SCIENCE

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SPRINGFIELD MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SECTION B. PHYSICS.

THE address of the Vice-President, Prof. W. Le Conte Stevens, was upon 'Recent Progress in Optics.' He introduced the subject by referring to the impossibility of summarizing all of the work, even of a meritorious order, that has been accomplished, and preferred to discuss certain investigations of special merit. First among these was the standardizing of the metre in terms of a wave-length of light, an investigation begun by Michelson and Morley eight years ago, and recently completed by Michelson at the observatory of the International Bureau of Weights and Measures near Paris. A brief description was given of the construction and use of the interferential comparer, and the difficulties encountered in securing a perfectly homogeneous spectrum tint. Spectral lines that had been supposed to be single, and hence due to approximately homogeneous light, were found to be multiple, presenting the phenomenon of optical beats, or maxima and minima of brightness in the interference fringes that pass across the field of view in the observing telescope. So delicate is the method that it is possible to detect a variation of wave-length corresponding to as little as one-thousandth of the interval between the two main components of what is commonly known as the sodium line. The red line of cadmium was found the most nearly simple of all those examined, and the length of the standard meter was determined to be 1,553,163.5 wave-lengths of cadmium light. This was the mean of two independent

determinations differing from it about one part in two millions. This achievement is deemed a signal scientific triumph that ranks with the brilliant work of Arago, Fresnel and Regnault. In the conception, mechanical design and execution it is wholly and distinctively American; and it tends to do away with the reproach, too often deservedly cast against America, that our people have little appreciation for scientific work unless its value can be expressed in dollars.

The subject of luminescence was next taken up, in connection with important work done in Germany, by Wiedemann and Schmidt, and not yet fully published, with a view to clearing up the uncertainties regarding the nature of this in its two chief manifestations, phosphorescence and fluorescence. We have here, as in photography, a transformation of radiant energy; and it is shown that in a large proportion, if not all, of the cases examined, at least a part of the transformation is into chemical energy, to which is superadded the retransformation into energy of longer period; and this either at the same time or long after the action of the exciting rays. Many substances which manifest no luminescence at ordinary temperatures after exposure, or which do so for only a very short time, become distinctly luminescent when warmed, some even after the lapse of days or weeks. This thermo-luminescence is thus analogous to the chemical storage of electrical energy in an accumulator cell. The capacity for giving out colored light continues until the cessation of the chemical action thus brought into play. The effect of great depression of temperature is also considered, some remarkable results having been attained by Dewar on subjecting various luminescent substances to the temperature of liquid air.

By proper selection of luminescent salts it is possible to produce a selected series of tints during and after exposure to those spectrum rays which are most effective in photography; but such colors cannot be made fixed and permanent. The problem of securing on the photographic plate a faithful and lasting reproduction of the various hues of a spectrum thrown upon it has long baffled most of those who grappled with this subject. While not yet completely solved, it has been handled with much nearer approach to success during the last five years than during an equal number of decades previously. Two quite different methods are to be considered in tracing this success. The first, originally due to Becquerel, has been greatly improved by Lippmann in Paris. It depends upon the production of stationary waves of light. The theoretical possibility of producing these has long been apprehended, but demonstrated success was attained for the first time a few years ago by Otto Wiener, in Strassburg, a physicist whose admirable work in optics has received but little attention in America. The conditions requisite for success are here given, and Wiener's method is explained; as is also the application of his results to confirm the views of Fresnel, in opposition to those of Neumann and MacCullagh, in regard to the relation between plane of polarization and direction of vibration of polarized light, and in regard to change of phase in the reflection of light at the boundary between two media differing in density.

