

PROCEEDINGS
OF THE
AMERICAN PHYSICAL SOCIETY.

MINUTES OF THE PASADENA MEETING.

THE ninety-eighth meeting of the American Physical Society was held in the Physics lecture room of Throop College, Thursday, June 19, in connection with the meeting of the Pacific Division of the American Association for the Advancement of Science. On Friday morning a joint meeting with the Astronomical Society of the Pacific was held. Dr. J. A. Anderson presided at both meetings. There was an attendance of about forty. Members of the society were entertained at luncheon by Throop College on both days. On Friday they were invited to a garden party by Dr. and Mrs. Hale.

The National Research Council's laboratories at Throop College and various industrial laboratories in the vicinity were open to visitors. On Saturday morning many members of the society inspected the physical laboratory of the Mount Wilson Observatory in Pasadena, and later went by stage to the observatory, where they were entertained at luncheon and given an opportunity to inspect the equipment. Those who remained until evening made observations with the 60- and 100-inch telescopes.

On adjourning a vote of thanks was extended to the authorities of Throop College and Mount Wilson Observatory for their courtesies.

The following papers were read:

The Stability of a Rotating Parachute or Falling Body Rotating about a Vertical Axis of Symmetry. H. BATEMAN.

The Most Probable Value of the Planck Constant h . RAYMOND T. BIRGE.

The Stark Effect for Metals in the Ultra-Violet. J. A. ANDERSON.

Absorption Effects with the Electric Furnace as Related to Temperature Classification. A. S. KING.

The Electric Furnace Spectra of Metals in the Infra-Red. A. S. KING.

The Spectra of Krypton and Xenon in the Infra-Red. PAUL W. MERRILL.

A Study of the Comparative Intensities of Spectrum Lines in Different Regions of the Arc as Compared with their Behavior in Other Sources. PAUL W. MERRILL.

The Vapor Pressures of Hydrogen Chloride and Hydrogen Bromide above Their Aqueous Solutions. S. J. BATES and H. D. KIRSCHMAN.

Recent Observations of Tube-Arc Spectra, Especially in the Infra-Red. ARTHUR S. KING and PAUL W. MERRILL.

The Reflective Power of Metals and Dielectrics in the Ultra-Violet. E. P. LEWIS and A. C. HARDY.

Determination of the Normal Temperature by Means of the Equation of the Seasonal Temperature Variation and the Thermograph Record. F. L. WEST, N. E. EDLEFSEN and S. P. EWING.

Snow Crystal Studies. JOHN C. SHEDD.

A Study of the Reversible Pendulum. JOHN C. SHEDD and PAUL KIRKPATRICK.

The Movement of Moisture in Soil by Capillarity. WILLARD GARDNER.

Physical Constants Pertaining to the Ocean. GEORGE F. MCEWEN.

Sparking Voltage of Point-to-Sphere Discharge by Means of a High-Voltage Direct Current Generator. E. R. WOLCOTT.

Formula for the Wave-Length of *M*-Radiation. FERNANDO SANFORD.

The Effect of Chemical Treatment on the Rate of Percolation of Water through Soils. A. E. VINSON and C. N. CATLIN.

E. P. LEWIS,
Local Secretary.

THE SPECTRAL TRANSMISSION OF FILTERS USED TO DETECT CAMOUFLAGE OR IMPROVE VISIBILITY.¹

By K. S. GIBSON, E. P. T. TYNDALL AND H. J. MCNICHOLAS.

DURING the war, the spectral transmissions of a large number and variety of filters were measured by the Bureau of Standards. Among the many uses to which these filters were put, were the detection of camouflage or the improvement of visibility. By the latter is meant increasing the ability of the eye or the photographic plate to detect the details of distant objects.

Examples of the different types of filters used for these purposes are given in the accompanying figures. In each figure is given also the relative visibility curve of the average human eye, that is, the relative sensibility of the eye to radiant energy of different wave-lengths.

In Fig. 1 are shown a number of types of filters used to improve visibility. This is done by the absorption of the shorter wave-lengths, blue haze or brilliant glare being thus partially or completely eliminated. Goggles whose transmissions are represented by curves 1 to 4 were much used by aviators, and those represented by curves 2 to 8 in photographic work, especially from airplanes. Numbers 1 to 8 are different shades of Corning glass G 38 (Noviol), G 36, G 34, and G 24. This same type of curve, in many of the goggles examined, was produced by dyed gelatine or celluloid between glass.

In Fig. 2 are given curves for certain types of aviator goggles known as "Brock" goggles, the color being produced by means of dyed gelatine between glass. No. 23 and No. 73 are similar to those of Fig. 1 and are doubtless used

¹ Abstract of a paper presented at the Washington meeting of the American Physical Society, April 25 and 26, 1919.

for the same purpose. The others, except No. 79, are dichromatic and used for the detection of camouflage. In most of the dichromatic screens successfully used for this purpose, the two colors transmitted are approximately equal in luminosity. Other Brock goggles examined were No. 93, No. 14, and No. 25. Filters represented by curves 9 (gelatine dyed with methyl violet) and

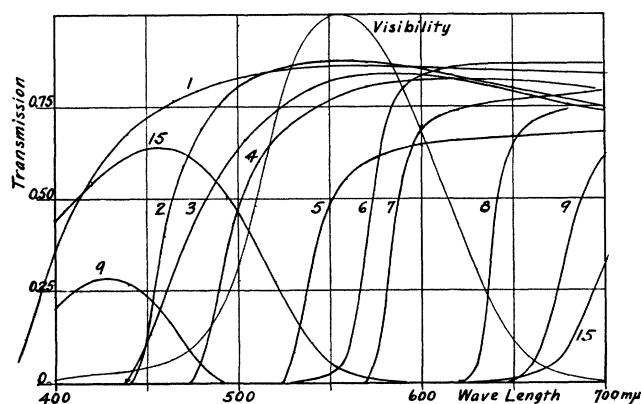


Fig. 1.

