposures of 24–36 hrs. yielded three scattered bands which are to be designated as the "4150 band," the "4680 band" and the "5157 band." The 4150 band is a doublet excited by the 3650 mercury line and the 4680 band, a triplet excited by the mercury pair 4046 and 4077. These bands can be accounted for by two infra-red wave-lengths 2.92μ and 3.13μ whose existence Ellis has also postulated in order properly to correlate the infra-red spectrum.

	Scattered wave-length	Exciting line	Infra-red scattering frequency
"4150"	4126 (24237)	3650 (27398)	3.16μ (3161)
	4158 (24050)	3650 (27398)	2.98μ (3348)
"4680"	4647 (21520) strong	4046.6 (24712)	3.13μ (3192)
		4046.6 (24712)	2.92μ (3417)
	4696 (21295) very strong	4077.8 (24538)	3.09μ (3233)
	4737 (21100)–weak	4077.8 (24528)	2.92μ (3417)

The centers of the 4680 band can be determined within 5A introducing an error of about 25 cm^{-1} and about 0.04μ in the infra-red scattering wave-length. In addition 4647 would also coincide with a band from the mercury line 4358 scattered by 6.31μ of which 3.13μ is the first harmonic. The fact that 6.31μ does not produce Raman scattering or if so, so feebly as to escape detection, is indicated by the absence of the 4180 triplet when the exciting light contained only the 4358 mercury line, 4046 and 4077 being removed by a suitable filter.

8. Relative intensities of lines in a generalized multiplet of Ti II. HARRY ENGWICHT, *Stanford University*—The multiplet $a^4P'-a^4D'[(3d)^2]3d-4p$ of Ti II has been shown by Harrison to have extremely anomalous intensities. Measurements have been made on this and the related multiplet $a^2P'-a^2D'$, together with their inter-system combination lines, many of which are strong. The quartet, doublet and their inter-system lines form a generalized multiplet (Ornstein and Burger's "Erweiterte Multiplett"). A titanium vacuum arc was used as a source, the necessary self-reversal correction being small. Measurements were made using the second order of a ten meter concave grating, more than fifty exposures being used. When an excitation correction corresponding to 3500°A is applied the total intensities of quartet to doublet are found to have the theoretical ratio 2:1. The sum rule is more closely approached when the inter-comb nation lines are included in the sums than when they are omitted, but the lack of agreement is still many times the experimental error. The results indicate that this group of lines must be considered in conjunction with the remainder of a still more general group; perhaps that group containing their remaining members of the generalized super-multiplet of which this is a part.

9. The recombination of ions and of ions and electrons in gases. LAURISTON C. MARSHALL, *University of California.* (*Introduced by Leonard B. Loeb.*)—Using a method described in a previous paper (Phys. Rev. **33**, 266 (1929)), the recombination coefficient, α, in air is found to vary with the x-ray exposure, t', and the recombination time, t, and is consequently also a function of the initial ion concentration, n_0. α decreases with increase of the above quantities and approaches a constant value between 0.8 and 0.9×10^{-6}. Explanation is based on the assumption that the ions are initially distributed in pairs along the paths of the x-rays leading to fictitiously high calculated values at short time intervals. This lends support to

J. J. Thomson's theory that diffusion plays the major role in the initial stages of the mechanism. In argon, where electrons remain free for appreciable intervals, α takes on a nearly constant value less than half that expected on the kinetic theory basis. Rapid achievement of random distribution when free electrons are present, accounts for the constancy. The value agrees qualitatively with spectroscopic results of Kenty and indicates a low rate of recombination between electrons and positive ions. α, as observed here, is not a true measure of the recombination process, but serves as an indication of the rate of negative ion formation through attachment of electrons to impurities present.

10. The theory of recombination of gaseous ions. LEONARD B. LOEB AND LAURISTON C. MARSHALL, *University of California.*—The bearing of the recent results of Marshall on the theory of recombination of gaseous ions is discussed. It is shown, by solution of the Brownian movement equation for two ions of opposite sign in a gas, that the average relative displacement in a time t is little influenced by the attractive forces, except for distances of the order of magnitude of 10^{-5} cm or less at ordinary temperatures. This conclusion, that in general the motion of the ions relative to each other is largely one of random diffusion, is in good agreement with the interpretation forced by Marshall's study of the variation of the coefficient of recombination α with time and concentration of ions. This also indicates that the theoretical approach of Langevin to the solution of the recombination problem is untenable, while that of Thomson is justified. The theoretical evaluation of the coefficient α, using Thomson's approach, is discussed and is compared with observation. It appears to fit qualitatively as accurately as the facts are known. It is then shown how the success of any theoretical treatment is limited due to our ignorance of the nature of the mass of the ion, a condition which, however, enables us to understand the very small range of variation of α among the different gases.

11. Intermolecular attractions in liquids. J. H. HILDEBRAND, *University of California.*—The volume energy of a liquid is formulated in terms of inverse power attractive and repulsive forces. The expression thus obtained is introduced into the thermodynamic equation of state. The general equation resulting is shown to meet several severe tests with a number of normal liquids.

