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Part One: 1869-1893

Volume 1

CHARLES SANDERS PEIRCE: CONTRIBUTIONS TO THE NATION: 1869

9 (22 July 1869) 73-74: ROSCOE'S SPECTRUM ANALYSIS

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9 (22 July 1869) 73-74: ROSCOE'S SPECTRUM ANALYSIS

Spectrum Analysis. Six Lectures delivered in 1868, before the Society of Apothecaries of London.

By Henry E. Roscoe, B.A., Ph.D., F.R.S., Professor of Chemistry in Owens College, Manchester. New York: D. Appleton & Co. 1869.

CSP, identification: Haskell, *Index* to The Nation. See also: Burks, *Bibliography*; Fisch and Haskell, *Additions to Cohen's Bibliography*.

Sir Henry Enfield Roscoe (1833-1915) was a chemist of great renown, having been graduated with honors from University College, London, in 1852, at which time he undertook work with R. W. von Bunsen in Heidelberg, an association which resulted in important scientific advances. In 1857 he was elected to the chair of chemistry at Owens College. Manchester. He was knighted in 1884, and elected Member of Parliament for South Manchester in 1885. While in Parliament, he supported and sponsored many articles of industrial reform legislation.

The sudden impulse which spectroscopic researches received in 1860, and which has resulted in several brilliant discoveries in chemistry and astronomy, affords a singular problem in the history of scientific progress. There was nothing absolutely new in the method of Kirchhoff and Bunsen. It consisted essentially in observing the spectra of the colorations imparted by different substances to the non-luminous gas-flame generally used in laboratories. Colored flames had been used since an early period in the history of chemistry for distinguishing the different alkalies and alkaline earths; and J. F. W. Herschel in 1822, H. F. Talbot in 1826, and W. A. Miller in 1845, had made some study of the spectra of these flames with reference to chemical analysis. The black lines of the spectra of some of the stars had been examined by Fraunhofer, and found to differ from those of the examined by Fraunhofer, and found to differ from those of the spectrum common to the sun, moon, and planets. The absorption-lines produced by some gases had been studied by Brewster; and Stokes had pointed out the use of absorption-bands in detecting certain metals in solution. The coincidence of the bright line of incandescent sodium vapor with the D line of the solar spectrum had been noticed by Fraunhofer; and Stokes and William

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Thomson thence inferred that sodium was contained in the atmosphere of the sun, because a substance can only emit what it is capable of absorbing.

These investigations appertain to all parts of spectral analysis. Why, then, did they remain comparatively unfruitful while the very first memoir of Kirchhoff and Bunsen created a sensation such as the scientific world had not felt since the discovery of Neptune? Kirchhoff himself seems to think that it was because he and Bunsen first clearly showed that the positions of the spectral lines depend solely upon the chemical constituents of the glowing gases. No doubt, the effect upon the imagination of so broad a proposition upon a new matter of science is great, yet the habitual reliance by chemists upon the flame reaction of sodium seems to show that this law had been implicitly assumed upon all hands to be true in practice. Perhaps the chief causes of the profound impression produced by Kirchhoff and Bunsen's papers were these three: 1st, The flame of the Bunsen burner, which was employed by them, was capable from its intense heat and small lighting power of giving much more satisfactory results than the alcohol flames used by the early experimenters; 2d, The new investigations were conducted with a tact and thoroughness which commanded admiration; and 3d, Bunsen had the good fortune and the skill to detect by the new method two metals--rubidium and caesium--before unknown, in some mineral water he was analyzing, the mixed chlorides of these metals being contained in the proportion of about a drachm in twenty tons of the water.

Bunsen not only discovered these elements, but studied them so well (working partly in company with Kirchhoff) that they are now among those whose chemical relations are the best understood. They have been found to be somewhat widely distributed through the mineral kingdom in very small quantities. An Italian mineral, which had formerly been analyzed by the celebrated mineralogist Platner, has been found to contain 34 per cent of the oxide of caesium, which had been mistaken for potassa. Platner's analysis did not add up 100 per cent at all correctly, owing to the great difference in the combining numbers of potassa and caesium. Many a chemist would have been ashamed to own such an analysis; Platner was willing to publish a work which there was no other reason for condemning than one which was perfectly patent, and the result is that time has shown that his experiments were correctly performed. In 1861, an English chemist, Crockes, hardly known before, discovered by means of the spectroscope another metal (thallium) of very singular chemical characters; and this is a discovery which may lead to others, for with thallium a glass has been made which is reported as wonderfully adapted for prisms. In 1863, a fourth metal--indium--resembling zinc was discovered by means of the spectroscope in the zincblende of Freiberg.