The theory of Lippmann's method of photographing in natural colors is now discussed, but the conclusion is expressed that the method cannot long remain practically important because, like the daguerreotypes of fifty years ago, these colored photographs are incapable of multiplication. Wiener has lately published an elaborate research upon this subject, in which he recognizes the necessity for the employment, not of interference colors, but rather of what he

calls body colors (Körperfarben) due to chemical modification of the reflecting surface. While it is abundantly possible that colored illumination upon suitable color-receptive materials can give rise to similar body colors, we are still far from having these materials under control. There seems at present to be greater promise in a second and quite different application of optical principles, that of taking three separate negatives simultaneously from the same object through color screens appropriately chosen in accordance with the Helmholtz theory of color. The positives from these, taken on suitably dyed plates, are then superposed; or light transmitted through the negatives is combined by an appropriate instrument, as in the method of F. E. Ives, which was explained. This solution of the problem gives very beautiful results, but the necessity for an auxiliary instrument interferes with its general availability. It does not seem probable therefore that photography in colors will soon interfere seriously with that photography in light and shade with which most of us have had to content ourselves thus far.

Investigations in the infra-red region of the spectrum were now considered, the foremost place being given to Langley's recent work, which will undoubtedly make it possible to determine in large measure to what extent the cold bands in the heat spectrum are due to atmospheric absorption, and which of them are produced by absorption outside of the earth's atmosphere. Notice was given to the work of Snow, Rubens, Angström, Paschen and Percival Lewis in their studies of the infra-red spectra of various chemical elements.

In regard to the visible spectrum, reference was made to Rowland's extensive work in the determination of wave-lengths for all the chemical elements; to the recent discovery of argon and helium; to the grouping of spectral lines by Kayser and Runge; to Keeler's spectroscopic study of Saturn's rings, and Hale's use of the spectroheliograph.

In the domain of polarized light the work of Nichols and Snow, of Merritt, of Marston and of Crehore was duly noticed, including the application to gunnery.

Physiological optics is a subject too large to receive its proper share of attention in an address chiefly on physical optics. Mrs. Franklin's theory of light sensation was discussed, and a brief account was given of Mayer's ingenious experiments on simultaneous color contrast, which have been confirmed by the experiments of the author. Reference was then made to Ferry's law of retinal persistence, and its application to the explanation of the 'artificial spectrum top,' which has excited such general interest during the last year. That it should have been copyrighted is deemed a precedent that may yet result in an attempt to copyright the solar spectrum.

IN addition to the address of the Vice-Preisdent twenty-five papers were read in full and three by title, about the same number as last year at Brooklyn.

1. *Expansion of Jessop's Steel, Measured by Interferential Method* (30 m.), by E. W. MORLEY and WM. A. ROGERS. The Fizean method with numerous adaptations and improvements was employed to determine the thermal expansion of Jessop steel, with the result that the measurement of the elongation is now much more accurate than the temperature observations. The latter appears to be correct to $\pm 0.1°$C. and hence the coefficient of expansion is correct to 0.1%; which is about the accuracy at present attained by other methods. The authors expect to improve the thermometric part of the apparatus and attain an accuracy much greater than at present.

2. *Flow of Alternating Currents in an Electric Cable* (20 m.), by M. I. PUPIN. This

question has heretofore been treated only mathematically and without considering the end conditions, and hence no satisfactory conclusions have been reached. The author treats the current in a cable like a swinging string and similarly introduces the members representing the end conditions. The result of the analysis shows that the representative curves are produced by superimposing a sine curve upon a catenary. Experimental measurements upon an artificial cable, with rates of alternation between 650 and 3,000 verified the analytical conclusions very beautifully.

3. *The Most General Relation between Electric and Magnetic Force and their Displacements* (20 m.), by M. I. Pupin. It was shown that the difference between Maxwell's ideas concerning electricity and those of his predecessors lies in the form and in the extension of his considerations to the medium. The author believes that by a suitable extension of the equations of condition of the ether the phenomena of light can be more simply explained by the electro-magnetic theory than by the elastic solid theory.

4. *Relations of the Weather Bureau to the Science and Industry of the Country* (15 m.), by Willis L. Moore.

5. *Solar Magnetic Radiation and Weather Forecasts* (15 m.), by Frank H. Bigelow.

6. *Clouds and Their Nomenclature* (20 m.), by Cleveland Abbe.

7. *Cloud Photography* (10 m.), by Alfred J. Henry.

Numbers 4, 5, 6 and 7 were read before a joint session of Sections A, B, E and I, and will receive ample attention elsewhere.