12. Relative probabilities of the ionization of K and L series electrons of equal ionization energy. GERALD L. PEARSON, *Stanford University.* (*Introduced by D. L. Webster.*)—The probability that an atomic electron will be ejected by a cathode ray depends at least on the ionization potential and the energy of the cathode ray; it may depend also on quantum numbers. Between the L_{11} and the L_{21} states there are inverse changes in radial and azimuthal numbers; a K electron is like L_{11} in azimuthal and L_{21} in radial. The present experiments are on rays from PbSe, where the Se K electrons have nearly the same excitation energy as the Pb L_{22}. Assuming first that every ionization results in radiation of some line of the appropriate series, the relative probabilities of ionization were calculated from the observed line intensities, corrected for differences of excitation voltages. The number of Se K ionizations is nearly that of Pb L_{21} but far greater than Pb L_{11}. This indicates that the probability of ionization varies with the radial quantum number, rather than the azimuthal. Since some atomic reorganizations result in secondary photoelectrons, and the term efficiency of emission signifies the probability that a reorganization will result in radiation, the above ratios are really those of products of probabilities of ionization by efficiencies of emission.

13. A new method of measuring the thermal conductivities of gases. E. D. MCALISTER AND H. J. YEARIAN, *University of Oregon.*—By placing a sensitive thermocouple at the center of a spherical shell a radial flow of heat from the receiver of the couple through the intervening gas to the inner wall of the shell is accomplished. This arrangement is free from boundary corrections. The temperature difference between the couple and the walls is 1°C or less thus practically eliminating convection currents. The coefficient of conductivity for ordinary pressures is given by

$$k = L_v\left[\frac{i_v}{i_p} - 1\right]\frac{r_2 - r_1}{4\pi r_1 r_2},$$

where L_v = heat loss from thermocouple in vacuo (10^{-5} mm Hg), i_v = current from thermocouple when in vacuo, i_p = current from thermocouple when in a gas at pressure p, r_2 = radius of shell, r_1 = radius of a sphere equivalent to the receiver of the couple. Experimental values obtained at atmospheric pressure and 20°C are for dry air, $k = 5.86 \times 10^{-5}$ cal cm^{-2} sec^{-1} deg^{-1}; H_2, $k = 3.87 \times 10^{-4}$; O_2, $k = 5.95 \times 10^{-5}$, and CO_2, $k = 3.78 \times 10^{-5}$ (at 0°C). This value for CO_2 gives 1.70 for $k/7C_v$ which compares favorably with Jeans' value 1.72.

14. Field of view of secondary image, with point-object stationary, for two independently variable plane mirrors having limited widths. L. E. DODD, *Department of Physics, University of California at Los Angeles.*—Optical system composed of two plane mirrors variable about parallel axes, $A \equiv (d, O)$, $A_0 \equiv (O, O)$, situated in the respective planes, point object $O \equiv (x_0, y_0)$, forms secondary image, O'', in polar coordinates located at $\rho = f(x_0, y_0, d, \xi)$, $\phi = f(\rho, \eta)$, ξ and η being slope-angles of M_1, M_2. [L. E. Dodd, J.O.S.A. & R.S.I., *17*, 369 (1928). (Minor change has been made in subscript of symbols.)] These eqs. used in the oclinometer, developed by Liggett and Dodd, and described elsewhere. Further problem, "field of view," $\Delta\sigma = [(\sigma_3)_2 - (\sigma_3)_1]$, of O'' to eye at $E \equiv (x_3, y_3)$. σ's are slope-angles of two limiting emergent rays, both determined by outer edge of M_1, $A_e \equiv (x_e, y_e)$. Direction of $\Delta\sigma$, $\sigma_v = [(\sigma_3)_1 + (\sigma_3)_2]/2$. $(\sigma_3)_1$ obtained from θ_1 by (1)$\sigma_3 = f(\xi, \eta, \theta)$, (2)$\eta = f(d, y_0, \xi, x_e, y_e, x_3, y_3, x_1, y_1)$, where $\theta \equiv$ angle AOB_1, $\tan\theta = (d - x_1)/(y_1 - y_0)$. $(\sigma_3)_2$ known already. Desirable to find θ_2. But reverse solution $[\theta = f(\sigma_3)]$ of (1), (2), less practicable. However, θ_2 obtainable from $(\sigma_3)_2$ by (1) above, (3)$\eta = f(\xi, \phi, \alpha, \psi)$ (previous paper), (4)$\phi = f(\sigma_3, \rho, x_3, y_3)$. Again, reverse solution $[\sigma_3 = f(\theta)]$ of (1), (3), (4), impracticable. Other general expressions given: slope-angles of "incident" and "transmitted" ray-segments, OB_1, B_1B_2; incidence-points, $B_1 \equiv (x_1, y_1)$, $B_2 \equiv (x_2, y_2)$, of ray on M_1, M_2, (useful areas of mirrors from these); incidence-angles; deviations; η. All eqs. applied to rays limiting $\Delta\sigma$. Effects on $\Delta\sigma$, σ_v, of parameters ξ, d, y_0, x_3, y_3. Present conditions [$x_0 = d$, $\xi = 160° = const.$, η variable, $d = 9$ cms., width of M_1 2.3 cm, of M_2 8.0 cm, O'' above x-axis] permit $-20 > y_0 > -\infty$ cm (upper limit here provides approximately distance most distinct vision), with corresponding $47° > \Delta\sigma > 41°$, and $90° < \sigma_v < 93°$ approximately, giving to desirable degree, constancy of $\Delta\sigma$, σ_v.