Spectral transmission of filters used to detect camouflage or improve visibility.

15, and others similar have been of considerable value. In addition to the dichromatic screens, monochromatic filters are often of value, especially red (curve 8), violet or ultra-violet.

Other dichromatic filters of very low transmission are shown in Fig. 3.

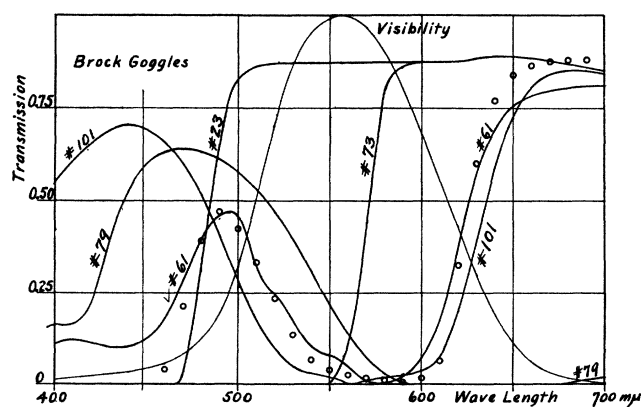


Fig. 2.

Spectral transmission of filters used to detect camouflage or improve visibility.

These are valuable for producing chromatic contrast between greens which match in daylight but have different reflecting powers for red.

Considerable time and effort was spent at the bureau during 1918 in making filters to detect camouflage, both in reproducing filters by request when the composition was unknown and only the spectral transmission determined, and in producing new ones. In Figs. 2 and 3 are shown, by circles, optical reproductions of Brock No. 61 and another filter of unknown composition (curve 14). The other filters shown in Fig. 3 were also made at the bureau as

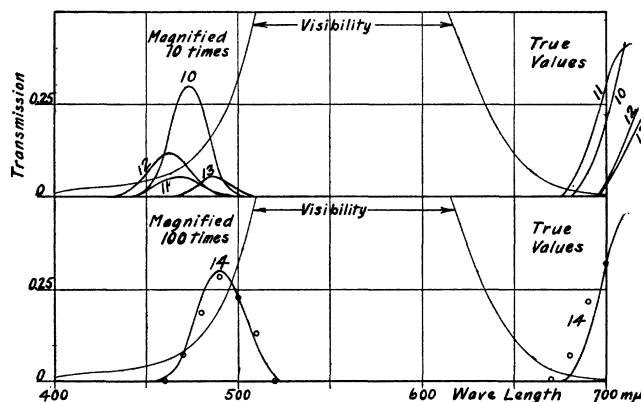


Fig. 3.

Spectral transmission of filters used to detect camouflage or improve visibility.

well as many others not shown. Capt. W. E. Mathewson, U. S. A. Ordnance, who was stationed at the bureau, and Irwin G. Priest, coöperated in the preparation of these dyed filters. The compositions of these various filters are as follows:

FILTER	COMPOSITION
Filter made to duplicate Brock No. 61.	Separate gelatine solutions of iris violet and picric acid flowed on glass and cemented together with Canada balsam.
Made to order to duplicate the transmission of filter submitted (Curve 14, Fig. 3).	Three separate films of gelatine on celluloid dyed respectively with iris violet, tartrazine, malachite green.
Curve 10. Made to show chromatic contrast in viewing greens.	
Curve 11. Made to show chromatic contrast in viewing greens.	Film dyed with guinea green B + film dyed with naphthalene red.
Curve 12.	Glass, cobalt blue D and Noviol C.
Curve 13.	Glass, cobalt blue C and 2 samples Noviol C.

BUREAU OF STANDARDS,
WASHINGTON, D. C.,
April 21, 1919.

A METHOD FOR THE COLOR GRADING OF RED FLARES.¹

BY IRWIN G. PRIEST.

THE development of a method for the color grading of red flares was requested by the Colored Lights Section, American University Experiment Station. The flares submitted were classed as follows: (1) carbonate flares, burning with a yellowish red flame; (2) nitrate flares, burning with a comparatively purer red flame; (3) a standard railway red fusee. It is understood that the red flame is due to strontium.

Fundamentally considered, the ideal method of expressing the color of these flares would be by means of an energy-wave-length function showing the relative energy at each point in the visible spectrum. On account of the extremely erratic burning and consequent enormous instantaneous variations of intensity, such determinations are quite impracticable. For the same reason a monochromatic or trichromatic analysis would be difficult.