8. *A New Apparatus for Studying Color Phenomena* (30 m.), by E. R. von Nardroff. This consists of a mechanism by which three beams of light are taken from the condenser of a projection lantern, and controlled as to intensity by diaphragms and as to color by various colored screens. These beams then fall upon a distant screen and may be caused to appear distinct or overlapped and combined, and afford an excellent means for studying a large variety of color phenomena.

9. *Voice Production with Photographs of the Vocal Cords in Action* (15 m.), by F. S. Muckey and W. Hallock. It is ordinarily assumed that increase of tension is the only means provided for raising the pitch of the note sung. Dr. Muckey has found that with proper training the arytenoid cartilages may be rotated, thus shortening the effective length of the cord, and probably also lightening its weight by holding the thicker muscular part of the cord. The photographs verify the conclusions as to the rotation and shortening of the cords.

10. *Note on the Limits of Range of the Human Voice* (5 m.), by W. Le Conte Stevens. The author finds the singing limits to be from 43 to 2,048 vibrations per second, and has observed the squeal of a child as high as 3,072 per second.

11. *Voice Analysis with Photographic Record* (20 m.), by F. S. Muckey and W. Hallock. Resonators tuned to the pitch of bass C and its seven first overtones are provided with manometric capsules of improved form and adaptation. While this note (128 per sec.) is sung on different vowels and by different singers the flames are photographed as described in the 'Physical Review,' Vol. II., p. 305. In this way many negatives have been obtained illustrating the different *timbre* or *klangtint* of the vowels and voices. Many more must be taken before reliable conclusions can be drawn.

12. *The Reproduction of Colors by Photography* (60 m.), by F. E. Ives. By taking negatives through color screens, and then projecting the pictures through similar screens and superimposing upon the screen, effects are obtained which are very wonderful, though not entirely above criticism. A similar process has been applied to the stereoscope, giving better results.

13. *Color Definitions for the Standard Dictionary* (10 m.), by W. HALLOCK and R. GORDON. Disks painted with English vermilion, mineral orange, light chrome yellow, emerald green and artificial ultra-marine blue, in a *thick* solution of gum arabic, have had their wave-length determined. These combined with white, and a disk covered with lamp black and shellac, enable one to place such combinations upon a rotation machine as to match any color in nature or art. This process was applied to the study of 6,000 samples of colored objects resulting in formulæ for some 500 named colors.

14. *On Standard Colors* (20 m.), by J. H. PILLSBURY. The author urges correct and scientific teaching of color especially in early youth, approving the use of Maxwell disks, printed red, orange, yellew, blue and violet, by lithography, with black and white.

15. *Significance of Color Terms* (15 m.), by J. H. PILLSBURY. The uncertainty attached to color nomenclature was pointed out and the desire expressed that it should be removed by the introduction of a method of definition similar to that explained in the previous paper (No. 14). Numerous illustrations were given showing varieties of colors, including some well-known flowers.

16. *On the Comparison in Brightness of Differently Colored Lights and the 'Flicker Photometer'* (20 m.), by FRANK P. WHITMAN. A very interesting and successful comparison test of the Rood flicker photometer, an ingenious device of rotating semi-disc, allowed the easy and accurate comparison of lights, etc., upon an ordinary photometer bench. The tests upon the colors of the spectrum brought out the accepted maximum of luminosity in the yellow, and also showed a slight increase in luminosity at the extreme violet. It must, however, be said that these measurements were made upon colored papers and not upon the spectrum itself.

17. *Observation on the Relations of Certain Properties of Line Spectra to the Physical Conditions under which they are Produced* (20 m.), by J. F. MOHLER and W. J. HUMPHRIES. Experimenting upon the spectra of metals under pressures of air up to 15 or 20 atmospheres, certain widenings and displacements of the lines were noted, and an increasing similarity in appearance to the solar spectrum.

18. *An Experimental Investigation of the Rotary Field* (20 m.), by H. S. CARHART. An iron ring wound with a continuous coil tapped at four, six, or more points combined with an ingenious commutator furnished a rotary field that could be stopped and studied at any instant. The photographs of iron filings in the field, show a 'measuring worm motion' of the poles, with no essential difference between the two and three phase connection.

