11. *Molecular Velocities.—*A. Schuster and G. A. Hemsalech@@1 have measured the velocity with which the luminous molecules are projected from metallic poles when a strong spark is passed through the air interval which separates the poles. The method adopted consisted in photographing the spectrum on a film which was kept in rapid motion by being attached to the front of a rotating disk. The velocities ranged from about 400 to 1900 metres, the metals of small atomic weight giving as a rule the higher velocities. In the case of some metals, notably bismuth, the velocity measured was different for different lines, which seems intelligible only on the supposition that the metal vapour consists of different vibrating systems which can differ with different velocities. C. C. Schenck@@2 subsequently conducted similar experiments, using a rotating mirror, and though he put a different interpretation on the effects, the main con­clusions of Schuster and Hemsalech were not affected. These have further been confirmed and extended by the experiments of J. T. Royds made with the same rotating disk, but with im- proved optical appliances. The photographs taken by Royds show the separate oscillations of each spark discharge even when the circuit only contained the unavoidable capacity of the leads. It was found that during the successive electrical oscillations the metallic lines can be observed to stretch farther and farther away from the poles, thus giving a measure of the gradual diffu- sion of the metal. The subject wants further investigation, especially with a view to deciding the connexion between the molecular rush and the discharge. λVhile some of the phenomena seem to indicate that the projection of metallic vapours into the centre of the spark is a process of molecular diffusion independent of the mechanism of the discharge, the different velocities obtained with bismuth, and the probability that the vibrating systems are not electrically neutral, seem to indicate that the projected metallic particles are electrified and play some part in the discharge.

12. *The Zeeman Effect.—*The change of frequency of oscilla­tion of radiating molecules placed in a magnetic field, which was discovered by P. Zeeman, and the observed polarization of the components, arc all beautifully explained by the theory of II. A. Lorentz, and leave no manner of doubt that the radiating centres are negative electrons. The fact that in certain simple cases where a line when looked at equatorially splits into a triplet, the ratio of the charge to the mass is found by Lorentz’s theory to be equal to that observed in the carrier of the kathode ray, shows that in these cases the electron moves as an independent body and is not linked in its motion to other electrons. On the other hand, most of the lines show a more complicated structure in the magnetic field, suggesting a system of electrons rather than a single free corpuscle. The question has been fully discussed by C. Runge in the second volume of Kayser’s *Handbuch* (see also Magneto-Optics), and we may therefore content ourselves with the mention of the law discovered by Th. Preston that all the lines of the same series show identical effects when measured on the frequency scale, and the fact recently announced by Runge@@3 that even in the more compli­cated cases mentioned some simple relation between the distances of the components exists. If *a* is the distance shown by the normal triplets the type of separation observed in the line D2 shows distances from the central line equal to a∕3, 3α∕3, 5α∕3, while the type of D1 gives 2α∕3, 4α∕3. In all observed cases the distances are multiples of some number which itself is a sub-mutiple of *a.* The component lines of a band spec- trum do not as a rule give the Zeeman effect, and this seems to be connected with their freedom from pressure shifts, for when Dufour had shown that the bands of the fluoride of calcium were sensitive to the magnetic field, R. Rossi@@4 could show that they were also sensitive to pressure.

13. *Identification of Spectra.—*The interpretation of spectroscopic observation seemed very simple when Kirchhoff and

Bunsen first announced their discovery, for according to their view every combination of an element showed the characteristic spectrum of its constituent atoms; it did not matter according to this view whether a salt, *e.g.* sodium chloride, introduced into a flame, was dissociated or not, as in either case the spec­trum observed would be that of sodium. It was soon found, however, that compounds possess their own characteristic spectra, and that an element may give under special conditions of luminosity several different spectra. When we now speak of the identification of spectra we like to include, wherever possible, the identification of the particular compound which is luminous and even—though we have only begun to make any progress in that direction—the differentiation between the molecular or electronic states which yield the different spectra of the same element.

One preliminary question must first be disposed of. The fact that the gases with which we are most familiar are not rendered luminous by being heated in a tube to a temperature well above a white heat has often been a stumbling block and raised the not unreasonable doubt whether approximately homogeneous oscillations could ever be obtained by a mere thermal process. The experiment proves only the transparency of the gases experimented upon, and this is confirmed by the fact that bodies like bromine and iodine give on heating an emission spectrum corresponding to the absorption spectrum seen at ordinary temperatures. The subject, however, required further experimental investigation, which was supplied by Paschen. Paschen proved that the emission spectra of water vapour as observed in an oxyhydrogen flame and of carbon dioxide as observed in a hydrocarbon flame may be obtained by heating aqueous vapour and carbon dioxide respectively to a few hundred degrees above the freezing point. The same author proved that a sufficient thickness of layer raised the radiation to that of a black body in agreement with Kirch- hoff’s law. The spectra experimented on by Paschen were band spectra, but as these split up into fine lines' the possibility of homogeneous radiation in pure thermal oscillation may be con- sidered as established. Paschen’s observations originated in the desire to decide the question raised by E. Pringsheim, who, by a series of experiments of undoubted merit, tried to establish that the emission of the fine spectra of the alkali metals was invari­ably associated with a reduction of the metallic oxide. Pring- sheim seems, however, to have modified his view in so far as he now seems to consider that the spectra in question might be obtained also in other ways, and to attach importance to the process of reduction only in so far as it forms an effective inciter of the particular spectra. In spite of the fact that C. Freden- hagen has recently attempted to revive Pringsheim’s original views in a modified form—substituting oxidation for reduction— we may consider it as generally admitted that the origin of spectra lies with vibrating systems which are definite and not dependent on the method of incitement. These systems may only be semi-stable, but they must last a sufficient length of time to give a train of waves having a length corresponding to the observed homogeneity of the line.

In many cases there is a considerable difficulty in deciding whether a particular spectrum belongs to a compound body or to one of the elements composing the compound. Thus one of the most common spectra is that seen at the base of every candle and in every Bunsen burner. Everybody agrees that carbon is necessary for its appearance, but some believe it to be due to a hydrocarbon, others to carbon monoxide, and others to volatilized carbon. There is a vast amount of literature on the subject, but in spite of the difficulty of conceiving a luminous carbon vapour at the temperature of an ordinary carbon flame, the evidence seems to show that no other element is necessary for its production as it is found in the spectrum of pure carbon tetrachloride and certainly in cases where chlorine is excluded. Another much disputed spectrum is that giving the bands which appear in the electric arc; it is most frequently ascribed to cyanogen, but occasionally also to carbon vapour.

Compounds generally show spectra of resolvable bands, and

*@@@1 Phil. Trans.* (1899), 190, p. 189.

*@@@2 Astrophys. Journ.* (1901), 14, p. 116.

*@@@3 Phys. Zeitschrift,* 8, p. 225.

*@@@4 Proc. Roy. Soc.* (1909), 82, p. 518.