Determinations by means of the Arons Rotatory Dispersion Quartz Plate Chromoscope² have been found feasible and apparently satisfactory. As actually used the arrangement of apparatus is as follows:

1. *The Comparison Light Source* is a vacuum tungsten lamp. This illuminates a magnesium carbonate block which reflects the light to the eye through the train of nicol prisms, quartz plates, and the Lummer-Brodhun cube constituting one arm of the chromoscope. This lamp is operated at a constant voltage such that the light in the photometric field is color-matched with a standard acetylene flame³ when the quartz plates are removed from the path.

2. *The Train of Nicols and Quartz Plates* in order from the source to the eye is: Nicol No. 1, nicol no. 2, quartz plate no. 1, nicol no. 3, quartz plate no. 2, nicol no. 4. Each quartz plate is 2 mm. thick. Rotation of nicol no. 1 with respect to no. 2 serves to vary brightness. Rotations of nicols nos. 2 and 4 with respect to no. 3 when the quartz plates are in place serve to vary spectral distribution. These rotations are measured from zero for the extinction position with quartz removed.

3. *The Light from the Flare* is reflected by another magnesium carbonate block to the eye through a pair of nicols and the Lummer-Brodhun cube. The photometric field is thus illuminated, in one part by the light from the flare and in the other part by light the spectral distribution of which can be varied by rotation of the nicols nos. 2 and 4.

For the color variation in the flares submitted, it was found that nicol no. 2 could be kept set constantly at 80° while the color variations could be followed by rotation of nicol no. 4. By using both hands the observer can control both total intensity (nicol no. 1) and spectral distribution (nicol no. 4).

¹ Abstract of a paper presented at the Washington meeting of the American Physical Society, April 25 and 26, 1919.

² Ann. der Phys., 39, 545, 1912.

³ Coblentz and Emerson, B. S. Sci. Paper 279, 1916.

For the flares submitted the following rotations of nicol no. 4 gave color-matches:

Carbonate flares.....	70°
Nitrate flares.....	54°
Railway fuses.....	57°

From the above data, the relative spectral energy distribution of acetylene¹ and the rotatory dispersion of quartz, *the relative spectral energy distribution of the light found to color-match the light from the flare can be computed.*² These computations have been made and the results are shown in the accompanying figure. To facilitate comparison, the ordinates are all arbitrarily made 100 for wave-length 720 millimicrons. These computations would ordinarily be

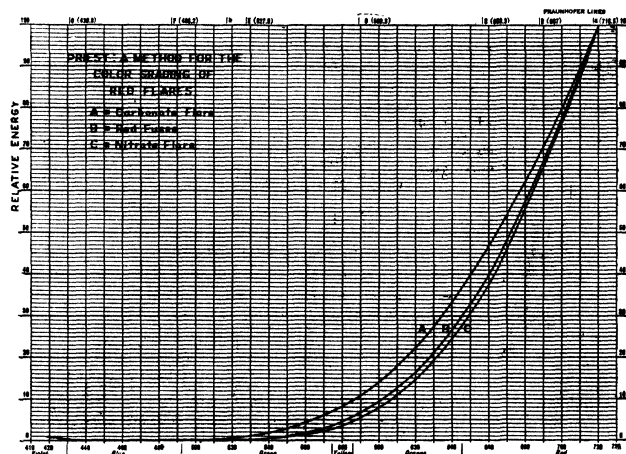


Fig. 1.

very tedious, but are greatly facilitated by extensive tables which have previously been prepared and are on file at the bureau.

The method thus determines not the actual spectral energy distribution of the flare but *a spectral energy distribution which color-matches it.* This apparently meets all present actual needs for color-grading these flares.

The apparatus could also be adapted to determine the candlepower of the flares.³

The report which is abstracted above was made to the American University Experiment Station, July 6, 1918.

NATIONAL BUREAU OF STANDARDS,

April 22, 1919.

¹ Coblenz and Emerson, B. S. Bull. 13, 363.

² See also Priest, PHYS. REV., (2), 10, 208, August, 1917.

³ Priest, PHYS. REV. (2), 6, 64; 9, 341.

APPLICATIONS OF THE CATHODE-RAY TUBE IN RADIO WORK.¹

BY L. E. WHITEMORE AND L. M. HULL.

THE cathode-ray oscillograph furnishes the only means of mapping wave forms and of determining directly the phase relations of currents and voltages in radio frequency circuits. It is particularly useful in studying generating or receiving circuits in which continuous oscillations are maintained.

Two general types of cathode-ray tube have been used in such investigations at the Bureau of Standards, those having the usual plane cathode of metal and those having a cathode consisting of a heated filament from which the electron emission is spontaneous. Tubes of the former type are constructed in the usual way, with aluminum electrodes, a screen coated with calcium tungstate, and aluminum plates for electrostatic deflections of the cathode beam sealed inside the tube. They require exciting voltages of from 8,000 to 20,000 volts, and are suitable for the measurement of oscillating currents of the order of magnitude of one ampere. The high voltage is obtained from a 60-cycle power line and is rectified with two kenotron rectifiers with a suitable combination of choke coils and capacities for smoothing out the rectified wave.

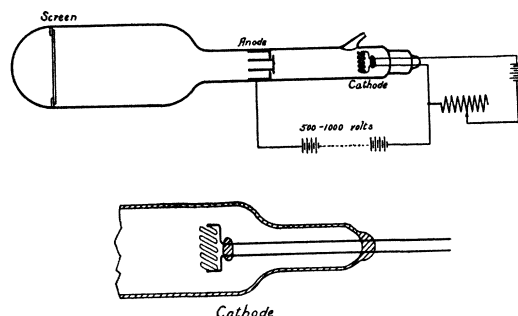


Fig. 1.