15. A new graphical arrangement of the periodic table. A. E. CASWELL, *University of Oregon.*—The chemical elements are represented by points on a spiral plotted on polar coordinate paper. The atomic numbers are used as radial coordinates. Successive elements, in general, are plotted at angles 20° apart. Thus, the inert gases lie on the radial line $\theta = 0$, the alkali metals on $\theta = 20°$, the alkaline earth metals on $\theta = 40°$, the halogens on 340°. Beryllium and magnesium are on the 40° line, while boron and aluminum are on the 260° line, adjacent to carbon and silicon, respectively. The rare earth elements are all placed together on the 60° line. The so-called transition groups (Fe, Co, Ni, etc.) fit into the chart naturally. The metals and non-metals divide the chart into two compact areas. Periodic properties of the elements are easily shown on the chart. For example, basicity increases with increase in radius, but decreases with increase in angle. High atomic volumes lie at the right, low at the left. At the right, relationships are radial rather than tangential, but toward the left tangential relationships become more pronounced.

16. A projection lantern microphotometer. CEDRIC E. HESTHAL AND GEORGE R. HARRISON, *Stanford University.*—The photographic plate to be measured is mounted in screw-controlled vertical and horizontal ways in a projection lantern, and a photoelectric cell is placed behind an adjustable slit in the projection screen. The current from the cell is amplified by a two-tube Wheatstone bridge circuit of the Wynn-Williams type. A micro-ammeter or quick acting galvanometer is used as the recording instrument, and the system is extremely sensitive, stable, and readily controlled. A potential of only six to twenty volts is used on the photoelectric cell and on the leak cell, to reduce fatigue. The advantages of this type of microphotometer are: (1) a large field of the plate is visible at all times, so flaws in the emulsion can be avoided and lines can be set on very accurately; (2) the resolving power can be quickly made extremely high or low as desired; (3) an extremely quick acting but stable in-

strument can be used for recording; (4) 10-fold changes in sensitivity can be quickly made to increase accuracy for very high densities; (5) the scale of the apparatus is such that errors due to handling and adjustment are minimized.

17. Apparent modulation of light by films of dielectrics on cathodes of alkali metal photoelectric cells. A. R. OLPIN, *Bell Telephone Laboratories.*—Cathodes of alkali metal photoelectric cells have been highly sensitized to light by the use of small amounts of various dielectrics. Changes in the shape of the spectral response curve are attributed to modulation of the frequencies of the incident light upon absorption. Differentiation is made between the incident light frequency and the exciting frequency. If light of frequency p is incident on a film of dielectric having vibration-rotation frequencies q, new frequencies $p \pm q$, $2p \pm q$ will appear to liberate electrons whenever such frequencies fall in the spectral region to which the alkali metal responds. The summation frequencies appear to be almost insignificantly small. Modulation of the incident beam to give the $p-q$ frequency is apparently responsible for the increased response to light of short wave-lengths, while the $2p-q$ frequencies cause a new maximum to appear at longer wave-lengths. Experimental data are shown which confirm these theoretical considerations. Work with subharmonics in non-linearly coupled electrical circuits offers an analogy. Variations in Einstein's equation for different spectral regions are indicated if the incident light is modulated.

18. Multiple processes in the x-ray region. R. M. LANGER, *National Research Fellow, Bureau of Standards.* S. B. HENDRICKS, *Bureau of Chemistry and Soils, Department of Agriculture.*—I. B. B. Ray and R. C. Mazumdar (Zeits. f. Physik **53,** 646 (1929)) postulated the existence of simultaneous multiple electron transitions in a particular atom as an explanation for the numerous excitation potentials in the soft x-ray region. The data are in better agreement with the idea that the process is one of consecutive collisions of a single electron with separate atoms rather than the one mentioned above. Such a process is, moreover, inherently more plausible than the first. H. Coster and Druyvesteyn (Zeits. f. Physik **40,** 265 (1927)) and more recently F. K. Richtmyer (Phil. Mag. **6,** 68 (1928)) have explained the appearance of certain x-ray non-diagram lines as being produced by simultaneous electron jumps in a multiply excited atom. A class of such satellites, appearing as a rule on the low frequency side of the diagram line and near to it, can possibly be explained as arising from single electron transitions in atoms, the levels of which have been altered by modifications in the configurations of the outer electrons of the atom. Considerable qualitative evidence supports this postulate. Approximate calculations of charge distribution, using crude hydrogen-like wave functions, show that the screening effect of the outer electrons is of the required order of magnitude.