The study of the celestial spectra has afforded important information concerning the sun, the stars, the nebulas, some comets, and the aurora borealis. We have learned that many chemical elements which are found upon the earth exist in the atmosphere of the sun, including nearly all of those which form a large proportion of the earth's crust. We have also ascertained, what might have been known *a priori*, that the most elastic of the gases (hydrogen) extends higher from the sun's

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centre than any of the other substances. The solar spots are getting examined; and if some observations lately reported are confirmed, we shall have some of the theories upon this subject brought to a test. In the stars have been recognized a number of the chemical elements which we know; yet in many of them some of the commonest substances here, and those most essential to life as we know it, are altogether wanting. A displacement of one of the hydrogen lines in the spectrum of Sirius is held to prove that that star is moving rapidly towards our system. The nebulas have been found to be of two entirely different kinds; for the spectra of some of them have been found to consist of isolated bright lines, showing that these nebulas are gaseous, while by far the larger proportion show the continuous spectrum which is seldom produced by an incandescent gas. This difference between the spectra corresponds strictly to a difference between the ordinary telescopic appearances of the nebulas. This is the more interesting, as the first proposition upon which Sir William Herschel founded his nebula hypothesis was that there was no natural classification among nebulas. None of the nebulas have been proved to contain any substance otherwise known to us. Several minute comets have been subjected to spectroscopic examination, and two of them have been shown to contain carbon in some gaseous state. The spectrum of the aurora, as usually seen, consists of a single yellowish-green line, which belongs to no substance with which we are acquainted. As the aurora is held to be above the ordinary atmosphere (and this is confirmed by its showing no nitrogen lines), it follows that there is some unknown gas reaching above the other constituents of the atmosphere. According to the laws of gravity and of diffusion of gases, this substance must extend down to the surface of the earth. Why, then, have not chemists discovered it? It must be a very light elastic gas to reach so high. Now, the atomic weights of elementary gases are proportional to their density. It must, then, have a very small atomic weight. It *may* be as much lighter than hydrogen as hydrogen is than air. In that case, its atomic weight would be so small that, supposing it to have an oxide on the type of water, this oxide would contain less than one per cent of it, and in general it would enter into its compounds in such small proportions as almost infallibly to escape detection. In addition to the green line usually seen in the aurora, six others were discovered and measured at the Harvard College Observatory during the brilliant display of last spring, and four of these lines were seen again on another occasion. On the 20th of June last, a single narrow band of auroral light extended from east to west, clear over the heavens, at Cambridge, moving from north to south. This was found to have a continuous spectrum; while the fainter auroral light in the north showed the usual green line.[†*]

Professor Roscoe's book contains an interesting and very thorough account of spectrum analysis. The paper, ink, type, and plates are beautiful. In his style, Mr. Roscoe neither aims at sensational effect, nor so strains after simplicity as to verge upon baby talk. And these are the two commonest faults of popular science. The only exaggeration which we have noticed is in the chromo-lithograph

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of the spectrum of nebula. If the book be taken into a nearly dark room, so that at first glance nothing is seen but the dark oblong shapes of the whole spectra of that plate, the figure in question *will* "serve to give some idea of the peculiar beauty of the phenomenon in question." The lines in the spectrum of Sirius, on the same plate, are made much too distinct, both absolutely and relatively to the other stars.

The practical spectroscopists will find here an exceedingly convenient repertory of facts. Kirchhoff's chart of the solar spectrum, with the extension of Angstrom and Thalen, is very beautifully reproduced in miniature. Huggin's maps of the metal lines are given in a form far more convenient for use at the spectroscope than the two folding sheets in a huge quarto in which alone they have hitherto been published. The numerical tables in full accompany both sets of maps. It is much to be regretted that Dr. Gibb's important tables for the comparison of Kirchhoff's, Huggins's, and the Normal scales have not been given. We should also have been glad to have Thalen's metallic spectra. At the end of the book there is a "List of Memoirs, etc., upon Spectrum Analysis." This is certainly valuable, and appears to be full. We observe, however, the omission of Stoke's paper upon the absorption-bands as a reagent, and also of **Secchi's** catalogue of the spectra of the stars. As the work contains little about the spectra of particular celestial objects, the last-named paper might well have been translated and inserted in full, with notes.

Professor Roscoe's book may truly be said to be popular and scientific at the same time. And we call it scientific, not only because it is a thorough account of the facts, but also because it contains long extracts from the original memoirs of the serious workers in this branch of science. There is, doubtless, a vast difference between that knowledge of scientific research which comes of actual practice and that which recommends this book to general readers. No one need be scared by a fear that it is mathematical, for everything which borders upon that subject is omitted. There is nothing about the angles of prisms, the theory of exchanges, or the theory of the displacement of lines owning to the motion of the source of light.

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