A successful hot cathode tube has been constructed using a platinum filament coated with a mixture of calcium and barium oxides. A diagram of this tube and the exciting circuit is shown in Fig. 1. The diaphragm is constructed of metal and is made the anode. For the particular type of diaphragm construction shown in the figure we are indebted to the General Electric Company. A concentrating coil of 500 ampere turns is used with the tube and an extremely fine, sharp spot is produced on the screen. Since relatively low exciting voltages are used, the cathode stream is quite sensitive to electrostatic or electromagnetic deflecting fields, and the tube is suitable for measuring the oscillating electron currents obtained in three-electrode electron tubes, which are of the order of magnitude of 0.05 ampere.

Oscillograms are made with these tubes as a part of the regular tests per-

¹ Abstract of a paper presented at the Washington meeting of the American Physical Society, April 25 and 26, 1919.

formed upon radio transmitters submitted to the Bureau of Standards. The quenching action of different spark gaps is determined directly by passing the gap currents through suitable deflecting coils placed around the tube below the anode, a time axis perpendicular to the current deflection thus produced being provided by connecting the electrostatic deflecting plates across the capacity in the closed oscillatory circuit.

The cathode-ray oscillograph is now being used in an investigation of the harmonics produced in antenna circuits by electron tube generators. Dynamic characteristic curves are obtained for a given generator by impressing the oscillating grid voltage upon the deflecting plates and allowing the electron currents to flow through the deflecting coils. The wave forms of the antenna currents are determined by providing a sinusoidal time axis from a separate generator tuned to a lower frequency of which the frequency of the current oscillation is a suitable multiple.

The combination of an electron tube generator, which is capable of furnishing currents at any frequency up to that corresponding to a wave-length of a few centimeters, with a cathode-ray tube having a slow-moving electron stream, whose deflections are closely proportional to the instantaneous values of these oscillating currents, offers an opportunity for much profitable research, with possibilities of valuable contributions to modern electron theory.

COMMENTS ON SPECTRAL RADIATION FORMULÆ.¹

BY W. W. COBLENTZ.

AT the New York meeting of this society (March 1, 1919) Mr. I. G. Priest presented an empirical radiation formula,² and data purporting to show that this formula fits the experimental observations at least as well as, if not better than, does the Planck spectral energy equation from which it was obtained.

There are two sets of experimental data available for determining the merits of a proposed spectral radiation formula; (1) the data published by the writer,³ which pertain to the spectrum extending from $0.9\ \mu$ to $1.5\ \mu$ and from $3.6\ \mu$ to $5.5\ \mu$, and especially (2) the data published by Rubens and Kurlbaum⁴ which relate to the spectrum at $24.0\ \mu$, $31.6\ \mu$ and $51.2\ \mu$. In fact, any formula which is not in agreement with the data at these long wave-lengths is usually given but little consideration.

Mr. Priest makes the mistake of computing his data in terms of the maximum emission, which point, for the temperatures attainable, involves the greatest errors owing to spectral impurity and the greatest atmospheric absorption.

¹ Abstract of a paper presented at the Washington meeting of the American Physical Society, April 25 and 26, 1919.

² Priest, *PHYS. REV.*, 13, p. 314, 1919; *Jour. Opt. Soc. Amer.*, 2, p. 18, 1918.

³ Coblenz, *Bulletin Bureau of Standards*, 13, p. 459, 1916; see Figs. 1 and 2.

⁴ Rubens and Kurlbaum, *Sitzber Akad. Wiss. Berlin*, XLI., p. 929; 1900.

And he makes the further mistake of using the single, highest point, $E_m = 463$ of Fig. 2 (*loc. cit.*) instead of the more probable value, $E_m = 450$, which is in common with the two series of measurements. Now it so happens that the value $E_m = 463$ is high because at this point the temperature of the radiator was slightly above the average for the series. The rest of the observations are in close agreement. They do not differ systematically throughout the two curves which were obtained at an average temperature difference of only 0.5°C . (4 microvolts by the thermocouple). The published difference in temperature, of 1° , is the result of a supposed change in the thermocouple calibration. As a result, the "experimental data," given in col. VI. of his table, are erroneous. For example, at $\lambda T = 1900$, $E_\lambda = 0.605$ instead of 0.581 .

Instead of the excellent agreement claimed by Priest, using the most probable radiation constants $C_2 = 14350$ and $A = 2890$ ($= \lambda_m T$) the computed curve falls below the observed curve by 3 to 4 per cent. at 3.6μ by 8 per cent. at 4.5μ and 10 to 11 per cent. at 5 to 6.2μ . (See his tables for $\lambda T = 6,000$ to $9,900$, column (II.)-(III.).) Upon my insistence that the formula must fit the data closer than 5 to 10 per cent., he adopted the value of $A = 2940$, which is the old Lummer Pringshein value, long since abandoned as erroneous because of an erroneous temperature scale, and wave-length calibration curve.