19. Thermal expansion of tantalum. PETER HIDNERT, *Bureau of Standards.*—Data on the linear thermal expansion of three samples of worked and annealed tantalum over various temperature ranges between $-190°$ and $+500°$C, have been obtained. These samples were nearly pure (99.9+ percent). Two types of expansion apparatus were used in this investigation. A summary of available data by previous observers on the thermal expansion of tantalum was prepared. Worked tantalum was found to expand practically the same as annealed tantalum. The following equation is given as the most probable second-degree equation for the expansion of tantalum between 20° and 500°C:

$$L_t = L_0 [1 + (6.59t + 0.00008t^2)10^{-6}].$$

The complete results have recently been published in Bureau of Standards Journal of Research **2,** 887 (1929).

20. Features of the furnace, arc and spark spectra of hafnium. ARTHUR S. KING. *Mount Wilson Observatory.*—The spectrum of hafnium, given by the metal in the carbon-tube furnace, has been examined from λ2650 to λ6500 and compared with the spectra of the arc and spark. The temperature classification of 337 lines within this range and the selection of ionized lines are based on the data from the three sources. The vaporization point of the metal being high, an initial temperature of 2600°C was required for the furnace spectrum, and 2900° was used as

a higher stage. No ionized lines were given by the furnace, and relatively few neutral lines appear at the lower temperature. The arc and spark spectra show decided differences in the excitation required for different groups of enhanced lines, and some of these may belong to the second ionization. A system of bands, each degraded toward the red, is distributed between λ3200 and λ5700. Their occurrence in the arc in air and their absence in the vacuum furnace point to the oxide as a probable origin.

21. An electric vacuum furnace for quantitative line intensity determinations. GEORGE R. HARRISON, *Stanford University.*—The unknown magnitude of the excitation correction often causes great uncertainty in interpreting line intensity determinations. The classical work of A. S. King with the electric furnace suggests the desirability of having such pure temperature excitation for quantitative intensity work. The disadvantages of the furnace are self-reversal, comparatively long exposures required, and greater background intensity. A furnace based on King's has been built, with modifications designed to reduce self-reversal and increase ease of handling. Base plate and cover are of tinned bronze, water-cooled externally and fastened together with soft wax. The graphite tube is so mounted that it can be removed and inserted through the end windows of the cover, making reloading a quick process. A slit in a thin graphite disk is placed near one end of the heating tube. This reduces diffusion of cooler vapor into the line of sight, and furnishes a radiation standard at the vapor temperature. Satisfactory spectrograms are obtained with the 10 meter grating in one to five minutes. Self-reversal remains in Class I and II lines, but experiments are in progress designed to reduce this by washing diffusing vapor to one side of the slit with a blast of hot gas.

22. A heavy electromagnetic pendulum for use as a self-regulating motor. L. E. DODD, *Department of Physics, University of California at Los Angeles.*—A heavy physical pendulum, approximate dimensions, length 155 cm (to center of bob), amplitude 31 cm, wt. 35 lbs. period 2.4 sec, is driven by four electromagnets, solenoid-plunger type, placed vertically in pairs tandem-fashion. Coils are No. 28 d.c.c. Cu wire, averaging roughly 5500 turns each. Energy fed to pendulum by good quality cord (fishline) passing from plungers, over light pulleys, to main support-rod at a point about $\frac{1}{3}$ length of pendulum from point of support. Two solenoids work half-time and two quarter-time, pendulum receiving energy practically continuously. Special make-and-break device distributes current of less than 1 amp. from 135-v. d.c. source. Wattage includes appreciable heating of solenoids. Pendulum regulates automatically its own amplitude. Separate wiring system for relay to minimize sparking at Hg contacts, but this is controllable by condensers. Present apparatus drives an aluminum lever $0.6\times1.8\times110$ cm, imparting up-and-down motion to sieve-like stirrer for work on miscibility of liquids. End of lever opposite stirrer passes somewhat loosely through rectangular aperture in brass slip, running in vertical guides, which is part of another cord-system, with pulleys, attached symmetrically to center of lens-shaped lead bob ($26\frac{1}{2}$ cm diam.) by means of two horizontal forks. Apparatus works smoothly for indefinite period.

23. Recombination of atoms. E. L. KINSEY AND JOSEPH KAPLAN, *University of California at Los Angeles.*—The shapes and relative positions of the Franck-Condon potential energy curves associated with the normal and excited levels of a diatomic molecule, determine whether or not it is possible for two atoms on a two body collision to combine into a homo-polar molecule. The following generalization arises, which is in accord with the Franck-Condon postulates. The collision of two atoms can result in the formation of a homo-polar molecule when, and only when the minimum energy in an excited state of the molecule is equal to or less than the heat of dissociation of the normal molecule. Three such cases arise. The total energy in one or more excited electronic levels of the molecule can be *a*) less than the heat of dissociation (no such case is known); *b*) more than the heat of dissociation (as in N_2 and NO); *c*) equal to the heat of dissociation (as in O_2). In every case the energy of recombination is lost as radiation. When no electronic level possesses an energy less than the heat of dissociation, energy cannot be lost by radiation and recombination by two body collision cannot occur (unless of course conservation of momentum is to be violated). Some other process such as a wall reaction is necessary. Hydrogen is an example of such a case.

