

REVIEWS

Handbuch der Spectroscopie. Von H. KAYSER. Erster Band.
Hirzel, Leipzig, 1900.

THE year 1859 is not likely to be soon forgotten in the annals of science. For though many years separate Lamarck and Buffon from Darwin, and though nearly half a century intervenes between Fraunhofer and the work of Kirchhoff and Bunsen, we must still reckon from 1859, the establishment of the modern evolution theory and the discovery of modern spectroscopy. The forty years of history which have been made since then illustrate well the difference between ideas which deal only with "dead matter" and those which touch the life-history of the individual and of the race.

Since the *Origin of Species* was first published, the press has poured forth a stream of literature—of which a volume a day would probably not be an overestimate—dealing principally with the developmental hypothesis. On the contrary, one might almost count upon the fingers of his two hands all the treatises, popular or technical, dealing with the subject of spectrum analysis. Among the names which occur to everyone are Schellen, Roscoe, Lommel, H. W. Vogel, Schuster, Kayser (*Lehrbuch*), Scheiner, v. Konkoly, Young, Huggins, and Lockyer. Besides the volumes associated with these names, almost the entire literature of the subject is contained in highly specialized memoirs. Some faint idea of the extraordinary amount of spectroscopic work hidden away in the journals of chemistry, physics, and astronomy may be obtained from the fact that the author of the work under review finds no less than five octavo volumes necessary to contain a brief survey (*Uebersicht*) of what has already been achieved, and achieved principally in the last forty years.

Rarely has a more fortunate combination of talent and time ever been brought to bear upon such a task. For the author himself, one of the foremost spectroscopists of the world, frankly informs his readers that he has given to this work a large part of his time during the past ten years, believing that in so doing he was serving science to better advantage than in pushing his own investigations. Whether workers

in this science concur in this judgment, they must admit themselves under deep personal obligations to Professor Kayser for what must have been to him a deep personal sacrifice. To a man whose brain is full of unsolved problems, and who is well equipped for their solution, ten years is a long stretch; and the task is perhaps less than half completed.

The present volume deals only with the history of the subject and with the description and theory of the apparatus employed. But the completeness of the treatment is such that if the other volumes are carried out in the same manner, it will be practically possible to say that a certain experiment has, or has not, been tried according as it is, or is not, "found in Kayser."

The first chapter clears the ground for all those which follow by placing before the reader an outline history of the entire subject. This sketch, occupying some 128 pages, takes up all the more important advances included between the work of Newton and the discovery of Zeeman. The arrangement is in nearly chronological order of the men who made the advances.

The second chapter deals with the three principal methods of producing luminous vapors, namely, the flame, the arc, and the spark. The eminent propriety of beginning the actual discussion of the subject with such a chapter will appeal to everyone who agrees with the logic of one who makes the capture of the hare the first item in the recipe for rabbit pie.

The phase of the subject here treated is not the mechanics of luminosity, but rather the various radiant sources at our disposal in the laboratory. So far from being a mere description of apparatus, every page is marked by keen judicial opinions and exhaustive references. But amidst all this array of devices for producing light, the description of which occupies more than a hundred pages, nothing perhaps is so impressive as the large number of contradictory views and *apparently* contradictory facts, compelling the author to insist, time and again, upon our almost entire ignorance of what is going on in either arc or spark. Speaking of the discharge in a vacuum tube (p. 203) he says: "Wir bewegen uns fast durchweg auf dem Boden von Hypothesen, denen andere ziemlich ebenso gut berechnete gegenüberstehen." Again (p. 243), speaking of the fickle character of this discharge: "Es darf freilich nicht vergessen werden, wenn man diese Veränderlichkeit der Geisslerröhren bespricht, dass sehr Vieles von unserer

mangelhaften Kenntniss der Gasspectra herrührt." And still again (p. 248), speaking of the effects of pressure, temperature, foreign gases, etc.: "Aber wir wissen über alle diese Verhältnisse noch so gut wie gar nichts."

The complexity of the process going on in a spark between pure carbon poles in ordinary (moist) air is strikingly illustrated by the list of spectra (p. 214) obtained by Eder and Valenta under these conditions, viz.:

1. The line spectrum of carbon.
2. The banded spectrum of carbon.
3. The cyanogen bands.
4. The line spectrum of air.
5. The banded spectrum of water vapor, together with hydrogen and oxygen lines.
6. The banded spectrum of nitrogen at the positive pole.
7. The emission spectrum of ammonia when the electrodes are moistened.
8. The spectrum of carbon monoxide in the aureole of the spark.
9. And, in closed vessels, the absorption spectrum of nitrous acid.