Using the arbitrary constant, $A = 2940$, brings a closer agreement, say 1 to 2 per cent. at 4 to 5μ , but then there are greater deviations at 0.9 to 1.5μ . This is merely a compromise. In these two spectral regions (0.9 to 1.5μ and 3.6 to 5.5μ) which comprise the most reliable data obtainable at present, computations made by using the Planck equation, fit the smooth curve drawn through the observations to ± 0.3 per cent. to ± 0.7 per cent. Readers in doubt about the matter can see a least square reduction of these data by consulting a paper by Mr. H. M. Roeser¹; and can make their own computations using the writer's experimental data, there published.²

Rubens and Kurlbaum (*loc. cit.*), using radiations of wave-lengths 24.0μ , 31.6μ (residual rays from fluorite) and 51.2μ (rock salt) and a temperature range of -188°C . to $+1500^\circ \text{C}$. found that computations based upon Planck's equation fitted the observed curves so closely that they resorted to tabulation in order to show the small deviations. For the impure residual rays from fluorite, the maximum deviation of the computed from the observed data was 3 to 5 per cent., for the whole temperature range; while in the temperature range of 750° to 1500°C . the deviation was from 0 to 1.5 per cent. For the residual rays, obtained by reflection from rock salt ($\lambda = 51.2 \mu$) the maximum

¹ Roeser, Bul. Bur. Stds., 14, p. 237, 1917; see Fig. 1, p. 241. These same data are plotted in Fig. 1; B. S. Bul., 13, p. 474.

² (Added by author subsequent to meeting.) In a paper presented at this meeting Mr. Priest has modified his formula in order to fit certain experimental requirements in the visible spectrum. Although the writer's "experimental data" have been adjusted to fit the formula, there is a difference of 5 to 8 per cent. between the computed and observed data, at 4.6μ to 5μ ($\lambda T = 7,408$ to $7,983$) and a still greater discrepancy at 50μ . The futility of attempting to make things fit in one part of the spectrum at the expense of another part should be apparent.

deviation of the computations from the observations, in the temperature range from -80° C. to $+1500^{\circ}$ C. is 1.7 per cent. and the predominating deviation is ± 0.9 per cent.—a truly remarkable agreement when one considers the difficulties involved in the experiments.

On the other hand, Priest's tabulated data show that, for $\lambda = 51.2 \mu$ and for a temperature range of -80° C. to $+1680^{\circ}$ C. ($\lambda T = 10,000$ to $100,000$), using $A = 2,940$, the difference between the data computed by his empirical formula and those computed by Planck's formula (which is in agreement with the experimental data) is -10 per cent. at 118° C., -3 p.c. at 507° C., $+7$ p.c. at 900° C., $+33$ p.c. at 1290° C., and $+53$ p.c. at 1680° C. The agreement is somewhat closer when using $A = 2,890$. This empirical formula offers no important advantages in simplifying experimental work, and in computing experimental data. The advantages claimed for the use of frequencies instead of wave-lengths are open to question.

The radiation constants are now known to such an accuracy that no new investigations should be undertaken unless the laboratories concerned are prepared to carry on the work for years, in order to attain a still higher accuracy. It will, therefore, be left primarily to the national laboratories. Some of these laboratories have their plans already formulated and since much preliminary computation has already been completed, using the Planck equation, which is known to fit the observational data for a spectral range of 0.6 to 50μ , with an accuracy of 1 to 3 per cent., which is the accuracy of the experimental data, experimenters will be loath to turn aside to test an empirical formula which, in the same parts of the spectrum, shows a disagreement of 10 to 50 per cent. with the observations.

The Planck equation is based on theoretical foundations, and after almost two decades of discussion it remains unchanged. It has been indicated that numerous other formulæ can be set up which will represent the experimental data. But it seems futile to set up a formula, without a theoretical foundation, especially when the accuracy attainable is as limited as in using the empirical formula just discussed.

BUREAU OF STANDARDS,
WASHINGTON, D. C.,
March 4, 1919.

THE STABILITY OF A ROTATING PARACHUTE OR FALLING BODY ROTATING ABOUT A VERTICAL AXIS OF SYMMETRY.¹

BY H. BATEMAN.

IT is found that when the falling body or parachute is rotating about a vertical axis the stability may be studied most conveniently by using a simple transformation of the equations of motion in which the coordinates

¹ Abstract of a paper presented at the Pasadena meeting of the American Physical Society, June 19, 1919.

used are complex quantities. The stability is thus seen to depend on the nature of the roots of a cubic equation with complex coefficients.

In the case of no rotation a study is made of the effect of varying some of the resistance coefficients while the others are kept constant. The effect of rotation on stability is discussed and particular attention paid to conditions in which the effect of rotation is entirely favorable.

THE STARK EFFECT FOR METALS IN THE ULTRA VIOLET

BY J. A. ANDERSON.

USING a large quartz spectrograph the spectra of Ag, Al, An, Cd, Co, Cu, Fe, Mg, Mo, and Ni have been photographed.

Some work has been done using a small 26,000-volt transformer with synchronous rectifier instead of the direct-current generators.

Direct photographic comparison of the spectrum given by the tube with that of the arc and spark has been made for iron with results so interesting that similar comparisons will be made for the other elements studied.

ABSORPTION EFFECTS WITH THE ELECTRIC FURNACE AS RELATED TO TEMPERATURE CLASSIFICATION.

BY ARTHUR S. KING.