24. Transition probabilities. E. L. KINSEY AND JOSEPH KAPLAN, *University of California at Los Angeles.*—The quantum nature of energy changes is expressed by the relation $E=h\nu$. The statement can be made in an altered form which gives rise to a connection between the transition probabilities P, and the time during which a transition takes place Δt. The statement is that $\Delta E\ \Delta t=h$, where ΔE is the energy change occurring during one vibration of the emitting or absorbing mechanism (or what amounts to the same thing, for emission, it is the energy associated with a single emitted wave). If we assume with Heisenberg that the probability of emission is measured by the square of the electric vector the expression for the energy density of electromagnetic radiation gives at once that ΔE is proportional to P/ν. This fact and the first relation show that for a given frequency the most probable transitions occur very rapidly. It seems reasonable to suppose that Δt measures the time during which radiation is emitted without phase change. $c\Delta t$ is then the length of the wave train formed, so that this is also the greatest path difference over which interference can occur. A measure of Δt is thus afforded. The complete relationship, $P\Delta t/\nu=$constant, can now be tested. The $P's$ can be calculated by matrix or wave mechanics methods and Δt estimated by interference experiments.

25. The influence of foreign gases on the intensity of the magnesium 4571 line excited at low pressure. JOHN G. FRAYNE, *California Institute of Technology.*—The 4571 magnesium line, 2^3P_1-1S, appears very faint in the arc at atmospheric pressure. This low intensity is explained by the long life, 10^{-3} sec., of the 2^3P_1 state. In this experiment, magnesium metal at 500°C gave sufficient vapor for a strong electrodeless discharge, using short wave oscillations. At this temperature, the 4571 line appeared fairly prominently in the spectrum. The addition of the noble gases argon, neon, and helium increased the intensity of the line. In the case of argon, the line was increased 100–fold relative to the triplet line 3838 at a partial pressure of around 3 cm. Neon at a pressure of about 1 cm increased the intensity of the line approximately 70–fold while helium raised the intensity about 40 times at 1 cm pressure. Nitrogen caused a gradual increase of intensity up to a pressure around 2 mm. Above this pressure, no discharge could be excited with nitrogen present in the tube. Carbon monoxide behaved similarly to nitrogen. Hydrogen up to a pressure of around 2 mm, caused no increase in the intensity of the line. The 2852 resonance line in general showed a maximum intensity at the lowest pressure of the admixed gas, and diminished gradually with increasing pressure. The sharp and diffuse singlet series diminished in intensity with increasing pressure of the foreign gases.

26. The effect of strong magnetic fields on the formation of bismuth single-crystals. A. GOETZ, R. C. HERGENROTHER AND A. B. FOCKE, *California Institute of Technology.*—Bismuth single-crystals were grown in strong magnetic fields (10,000 gauss and more) by means of a special method which avoids any stress or pressure occurring in the generally known methods. The orientation between the axis of the crystals and the axis of the rod being predetermined by a seed-crystal and the orientation of the gradient of temperature. Three main orientations were studied.

1) Trigonal axis normal to the axis of the rod, normal to the lines of magnetic force ($\{111\}$ parallel to the field lines).

2) Trigonal axis normal to the rod. Parallel to the lines of force ($\{111\}$ normal to the field lines).

3) Trigonal axis parallel to the rod. Normal to the lines of force. ($\{111\}$ parallel to the field lines).

To obtain reproducible results the first half of the crystal was grown in general without, the second, with field. The density of the two halves was measured and it was observed that it was different in all cases when the crystal had the orientation 1) or 3). i.e. when the trigonal axis was normal to the lines for force. *The density of the magnetic half is larger.* The maximum change observed on good crystals until now is 0.10 gr. cm.$^{-3}$ Bragg-diagrams were taken of the corresponding planes of the two halves of a crystal which show a distinct change of the intensity of the different orders from the $\{111\}$ plane. The decline of the intensity with the order is smaller for the magnetic crystal than for the normal, which is especially expressed in the 4th order (K_α of Mo) which disappears almost entirely for normal bismuth (Ogg, Phil.

Mag. **42,** 163 (1921); James, Phil. Mag. **42,** 193 (1921)) and exists distinctly for the magnetic crystal. If this change of the parameter is accompanied also by a change in the spacing, indicated by a shift of the lines in the spectrum could not yet be settled. For the {111} planes, the lattice constant remains unchanged (within 0.1 percent).