19. *Electrolytic Reproduction of Resonators* (5 m.), by W. HALLOCK. A wax ball is turned the size and shape of the spherical resonator, and then copper plated. After melting out the wax, the resonator is tuned by cutting off the lip of the mouth.

20. *A Photographic Method of Comparing the Pitch of Tuning Forks* (5 m.), by W. HALLOCK. Each fork is clamped before a manometric capsule, bowed, and the flames photographed, and the relative number of vibrations counted.

21. *Illustration of Gems, Seals, etc.* (5 m.), by W. HALLOCK. An impression of the gem is taken in the transparent wax, used first by O. N. Rood, and this is photographed by transmitted light in an enlarging camera.

22. *An Examination of the Statement of Maxwell that all Heat is of the Same Kind* (15 m.), by WM. A. ROGERS. The author argues, from his observations with his interferential comparator, that heat of radiation is different from heat of air contact and should be measured in a different unit.

23. *Phenomena of Electric Waves Analogous to those of Light with a Diffraction Grating*

(20 m.), by C. D. Child. A Righi vibrator and a tinfoil receiver were used to study the diffraction of electric waves by a tinfoil grating. The apparatus worked quite well and the resulting wave-length determinations were satisfactory.

24. *The Effect of Age upon the Molecular Structure of Bronze, Glass and Steel* (10 m.), by Wm. A. Rogers. As a result of comparisons extending over a period of five years, the author concludes that our fear as to the molecular changes of length of our standards is not well founded.

25. *A New Determination of the Relative Length of the Yard and Metre* (8 m.), by William A. Rogers. A new determination gives the metre as equal to 39.37015 inches, slightly different from the accepted international value, 39.3700, which, however, is being reviewed by the Bureau which may confirm the author's value.

The following papers were read by title:

26. *California Electric Storms* (20 m.), by John D. Parker.

27. *A New Formulation of the Second Law of Thermodynamics*, by L. A. Bauer.

28. *The Method of Reciprocal Points in the Graphical Treatment of Alternating Currents*, by Frederick Bedell.

It will be seen that the papers were of unusual interest, and they provoked much careful discussion. The attendance was large, ranging from 40 to 60, and the number of specialists present was remarkable.

A motion by William Orr, Jr., of Springfield, resulted in the appointment by the Council of the following committee to consider standard colors and color nomenclature; O. N. Rood, chairman; W. Le Conte Stevens and W. Hallock. Similarly a motion by H. S. Carhart, of Ann Arbor, resulted in the appointment of a committee upon electrical and other standards, consisting of T. C. Mendenhall, chairman; William A. Rogers, H. A. Rowland, H. S. Carhart, E. L. Nichols and R. S. Woodward, with power to add a seventh.

William Hallock.

SECTION C. CHEMISTRY.*

The address of the Vice-President of the Section, Dr. William McMurtrie, of Brooklyn, has been already printed in Science, September 6th. Owing largely to the efforts of the Vice-President and of others under his direction in preparing for the meeting, the attendance at the sessions of the Section was large and the papers presented were of more than usual interest.

FRIDAY MORNING, AUGUST 30.

The first paper was by Professor W. P. Mason, of Troy, N. Y., 8 on 'Foreign Laboratory Notes.' He spoke of recent experiments in Paris showing the effect of the liver in stopping poisons in the organism; also that it has been shown that urea is not toxic in action. Diagrams were distributed showing the way in which the number of deaths of children corresponds to the percentage of samples of bad milk found by the public analysts.

New methods used in Paris for the examination of potable waters were spoken of and Miquel's theory of the auto-contamination of waters was refered to.

Mrs. Ellen H. Richards and J. W. Ellms, of the Massachusetts Institute of Technology, read a paper on 'The Coloring Matter of Natural Waters, its Source, Composition and Quantitative Measurement.' The colors appear to be formed by the partial carbonization of organic matter. A series of natural waters furnishes the best secondary standard. Such standards fade and must be replaced at least once in six months. The tintometer is very satisfactory for making the comparison. The colors obtained

* Reported by W. A. Noyes, A. H. Gill and Francis C. Phillips.