A SERIES of experiments have been made in which a graphite plug was placed in the tube of a resistance furnace, producing absorption spectra of metallic vapors which the tube contained. By this means a study has been made of the absorptive power of spectrum lines at various temperatures, the dependence of the phenomenon on wave-length, and a comparison with the emission spectrum of the furnace at corresponding temperatures. A close connection appears between the absorptive power of a line and the temperature class in which it had been placed. A comparison with solar and stellar lines is in some respects simplified.

THE ELECTRIC FURNACE SPECTRA OF METALS IN THE INFRA-RED.

BY ARTHUR S. KING.

THE electric furnace spectra of Fe, Ni, Cr, Ti, Ba, Sr and Ca have been photographed by the use of plates dyed with dicyanin, an extension into the infra-red beyond λ 9000 being obtained. A considerable number of lines for each element have appeared at different furnace temperatures. Lines of special interest are those which maintain their intensity at the lower temperatures and those which are relatively stronger in the furnace than in the arc. For Ca, Ba and Sr, the temperature grouping of lines has proved useful in selecting lines which fit into series having first members in this region.

¹ Abstract of a paper presented at the Pasadena meeting of the American Physical Society, June 19, 1919.

RECENT OBSERVATIONS OF TUBE-ARC SPECTRA, ESPECIALLY IN THE INFRA-RED.¹

BY ARTHUR S. KING AND PAUL W. MERRILL.

THE presence of spark lines in the tube-arc spectrum, as previously observed by one of us has been found to extend through a long range of spectrum including the ultra-violet and the infra-red. The carbon spark lines are strong and much sharper than in the spark. Hence their wave-lengths can probably be more accurately determined from the tube-arc than from any other known source. Several new carbon spark lines have been identified. An interesting feature in the infra-red is the presence of numerous air lines, including the well-known oxygen triplet at λ 7770.

THE SPECTRA OF KRYPTON AND XENON IN THE INFRA-RED.¹

BY PAUL W. MERRILL.

THIS paper describes photographic measurements of the spectrum lines of krypton and xenon, principally in the red and infra-red, made at the National Bureau of Standards. There are numerous strong lines in this region in both spectra, most of which had not been previously observed.

Attention is called to a probable analogy between the spectra of the rare gases neon, argon, krypton and xenon which this investigation has brought to light.

A STUDY OF THE RELATIVE INTENSITIES OF SPECTRUM LINES IN DIFFERENT REGIONS OF THE ARC AS COMPARED WITH THEIR BEHAVIOR IN OTHER SOURCES.¹

BY PAUL W. MERRILL.

THIS paper deals with data concerning the strengthening of spectrum lines of iron, cobalt and nickel at the positive pole of the electric arc as compared with an adjacent region. It was found, in confirmation of results of other observers that "enhanced" or "spark" lines appear at the positive pole of the arc. Among the other lines the amount of strengthening at the pole was found to bear an interesting relation to Dr. King's classification based on the temperatures required to produce the lines in the electric furnace.

THE VAPOR PRESSURES OF HYDROGEN CHLORIDE AND HYDROGEN BROMIDE ABOVE THEIR AQUEOUS SOLUTION.¹

BY S. J. BATES AND H. D. KIRSCHMAN.

BY employing a method which avoided the errors due to the effect of spray and those due to the uncertainty in the volume of gas passed thru the apparatus, the vapor pressures of hydrogen chloride and of hydrogen bromide

¹ Abstract of a paper presented at the Pasadena meeting of the American Physical Society, June 19, 1919.

above their aqueous solutions was determined to two or three thousands of a millimeter over the concentration range from 4 to 10 mols per 1,000 grams of water. By combining the values for hydrogen chloride with the electromotive force data of Ellis, the free energy of hydrogen chloride is computed to be $-22,690$ calories.

PHYSICAL CONSTANTS PERTAINING TO THE OCEAN.¹

BY GEORGE FRANCIS MCEWEN.

PHYSICAL constants are fundamental data of the science of physics. They are essential for quantitative description of the behavior of substances. Refinement in physical measurements continually yields more accurate values. It also reveals the variable nature of quantities formerly regarded as constant, and shows the need of new constants. Under controlled conditions, approach seems to be had to constants, dependent only upon the nature of substances. Actually, however, all are more or less influenced by external conditions.

Quantitative expression of laws describing those cosmical or terrestrial phenomena involving correspondingly enormous magnitudes, require physical constants whose evaluation under controlled conditions is impossible. Coefficients of viscosity, conductivity, and diffusion applicable to oceanic conditions are of a much higher order of magnitude than values obtained from experiments necessarily limited to much smaller dimensions.

Moreover, ocean conditions found in a given locality or season are not sufficiently typical to be representative of other regions or seasons.

The high variability of these coefficients with respect to conditions in the sea, demands extensive and continuous "field" observations.²

Complicated as these facts are, encouraging results have already come from quantitative studies, not only in oceanography, but also in other geophysical investigations.

THE REFLECTIVE POWER OF METALS AND DIELECTRICS IN THE ULTRA-VIOLET.¹

BY E. P. LEWIS AND A. C. HARDY.

WHILE testing the photoelectric properties of methyl violet deposited as a mirror on a glass plate from an alcoholic solution it was found that 2 cm. of quartz cuts out about 90 per cent. of the effective radiation. Since Schumann found that this thickness cuts out practically all radiation

¹ Abstract of a paper presented at the Pasadena meeting of the Physical Society, June 19, 1919.