27. Differences in the directions of ejection of x-ray photoelectrons from various atomic levels. E. C. WATSON AND J. A. VAN DEN AKKER, *California Institute of Technology.*—Magnetic spectra of photoelectrons ejected by x-rays from a very thin film, when taken *at different angles* by the method previously described (Phys. Rev. **30,** 479 (1927)) show large variations in the relative intensities of the various lines as well as the variations in absolute intensity already reported. Thus spectra of electrons emerging at 80° with the forward direction of the x-ray beam from a thin film of evaporated tungsten traversed by primary x-rays from silver show lines due to electrons from all three L levels; forward of 80°, the line due to the L_I electrons becomes gradually weaker relative to the other two lines and disappears in the forward direction; backward of 80°, the L_I line increases in strength relative to the other two. Similarly in spectra of electrons emerging from a silver chloride film traversed by primary x-rays from molybdenum, the lines due to electrons from the L_I level of silver and the K level of chlorine become gradually weaker relative to the line due to the L_{II} L_{III} electrons (unresolved) of silver as the angle is diminished from 80° to 0° and disappear in the forward direction, while they become relatively stronger than the $L_{II}L_{III}$ line as the angle is increased. Similar results have been obtained in other cases and for the M electrons. These results can only mean that the *directions of maximum photoelectric ejection are different for electrons from different atomic levels.*

28. The temperature dependence of electrical resistance. WILLIAM V. HOUSTON, *California Institute of Technology.*—To explain the fact that the resistance of a pure metal approaches zero with the absolute temperature, even though there is zero point energy of the crystal lattice, it is necessary to take into account the fact that all impacts of electrons with the lattice are inelastic and accompanied by a transfer of energy. The transfer of energy is restricted by the fact that the electron gas is degenerate, and that at low temperatures, many of the elastic oscillators are in the lowest possible energy states. When these restrictions are expressed as a transition probability, it is possible to derive a very satisfactory law of the temperature variation of resistance. Different metals will show a different variation for very low temperatures, but they will all lie between a variation with the first power and with the fifth power of the temperature.

29. Spatial distribution of photoelectrons ejected from a gas by x-rays. CARL D. ANDERSON, *California Institute of Technology.*—Photoelectrons ejected from the K level of the Br atom by x-rays of $\lambda = 0.586$A are studied by means of the Wilson expansion chamber to determine the effect of the binding energy of the scattering atom on the longitudinal space-distribution of the photo-electrons. In agreement with Auger (Comptes Rendus, **188,** 447, (1928)), the forward momentum of the photoelectrons is found to be proportional to $\nu - \nu_0$ to a first approximation. The average forward momentum, μ, of the photoelectrons can be expressed in the form $\mu = \sigma h(\nu - \nu_0)/C$ where the "asymmetry factor," σ, is equal to 1.5. Williams (Proc. Roy. Soc. **121,** 611, (1928)) and Auger (Comptes Rendus **187,** 1141, (1928)), working with light scattering atoms where ν_0 is negligibly small, have previously found values for σ of 1.3 to 1.4.

30. Ionization of nitrogen and air by positive ion bombardment. RICHARD M. SUTTON AND J. C. MOUZON, *California Institute of Technology.*—Previous work by one of us (Phys. Rev. **33,** 364, (1929)) showing positive ion ionization in argon and neon by potassium ions has been extended to the study of nitrogen and air. Both gases show the presence of ionization for accelerating potentials above 100 volts, at pressures between 0.1 and 0.7 mm. The abnormally high pressures indicate further evidence for the presence of long mean free paths for the positive ions. Secondary effects were investigated and duly accounted for. The calculated ionization at 750 volts in the gases studied to date, expressed as the number of ions formed per

initial positive ion per centimeter path reduced to one millimeter pressure, are: argon, 0.288; neon, 0.112; nitrogen, 0.124; air, 0.098; hydrogen, none detectable. These efficiencies are less than 4 percent of the electron ionization at the maxima for these gases (K. T. Compton and Van Voorhis, Phys. Rev. **26**, 436, (1925)).

31. Incoherent scattering and structure of diatomic molecules. F. RASETTI, *California Institute of Technology.*—Ultra-violet light from a mercury arc scattered by gases has been examined with a large quartz spectrograph. The fine structure of Raman spectra given by H_2, N_2, O_2, CO and NO has been analyzed. The result, in agreement with the theory outlined by the author in a recent paper, is that, when the molecule is in a S state (N_2, H_2, O_2, CO) only transitions with $\Delta j_k = 0, \pm 2$ can take place in the scattering process. In symmetrical molecules, if the nuclei have no spin (O_2) alternate rotational levels are missing, and this gives a pattern of equally spaced lines, the spacing being $8 \cdot h/8\pi^2 I_0$. If there is a nuclear spin (H_2, N_2) alternate weak lines are present; in H_2 the strong lines correspond to transitions between odd rotational levels, in N_2 between even levels. If the molecule is in a P state and has an electronic fine structure (^2P in the case of NO, $\Delta\nu = 124$ cm^{-1}) the transition between the two components of the doublet is observed in the Raman effect. This also is to be expected from the theory.

