if an elementary body shows a spectrum of the same type we are probably justified in assuming it to be due to a complex mole­cule. But that it may be given by the ordinary diatomic molecule is exemplified by oxygen, which gives in thick layers by absorption one of the typical sets of bands which were used by Deslandres and others to investigate the laws of distribution of frequencies. These bands appear in the solar spectrum as we observe it, but are due to absorption by the oxygen contained in the atmosphere.

If oxygen is rendered luminous by the electric discharge, a series of spectra may be made to appear. Under different conditions we obtain *(a)* a continuous spectrum most intense in the yellow and green, (*b*) the spectrum dividing itself into two families of series, *(c)* a spectrum of lines which appears when a strong spark passes through oxygen at atmospheric pressure, (*d*) a spectrum of bands seen in the kathode glow. We have therefore five distinct spectra of oxygen apart from the absorp- tion spectra of ozone. To explain this great variability of spectroscopic effects we may either adopt the view that molecular aggregates of semi-stable nature may be found in vacuum tubes, or that a molecule may gain or lose one or more additional electrons and thus form new vibrating systems. It seemed that an important guide to clear our notions in this direction could be obtained through the discovery of J. Stark, who examined the spectra of the so-called “ canal-rays ” *(Canalestrahlen).* These rays are apparently the trajectories of positively charged particles having masses of the order of magnitude of the gaseous molecules. Stark discovered that in the case of the series spectrum of hydrogen and of other similar spectra the lines were displaced indicating high velocities; in other cases no displacements could be observed. The conclusion seemed natural that the spectra which showed the Doppler effect were due to vibra- tory systems which had an excess of positive charge. More detailed examinations of the “ canal-rays ” by J. J. Thompson and others have shown however that they contain both neutral and charged molecules in a relative proportion which adjusts itself continuously, so that even neutral molecules may partake of the translatory motion which they gained while carrying a charge. No conclusion can therefore be drawn, as Stark@@1 has more recently pointed out, respecting the charge of the molecule which emits the observed spectrum. Nevertheless, the subject is well worth further investigation.

Previous to Stark’s investigation P. Lenard@@2 had concluded that the carriers of certain of the lines of the flame spectra of the alkah' metals are positively charged. He draws a distinction between the lines of the trunk series to which he assigns neutral, and the fines of carriers the two branch series of which are electrically charged. The numerical relations existing between the trunk series and the branch series make it somewhat difficult to believe that they belong to different vibrating systems. But while we should undoubtedly hesitate on this ground to adopt Fredenhagen’s@@3 view that the two branch series belong to the element itself and the trunk series to a process of oxidation, we cannot press the argument against the view of Lenard, because the addition or subtraction of an electron introduces two vibrating systems which are still connected with each other and some-numerical relationship is probable. Whatever ideas we may form on this point, the observations of Stark and Siegl@@4 have shown that there is a Doppler effect, and therefore a positive charge, for one of the lines of the trunk series of potassium, and E. Dorn@@5 has found the Doppler effect with a number of lines of helium, which contain representatives of the trunk series as well as of the two branch series. These facts do not countenance the view that there is an essential electric difference between the vibrating system of the three members of a family of series.

It is probable, however, that the above observations may

help to clear up some difficulties in the phenomena presented by flames. While we have seen that the radiation of sodium vapour has an intensity corresponding to that of the pure thermal radiation at the temperature of the flame, other flames not containing oxygen *(e.g.* the flames of chlorine in hydrogen) do not apparently emit the usual sodium radiation when a sodium salt is placed in them. In the light of our present knowledge we should look for the different behaviour in the peculiarity of the oxygen flame to ionize the metallic vapour.

14. *Fluorescence and Phosphorescence.—*When a simple peri- odic force acts on a system capable of oscillatory motion the ultimate forced vibration has a period equal to that of the impressed force, but the ultimate state is only reached theoreti­cally after an infinite time, and if meanwhile the vibrating system suffers any perturbations its free periods will at once assert themselves. Applying the reasoning to the case of a homo- geneous radiation traversing an absorbing medium, we realize that the mutual disturbances of the molecules by collision or otherwise must bring in the free period of the molecule whatever the incident radiation may be. It is just in this degradation of the original period that (according to the present writer) the main phenomenon of absorption consists.@@6 With most bodies the degradation goes on rapidly and the body mainly radiates accord­ing to its temperature, but there are cases in which these intermediate stages can be observed and the body seems then to be luminous under the influence of the incident radiation. Such bodies are said to be fluorescent, the degradation of motion towards that determined by its temperature gives rise to the law of Stokes, the fluorescent light being in nearly all cases of lower fre­quency than the incident light. With absorbing gases we should expect the degradation to proceed more slowly than with liquids, and hence the discovery of E. Wiedemann and Schmidt@@7 that the vapours of sodium and potassium are fluorescent, important as it was from an experimental point of view, caused no surprise. It is not possible here to enter into a detailed description of the phenomena of fluorescence (q.v.), though their importance from a spectroscopic point of view has been materially increased through the recent researches of Wood@@8 on the fluorescence of sodium vapour. After Wood and Moore had confirmed and extended the observations of Wiedemann and Schmidt and showed that the vibrating system of the fluorescent light seems identical with that observed by absorption in the fluted band spectrum, Wood excited the fluorescence by homogeneous radiation and discovered some remarkable facts. The fluores­cent bands in this case appear to shift rapidly when the period of the incident vibration is altered, though the change may be small. The author, no doubt correctly, remarks that the shift does not indicate a change of frequency but a change of relative intensity, consisting of a great number of fine lines; when the maximum intensity of the distribution of light is altered, the appearance is that of a shift. It would probably not be difficult to imagine a mechanical system having a number of free periods which when set into motion by a forced vibration shows a corre­sponding effect. If the forced vibration is suddenly stopped, the free periods will appear but not necessarily with the same intensity when the period of the original forced vibration is altered. There cannot, however, be a question that, as R. W. Wood remarks, the careful investigation of these phenomena is likely to give us an insight into the mechanism of radiation.

*Phosphorescence (q.υ.)* can only be here alluded to in order to draw attention to the *phenomena* studied by Sir William Crookes and others in vacuum tubes. When kathode rays strike certain substances, they emit a phosphorescent light, the spectroscopic investigation of which shows interesting effects which are important especially as indicating the influence of slight admixtures of impurities on the luminescence. It should be mentioned that the infra-red rays have a remarkable damping effect on the phenomena of phosphorescence, a fact which has

*@@@l Phys. Zeitschrift* (1910), 11, p. 171.

*@@@2 Ann. d. Phys.* (1905), 17, p. 197.

*@@@, Phys. Zeitschrift* (1904), 8, p. 735.

*@@@4 Ann. d. Phys.* (1906), 21, p. 457.

*@@@6 Phys. Zeitschrift* (1907), 8, p. 589.

@@@δ Schuster, *Theory of Optics,* p. 254.

*@@@7 Wied. Ann.* (1896), 57, p. 447.

@@@β R. W. Wood and Moore, *Astrophys. Journ.* (1903), 18. p. 95; R. W. Wood and Moore, *Phil. Mag.* (1905), 10, p. 513.