² For a detailed discussion of physical constants pertaining to the ocean see (McEwen, G. F., 1919, Ocean temperatures, their relation to solar radiation and oceanic circulation: Quantitative comparisons of certain empirical results with those deduced by principles and methods of mathematical physics (in press). Semicentennial Publications of the University of California.

below λ 1860, it seemed possible, by using a test electrode of this material with a sensitive electroscope, to determine the reflecting power of substances somewhat beyond the limit reached by Hulburt, about λ 1850. The source was a mercury arc in quartz, which appears to transmit radiation to about λ 1800 or slightly beyond. In some experiments the light was incident at an angle of 13 degrees, in others at 45 degrees. The methyl violet showed little evidence of fatigue, but the surface was renewed from time to time. In one series of experiments a polished iron electrode was used, in another one of zinc. As indicated by the greater reflecting power of the metals and the smaller reflecting power of other substances, the effective radiation with iron and zinc was of longer wave-length than in the case of the methyl violet. The silicon mirror was the plane polished surface of a large crystal, probably less perfect than the surfaces used by Hulburt. The speculum surface was that of an old mirror, repolished. At the limit observed by Hulburt, about λ 1870, the reflecting power of silicon was found to be about 60, but the curve falls so rapidly in this region that his results are not inconsistent with those given below, provided the effective radiation was of slightly shorter wave-length.

The reflecting power in percentages is given below:

	Methyl, 13°.	Violet, 45°.	Iron, 45°.	Zinc, 45°.
Silicon.....	25	31	35	44
Platinum.....	20	21	—	—
Speculum metal.....	9	10	11	18
Ordinary glass.....	13	13.5	11	10
Dense glass.....	10	—	—	—
Calcite.....	13	14	11	—
Quartz.....	9	10	9	—
Fluorite.....	7.5	8	8	—
Rock salt.....	8	9	9	—

Hulburt showed that the reflecting power of speculum metal is very low in this region, especially for old mirrors, even when repolished. For gratings which can not be repolished the efficiency must be very low, unless the reflectivity increases in the direction of short wave-lengths. The significant feature of the figures given above is that the reflectivity of glass exceeds that of speculum metal, and is still rising. It seems very probable that glass gratings will be found much better than those of speculum metal for the extreme ultra-violet, if difficulties of ruling can be overcome.

Calcite shows a high reflectivity, and, as we might expect, that of fluorite, quartz and rock salt is small. But even for these substances it exceeds that calculated from the index of refraction at λ 1850, indicating that absorption is rapidly increasing and metallic reflection beginning. Platinum, silicon and aluminum, continue to show greater reflectivity than glass, but the curve given by Hulburt falls off so rapidly that it is doubtful whether their supremacy over glass continues for any great distance in the extreme ultra-violet.

A methyl violet mirror showed a reflecting power of 17 per cent., indicating metallic reflection for the rays to which it is photoelectrically sensitive, as we might expect.

UNIVERSITY OF CALIFORNIA,
June, 1919.

DETERMINATION OF THE NORMAL TEMPERATURE BY MEANS OF THE EQUATION
OF THE SEASONAL-TEMPERATURE VARIATION AND OF A MODI-
FIED THERMOGRAPH RECORD.¹

BY FRANK L. WEST, N. E. EDLEFSEN AND S. P. EWING.

THE air temperature at a place of light rainfall is a periodic function of the time, there being two prominent periods, a twenty-four-hour period and an annual period. That part of the United States between the Rocky and the Sierra Nevada Mountains has a humidity of 50 per cent., a rainfall of from 10 to 20 inches, with more than 300 days of the year without rain.

The equation of the curve that represents the mean daily temperature in terms of the time of year for Utah, is

$$T = 48.5 - 22.2 \cos (\theta - 19^\circ - 54') - 2.7 \cos 2 (\theta - 149^\circ - 5') - 1.0 \cos 3 (\theta - 17^\circ - 3'), \quad (1)$$

the time θ being expressed in degrees. The equation is of rather general application because the first term is the mean annual temperature for the place considered (a function of latitude and elevation) and simply moves the curve up or down the page while the shape or amplitude is determined by the difference in temperature between summer and winter and varies at different places in the interior of the United States from the Salt Lake value by from one to four degrees.

The curve representing the twenty-four-hour temperature change modifies its shape gradually each day, flattening out as winter approaches, but the ratio of the hourly temperature to the mean daily temperature is nearly constant on any day of the year (for Fahrenheit scale only). The equation giving the temperature at any hour expressed as the percentage of the mean is as follows:

$$P = 97.3 - 25.2 \cos \theta - 67^\circ - 10' + 3.7 \cos 2 (\theta - 38^\circ) - 1.5 \cos 3 (\theta - 23^\circ - 16') \quad (2)$$

The two equations are empirical and were obtained by the method of the Fourier Series from the U. S. Weather Bureau data.

Variable diathermancy or cloudiness, evaporation or cloud formation, south or north winds are the main factors that cause variations from the normal. In short, cyclonic storms or rain cause the departures.