32. The magnetic properties of isolated ferromagnetic atoms. F. W. CONSTANT, *National Research Fellow, California Institute of Technology.*—In order to obtain a better knowledge of the elementary atomic magnet, its behavior when surrounded by non-magnetic atoms rather than by other magnetic ones has been studied. For this purpose, alloys of 90 and 95 percent platinum with the remainder cobalt and nickel, respectively, have been investigated and the cobalt ones found ferromagnetic. The magnetic moment per cobalt atom is greater than for pure cobalt. Various hysteresis loops, showing the relation between the magnetization and applied magnetic force have been obtained; heat treatment was found important, the wires in the hard drawn state showing considerably more hysteresis for the 95 percent Pt alloy, but after sufficient annealing, these more isolated magnetic atoms gave, conversely, less hysteresis. This last result is in agreement with Heisenberg's theory of ferromagnetism, based on resonance between the electrons of neighboring ferromagnetic atoms, this resonance decreasing as the ferromagnetic atoms are more isolated. Variation of magnetization with temperature and Curie points were also found, the latter falling rapidly as the cobalt content decreased, so that most of the measurements on hysteresis were made at liquid air temperatures.

33. The valence of sulfur in dithionates. RALPH WINGER, *California Institute of Technology.*—Lindh has shown that sulfur compounds show large shifts in wave-length of x-ray absorption edge, the main effect being due to chemical valence. It has been a question whether the two sulfurs in the dithionates (XS_2O_2) are in the valence states S_{II} and S_{VI}, as is generally assumed for the thiosulfates (XS_2O_3), or whether they are in the same state. If valence is calculated in the usual way, a value of V is obtained for the dithionate on the assumption that the sulfurs are equivalent. X-ray absorption data have been secured, showing the edge lying about halfway between the mean values for the 4– and 6–valent compounds. This indicates a valence of V for sulfur in the dithionates.

34. The electric moments of CH_3 and Br radicals in certain organic molecules. C. R. DAILY, *California Institute of Technology.*—As a further test of the Debye theory of binary liquid mixtures, the electric moments of various molecular combinations of CH_3 and Br radicals were determined from observations in binary mixtures with benzene of the dielectric constant, index of refraction, and density at various concentrations. The values obtained were: toluene 0.50×10^{-18} esu; brombenzene 1.70×10^{-18} esu; p-bromtoluene 2.15×10^{-18}; esu n-propyl bromide 2.00×10^{-18} esu; iso-propyl bromide 2.20×10^{-18} esu; ethyl bromide 2.12×10^{-18} esu.

Since the moment of Br is negative with respect to CH_3, p-bromtoluene should have a moment equal to the vector sum of the moments for toluene and brombenzene and close agreement is obtained. n-propyl bromide, iso-propyl bromide, and ethyl bromide have approximately the same moment which agrees with structural considerations of these molecules.

35. The electric volume-effects in bismuth single-crystals grown in strong magnetic fields. A. GOETZ AND M. HASSLER, *California Institute of Technology.*—The effect of strong magnetic fields on the electric volume effects (conductivity and thermo-electric effects) was studied on crystals which were grown one-half with the magnetic field and one-half without. There exists a thermo-electric force between both halves although there is no visible change in orientation. Besides, of this e.m.f. there is an e.m.f. which depends on the gradient of temperature, i.e. it depends on the heat-flow through the intersection between the magnetic and unmagnetic half. The conductivity of the two halves is also different. The changes of the volume effects depend on the orientation in which the crystal enters the field, which adds so much to the complexity of the matter that it cannot be described briefly.

36. A relation between lattice energy and shift in x-ray absorption edges. RALPH WINGER, *California Institute of Technology.*—Aoyama, Kimura, and Nishina have given a theory for the displacements of the x-ray absorption edges in certain chlorides having similar crystal structure and chemical binding. A consequence of their theory is that the shifts in frequency of the edges should be a linear function of the lattice energy. They have drawn a straight line through the few experimental points they were able to determine, but the points were too close together to furnish a convincing check. New points have been determined by using tetramethyl and tetraethyl ammonium chloride. The range of values is more than doubled, and the results show in general a progressive shift in frequency with increasing lattice energy. The new points lie roughly on a straight line which has a somewhat less steep slope. A straight line can be drawn through all the points within experimental error, but a curving line fits better. The theory seems too simple and there are probably other factors entering in.

37. Preliminary note on coefficients of relativity. S. R. COOK, *College of the Pacific.*—Coefficients in Lorentz's and Einstein's first paper are compared. The coefficients are then deduced from the difference between the paths of light in the Michelson-Morley interferometer experiment. It is shown that the coefficients deduced from the Michelson-Morley interferometer experiment correspond with those first deduced by Einstein, but differ from the Lorentz coefficients and from the coefficients finally deduced by Einstein and generally accepted by writers on relativity. It is further shown that wherever there is a transverse space coefficient there is a corresponding transverse time coefficient. The question is raised as to adequacy of the space and time coefficients most generally used by writers, and it is suggested that the more general coefficients first derived by Einstein and derived by the writer from the Michelson-Morley experiment would be more in accord with the facts of the Michelson-Morley experiment and with the genius of Einstein's theory of relativity.