The student who first attempts the separation of some of these spectra is brought very keenly to realize the wide gulf which at some point exists between spectroscopic theory and spectroscopic practice.

The third chapter, written by Dr. H. Konen, of Bonn, is entirely devoted to one of the two dispersion pieces, viz., the prism. Besides a complete account of the history and literature of the subject, one finds here an exceedingly clear discussion of dispersion and deviation along the lines laid down by Czapski in his *Theorie der optischen Instrumente*; and, what is perhaps more important to the spectroscopist, a full account of the results of Helmholtz and Rayleigh concerning resolving power, purity, and intensity. A compendium so complete as this on the various forms of prisms ought certainly to prevent, in the future, the frequent duplication of work which this and the other chapters of this volume have made evident. One form of prism originally devised by Brewster is mentioned as having been reinvented by no less than three different men.

A fourth chapter of nearly a hundred pages devoted to the diffraction grating completes the discussion of dispersion pieces. Here we find four sections dealing in turn with the manufacture of gratings, plane gratings, curved gratings, and the echelon of Michelson. So far as your reviewer is aware, this is the only single volume, in any

language, which presents a fairly complete account of what is known about gratings. Fraunhofer's work naturally forms the introduction; and those who have not read Fraunhofer's original papers (or Ames' translation in Harper's *Scientific Memoirs*) will be astonished at the thoroughness with which he covered the entire field of the grating and with the variety of forms which he manufactured and studied.

Here, too, will be found Rowland's powerful paper on the plane grating (*Astronomy and Astro-Physics*, 1893). The reader who approaches this paper only through the German will remain blissfully unconscious of how much time Professor Kayser has saved him by filling in a number of gaps and by correcting numerous typographical errors in the original. Then follows Cornu's elegant method of discussing the focal properties of both plane and curved gratings in one general equation, a paper which was translated in *Astronomy and Astro-Physics*, 1894.

Instead of Rowland's original handling of the curved grating (*Phil. Mag.*, 1883) the author wisely adopts the totally different and more elegant treatment of Runge, already familiar to the spectroscopic world through Kayser's article in Winkelmann's *Handbuch*. Near the end of this chapter the author offers, from his own experience, some excellent suggestions regarding the adjustment of the concave spectrograph.

The fifth chapter, dealing especially with the design and theory of the spectroscope, contains, in its first section, a description of practically every type of spectroscope ever made, together with numerous ones that never have been made. The second section, dealing with the ideas of purity and resolving power, as introduced by Helmholtz and Rayleigh and extended by Schuster, is one of the most valuable in the entire volume. Here, too, will be found a systematic account of the masterly manner in which Wadsworth has cleared up and perfected this whole subject.

Space permits us barely to mention some of the more important topics treated in the remaining sections of this chapter, namely, the interferometer—and Michelson's analysis of individual lines—the work of Higgs, Abney, and Schumann, the measurement of spectrograms, the automatic comparator of Kayser, and the bolometer.

The sixth and last chapter deals with the latest and finest achievements of spectroscopy considered as a quantitative science: and if we admit that the question *how?* can seldom be answered until after

the question *how much?* has been answered, we may reckon this the most fundamental chapter in the volume. Your reviewer is not familiar with any opinion in the literature of physics which combines in greater degree a judicial attitude of mind, critical acumen and complete impersonality than does the author's survey of the work which has been done on the measurement of the absolute wave-length of light. Naturally Bell's determination is given first place among all values obtained by means of a grating. However, excellent reasons are advanced for thinking that the highest possible accuracy attainable with this instrument is one-tenth of an Ångström unit. Indeed, the discrepancy between the values of Bell and Michelson, for the absolute wave-length, may be considered a closed chapter. For here one may find the facts concerning the grating and may find also that Michelson, in the superb and powerful method which he employed at Breteuil, left no room for an error as great as the one-hundredth part of an Ångström unit, in his final figure.

The standard relative values of Rowland, together with the corrected wave-lengths for the iron lines recently given by Kayser, are next taken up. The volume closes with a brief review of measurements in the ultra-violet and in the infra-red. An ample index of authors and subjects saves one that final disappointment which too often accompanies the closing of an English or a French book.

Concerning the volume as a whole, a reader gets the impression that the author has gone through the entire periodical literature of physical science with a drag net from which nothing has escaped.

The result is that these pages contain some matters which will probably prove new to the most accomplished spectroscopists of the world. In short, the work is of such a character that its possession is not only desirable but indispensable to every serious student of this science.

H. C.