Applying these equations and then checking on the actual temperature experienced, the differences were from 1 to about 15 degrees with a mean de-

¹ Abstract of a paper presented at the Pasadena meeting of the American Physical Society, June 19, 1919.

parture of about 7 degrees. The chances in the arid West are one in six that the departure will be less than 2 degrees, two in five that it will be as much as 5 degrees, one in four that it will be as much as 10 degrees and one in seven that it will be 15 degrees. Very rarely is it more than 15 degrees. The probable temperature can be determined by modifying the normal temperature as determined above after consultation with the Weather Bureau as to whether the day in question is to be warmer or colder (as determined from their weather maps) than usual.

By long time averages, normals for climates not as dry as here in the West can be obtained, but rains and variable cloudiness cause rather wide departures from these normals. The above method would give a suggestion of what might be expected even in these places.

PHYSICS DEPARTMENT,
UTAH AGRICULTURAL COLLEGE,
LOGAN, UTAH, June 1, 1919.

FORMULA FOR THE WAVE-LENGTHS OF *M*-RADIATION.¹

BY FERNANDO SANFORD.

IT is known that the Einstein photoelectric equation $Ve = \frac{1}{2}mv^2 = h\nu$ applies to the energy of the inducing electrons and the frequency of the x-radiation in most cases of x-ray emission. The writer has previously shown that for cases where this law applies if the radiating electrons are in orbital motion about a central positive charge, so that $Qe/R^2 = mv^2/R$, where Q is the magnitude of the central positive charge and R the orbital radius, the magnitude of the central charge is given from the equation

$$Q = \frac{2^{1/2}h^{3/2}c^{1/2}}{\pi em^{1/2}\lambda^{1/2}}$$

Assigning the usual values to e , m and h , this gives

$$Q = \frac{2.882 \cdot 10^{-12}}{\sqrt{\lambda}}.$$

It has also been shown that the same value of Q may be calculated from the Moseley equation, where for the shortest wave-lengths in the *K*-radiation band $Q = 2e(N-3.6)$ and for the shortest wave-lengths in the *L*-radiation band $Q = e(N-15.4)$, where N is the serial number of the element from which the X-rays are derived.

In a paper by W. Stenström² is given a table of the wave-lengths of the characteristic M-radiation of a number of elements from $N=66$ to $N=92$. If Q be calculated for these lines by the above formula and be introduced into the Moseley equation, it gives $Q = 2.882 \cdot 10^{-12} / \sqrt{\lambda} = 2(N-19.47) \cdot 10^{-10}$ for the α -line of the M-radiation band. The wave-lengths of the α -lines of

¹ Abstract of a paper presented at the Pasadena meeting of the American Physical Society, June 19, 1919.

² Ann. d. Phys., 57, 372.

the M -radiation band may then be calculated from the equation

$$\lambda = \left(\frac{2.882 \cdot 10^{-12}}{2(N-19.47) \cdot 10^{-10}} \right)^2.$$

The following table gives the values of λ as observed by Stenström and the values of Q and λ as calculated from the above formulæ.

TABLE I.

Element.	N	λ , Obs.	$Q \cdot 10^{10}$	λ , Calc.
U	92	$3.919 \cdot 10^{-8}$	145.5	$3.46 \cdot 10^{-8}$
Th	90	4.131	142	4.16
Bi	83	5.125	127	5.13
Pb	82	5.302	125.5	5.29
Tl	81	5.471	123.2	5.47
Au	79	5.847	119	5.85
Pt	78	6.058	117	6.05
Ir	77	6.276	115	6.27
Os	76	6.508	113	6.50
W	74	7.007	108.7	6.97
Ta	73	7.272	106.6	7.27
Cp	71	7.856	102.9	7.84
Ad	70	8.162	101	1.15
Er	68	8.813	97	8.82
Ho	67	9.168	95	9.18
Dy	66	9.556	93.2	9.55

It will be seen that with the exception of the uranium line the two values of λ differ by less than the probable error of measurement. Stenström finds a line in uranium with a wave-length of 3.487, which is in better agreement with our calculated value for the α -line.

STANFORD UNIVERSITY,

June 9, 1919.

THE MOVEMENT OF MOISTURE IN SOIL BY CAPILLARITY.¹

BY WILLARD GARDNER.

FOR the motion of ground water through soils under hydrostatic pressure, it has been assumed, with considerable experimental support, that the velocity is proportional to the pressure gradient, Slichter² has observed that the pressure satisfies Laplace's equation and he has made some extended theoretical mathematical calculations for the flow of underground water.

The essential distinction between the case considered by Slichter and the

¹ Abstract of a paper presented at the Pasadena meeting of the American Physical Society, June 19, 1919.

² Slichter, Charles S., Theoretical Investigation of the Motion of Ground Water. 19th Annual Report of the U. S. Geological Survey of the U. S. Geological Survey, 1898, Part II., p. 330.

case of capillary flow is that the density function is dependent upon the space coordinates and also upon the time; also that the pressure is a function of the density. For the pressure gradient, a tentative function of the density and density gradient has been substituted, and the velocity is expressed in terms of the density and density gradient. A substitution of this value in the equation of continuity for the case of one-dimensional flow gives a differential equation involving moisture content, one-space coördinate, and the time. This equation is solved for the case of steady motion and experimental results are given for this case. It is pointed out that the equation for steady motion is parabolic in character, the value of the exponent depending upon the validity of the assumptions made. The experimental results indicate that the assumptions are approximately correct.

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