38. Speech-power of speakers in auditoriums. V. O. KNUDSEN, *University of California at Los Angeles.*—Measurements of the speech-power of speakers indicate that the loudness of speech in auditoriums is considerably below the loudness level required for optimal hearing conditions. The average speech-power of six male speakers in a small auditorium (770 cu m) was 27.4 microwatts, and the average for eight speakers (six males and two females) in a large auditorium (6790 cu m) was 48.9 microwatts. From these data and the total absorption in the rooms, the probable loudness of the average speaker in the smaller auditorium is 50.7 db and in the larger auditorium 45.7 db. The optimal loudness for the hearing of speech is 70 db. The advantage of suitable speech amplifiers in large auditoriums is thus apparent. These data, together with known data on the interfering effect of noise and reverberation, make it possible to assign a quantitative rating to the hearing conditions in any auditorium. A series of curves gives the probable percentage of speech articulation in auditoriums of different sizes and times of reverberation. These curves also give the optimal time of reverberation for the hearing of speech in auditoriums, which varies from 0.80 seconds in small rooms to 1.50 seconds in very large auditoriums.

39. Classical scattering in x-ray reflection. PAUL KIRKPATRICK AND MARGARET DEWAR, *University of Hawaii.*—The classical treatment of the scattering of short wave-length radiation by electrons shows that the scattered intensity from an unpolarized primary beam should vary

as $(1+\cos^2 2\theta)$, where 2θ is the angle of deviation. We have investigated the validity of the expression in parentheses in its application to crystal reflection. Effectively unpolarized x-rays were reflected by a rock-salt crystal and the reflected beam allowed to strike an aluminum scatterer. The intensity distribution of the scattered radiation revealed the polarization imposed upon the reflected beam by the process of reflection, and this polarization was compared with that predicted by the classical scattering function. For deviations of 15°08′ and and 20°10′ the observed scattering is, within the limits of experimental error, classical. Reflection-scattering at deviations of zero and ninety degrees may also be shown to harmonize with these results, in the former case by symmetry and in the latter by reference to the observations of Mark and Szilard, (Zeits. f. Physik **35,** 743 (1926)).

40. The temperature coefficient of radioactive disintegration. OSCAR KNEFLER RICE, *National Research Fellow, California Institute of Technology.*—It is shown that the negligible temperature coefficient of radioactive disintegrations is what is to be expected from the known sizes of atomic nuclei, on the basis of the new quantum mechanical explanation of radioactivity. According to this explanation the alpha-particle in the nucleus which is to decompose is in some "discrete" state in the nucleus, but can leak out over a potential energy hump and appear in a continuous state outside the nucleus. If there is to be no temperature coefficient to such a process the alpha-particle must always be in its lowest state when in the nucleus. The energy to the next state can be calculated roughly from the size of the nucleus, and is shown to be so great that the probability that the alpha-particle will be in an excited state may be neglected, whence our proposition follows.

41. The mechanism of the spark discharge. L. J. NEUMAN, *University of California.*—It is well known that in a self-sustained electrical discharge it is necessary that electrons be liberated from the neighborhood of the cathode by some mechanism in addition to the cumulative ionization of the gas by electrons. Let us classify the possible mechanisms as follows: Those dependent on (a) the gas and velocity of the positive ions; (b) the gas, cathode material and the velocity of the positive ions; (c) the gas and cathode but *independent* of the velocity of the positive ions. A special discharge tube (Proc. Nat. Acad. Sci. **15,** 259 (1929)) was used to distinguish between these mechanisms experimentally. Assuming that most of the positive ions pass through the grid it has been shown that: (a) In A at low pressures the cathode material plays an important part in the mechanism of the spark discharge, as was previously observed by Holst and Oosterhuis, and J. Taylor; (b) under these conditions the principal mechanism producing electrons depends upon the *energy of impact of the positive ions with the cathode*; (c) as the pressure increases the predominating electron-producing mechanism changes from type *B* to *A* and the sparking potential becomes practically independent of the cathode material.

42. An electro-mechanical frequency analyzer. L. P. DELSASSO, *University of California at Los Angeles.*—For certain purposes in the study of complex sounds, analyzers which determine the amplitude and frequency of the components but not their phase relations are found useful. In this instrument the complex sound to be analyzed is converted, by a condenser microphone and a high quality amplifier, into potential fluctuations which are impressed on the quadrants of a modified quadrant electrometer. The needle of the electrometer is suspended by three fine tungsten wires forming a sharply resonant mechanical circuit. The period of this circuit is made continuously variable by changing the angular separation and tension of the suspensions. Vibrations of the mechanical circuit occur whenever its natural period agrees with the period of a component of the complex sound to be analyzed. The amplitude of the component is found from the amplitude of vibration of the needle and the frequency of the component from the tension on and angular separation of the suspensions. Frequency ranges of from 10 to 200 d.v./sec. and from 100 to 1700 d.v./sec. have been obtained. The work has been done with the help of a grant from the Guggenheim Fund for the Promotion of Aeronautics and is a part of an investigation to determine the practicability of using acoustic methods to measure the altitude of aircraft.