W. M. Hicks@@l has modified Rydberg’s equation in a way similar to that of Ritz as shown by (5) above. This form has the advantage that the constants of the equation when applied to the spectra of the alkali metals show marked regularities. The most extensive series which has yet been observed is that of the trunk scries of sodium when it is observed as an absorption spectrum; R. W. Wood has in that case measured as many as 50 lines belonging to this series.

The different series have certain characteristics which they seem to maintain wherever they have been obtained. Thus the trunk series consists of lines which are easily reversed while those of the side branch are nebulous. The lines of the trunk seem to appear at lower temperatures, which may account for the fact that it can be observed as absorption lines. If we compare together the spectra of the alkali metals, we find that the doublets of the branch series separate more and more as the wave-length increases. Roughly speaking the difference in frequency is proportional to the square of the atomic weight. Taking sodium and lithium we find in this way that the lithium lines ought to be double and seρa- rated by 7 Å. They have not, however, so far as we know, been resolved. The roots of the three series have frequencies which diminish as the atomic weight increases, but not according to any simple law.

In the case of other metallic groups similar series have also been found, but while in the case of the alkali group nearly the whole spectrum is represented by the combined set of three series, such is not the case with other metals. The spectra of magnesium, calcium, zinc, cadmium and mercury, give the two branch series, and each series is repeated three times with constant difference of frequency. In these elements the doublets of the alkali series are therefore replaced by triplets. Strontium also gives triplets, but only the side branch series has been observed. In the spectrum of barium no series has yet been recognized. The spectrum of helium has been very carefully studied by Runge and Paschen. All its lines arrange themselves in two families of series, in other words, the spectrum looks like that of the superposition of two spectra similar to those presented by the alkali metals. Each family consists of the trunk, main branch and side branch. The conclusion which was originally drawn from this fact that helium is a mixture of two gases has not been confirmed, as one of the spectra of oxygen is similarly constituted.

We must refer to Kayser and Runge's *Handbuch* for further details, as well as for information on other spectra such as those of silver, thallium, indium and manganese, in which series lines have been found.

Before leaving the subject, we return for a moment to the spectrum of hydrogen. In 1896, Professor E. C. Pickering discovered in the structure of the star ξ Puppis a series of lines which showed a remarkable similarity to that of hydrogen having the same root. Kayser on examining the spectrum recognized the fact that the two series were related to each other like the two branch series, and this was subsequently confirmed. If we compare Balmer’s formula with the general equation of Ritz, we find that the two can be made to agree if the ordinary hydrogen spectrum is that of the side branch series and the constants α@@1, *b, c* and *d* are all put equal to zero. In that case the main branch is found to represent the new series if a1 and b1 are also put equal to zero, so that

4-≤r=I-L ^rN 4 r2’

where *r* takes successively the values 1∙5, 2∙5, 3∙5.. A knowledge of the constants now determines the trunk series, which should be

\* = /—! 2).

N ∖(1.5)2 W

The least refrangible of the lines of this series should have a wave- length 4687·88, and a strong line of this wave-length has indeed been found in the spectra of stars which are made up of bright lines, as also in the spectra of some nebulae. It seems remarkable, however, that we should not have succeeded yet in reproducing in the laboratory the trunk and main branch of the hydrogen spectrum, if the spectra in question really belong to hydrogen.

Considering the complexity of the subject it is not surprising that the efforts to connect theoretically the possible periods of the atom considered as a vibrating system have met with no considerable success. Two methods of investigation are available. The one endeavours to determine the conditions, which are consistent with our knowledge of atomic constitution derived from other sources, and lead to systems of vibration similar to those of the actual atom. We might then hope to particularize or modify these conditions so as to put them into more complete agreement. An attempt in that direction has been made with partial success by J. H. Jeans,@@2 who showed that a shell-like constitution of the atom, the shells being electrically charged,

would lead to systems of periods not unlike those of a series of lines such as is given by observation. The other method starts from the observed values of the periods, and establishes a differential equation from which these periods may be derived. This is done in the hope that some theoretical foundation may then be found for the equation. The pioneer in this direction is E. Riecke,@@3 who deduced a differential equation of the 10th order. Ritz in the paper already mentioned follows in the footsteps of Riecke and elaborates the argument. On the whole it seems probable that the system of moving electrons, which according to a modem theory constitute the atom, is not directly concerned in thermal radiation which would rather be due to a few more loosely connected electrons hanging on to the atom. The difficulty that a number of spectroscopic lines seem to involve at least an equal number of electrons may be got over by imagining that the atom may present several positions of equilibrium to the electron, which it may occupy in turn. A collision may be able to throw the electrons from one of these positions to another. According to this view the different lines are given out by different molecules, and we should have to take averages over a number of molecules to obtain the complete spectrum just as we now take averages of energy to obtain the temperature.@@4 If it should be confirmed that the period called N in the above investigation is the same for all elements, it must be intimately connected with the structure of the electron. At present the quantity of electricity it carries, and also its mass, may be determined, and we can therefore derive units of length and of mass from our electrical measurements. The quantity N may serve to fix the third fundamental unit. One further point deserves notice. Lord Rayleigh,@@5 who has also in- vestigated vibrating systems giving series of lines approaching a definite limit of “ root,” remarks that by dynamical reasoning we are always led to equations giving the square of the period and not the period, while in the equation representing spectral scries the simplest results are obtained for the first power of the period. Now it follows from Rydberg’s second law put on a more accurate basis by Ritz that in one case at any rate a *nega­tive* period has reality and must be interpreted just as if it were positive. This looks indeed as if the *square* of the period were the determining quantity.

9. *Distribution of Frequencies in Band Spectra.—*In many cases the spectra of molecules consist of lines so closely ruled together in groups as to give the appearance of continuous bands unless high resolving powers are employed. Such spectra seem to be characteristic of complex molecular structure, as they appear when compounds are raised to incandescence without decom- position, or when we examine the absorption spectra of vapours such as iodine and bromine and other cases where we know that the molecule consists of more than one atom. The bands often appear in groups, and such spectra containing groups of bands when viewed through small spectroscopes sometimes give the appearance of the flutings of columns. Hence the name “ fluted spectra,” which is sometimes applied. Each band, as has been stated, is made up of lines indicating highly homo- geneous vibrations. A systematic study of the distribution of frequencies in these bands was first made by H. Deslandres,@@6 who found that the successive differences in the frequencies formed an arithmetical progression.

If *s* represents the series of integer numbers the distribution of frequency may be represented by

*n* = C+Bs2,

where C and B are constants. The brightest line, for which s = o, is called the “ head ” of the band; and as *s* increases the lines diminish in intensity. The band fades towards the red or violet according as A is positive or negative, and the appearance is some­times complicated by the fact that several sets of lines start from identical or closely adjoining heads. The equation which expressed “ Deslandres' law ” was only given by its author as an approximate one. The careful measurements of Kayser and Runge of the carbon bands show that the successive differences in the frequencies do

*@@@1 Proc. Roy. Soc.* (1909), 83, p. 226 (abstract).

*@@@2 Phil. Mag.* (1901), 2, p. 421.

*@@@3 Drude's Annalen* (1900), 1, p. 399.

*@@@4 Nature* (1895), 51, p. 293.

@@@6 *Phil*. *Mag.* (1897), 44, p. 356.

*@@@β Comptes rendus* (1885), 100, p. 1256.