(3) The groupings of rings on the outer part of the scale of large herrings. In a large number of cases of ringy scales there is a tendency for the "winter rings" to get closer and closer as we go from the centre of the scale, until they become very crowded at a certain point; after which they widen out, again get closer and closer, and again become crowded. Fig. 3 exemplifies this phenomenon. If the rings are read in groups, instead of singly, an estimate of age is arrived at, differing widely from that based on reading of single rings—in the present case 5 years instead of at least 14 years, the inner group under a high power being seen to consist of about 5 rings, and the outer of about 6 rings, and the three rings inside these two groups being read singly, as the sub-surface phenomena occurring inside these rings would not be considered as "annual rings" by any scale-readers.

FIG. 2.—Showing only four rings traceable all round the striated portion.

(4) The existence of rings in the outer part of the scale having stronger optical value than neighbouring rings, but similar optical value to the first 3 or 4 winter rings. These strong or "*a*" rings can often be traced out into the exposed part of the scale. If only these "*a*" rings are recognised as winter rings the age-estimate is of course lower than in the reverse case.

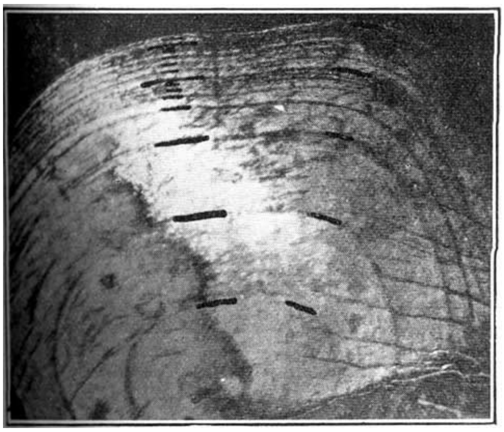

FIG. 3.—Showing three single rings and two groups of rings.

The above phenomena form the main basis of my disagreement with the Norwegian theory. To mention further evidence for my views or to describe my alternative theory would extend this beyond the bounds of a letter, but such evidence exists and will be laid before any workers interested in the matter. The scales from which the photos, here reproduced (Figs. 1-3), were taken, and many others, are also open to inspection.

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Ministry of Agriculture and Fisheries,
Fisheries Laboratory,
Lowestoft, July 17.

The Band Spectrum of Boron Monoxide.

IN two recent letters to NATURE (May 24 and 31) Mr. W. Jevons has questioned the adequacy of my evidence as to the oxide origin of a band spectrum which he had previously ascribed to boron nitride.[1] In his second letter he reports that these bands are absent from the spectrum of the discharge through a mixture of BCl_3 and O_2, although the ordinary boric oxide bands are present. This he considers convincing evidence against BO as the emitter of the bands in question. In view, however, of evidence outlined below, a full account of which will appear probably in the *Physical Review*, there seems little room for doubt that the bands are really due to BO and not to BN. The other oxide bands may then be ascribed, as in the past, and in accordance with their complex character, to B_2O_3.

When generated by the reaction of BCl_3 with active nitrogen, the intensity of the BO bands shows a maximum when perhaps 0·5 per cent. of oxygen is present. If the nitrogen is purified beyond this point, using phosphorus, its degree of activation, as gauged by the intensity of the α bands of the afterglow, is increased markedly, finally approaching asymptotically an upper limit. Unlike the BO bands, the SiN bands, obtained by using $SiCl_4$ instead of BCl_3, are stronger the less oxygen is present, and are practically extinguished by the amount of oxygen most favourable for BO. These facts appear to disprove Mr. Jevons's suggestion that the weakening of the BO bands in very pure nitrogen is due to a decrease in its activity when the oxygen is all removed. Probably, if this stage of purification was approached, phosphorus vapour replaced oxygen as a catalyst.

When the BO bands are at their strongest, the yellow of the α bands and the blue of the β bands of active nitrogen are roughly equal in intensity. Lord Rayleigh has shown[2] that the β (and γ) bands are due to the presence of oxygen, probably as NO. Prof. R. T. Birge has concluded[3] that the α bands are emitted by (metastable) excited N_2 molecules; also (private communication) that the β and γ bands are due to NO.[4] The formation of the emitters of the BO bands may then proceed somewhat as follows, denoting an electronically excited molecule by an accent ($'$):

(1) $BCl_3+N_2'\rightarrow BN+NCl_3$. (2) $BN+NO'\rightarrow BO'+N_2$.

Or, the formation of BO' may be more direct; in any case, some BN is probably also formed,[1] but apparently gives no spectrum.

In repeating Mr. Jevons's recent experiments, I have found the B_2O_3 bands best brought out with a very large excess of oxygen over BCl_3. Under these conditions the ratio of excited BO to excited B_2O_3 molecules present and emitting at any moment may well be negligibly small, in view of the chemically highly unsaturated character of BO. In active nitrogen,

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[1] W. Jevons, Roy. Soc. Proc. A, 91, 120-34 (1915).

[2] Roy. Soc. Proc. A, 93, 254 (1917).

[3] *Phys. Rev.*, 23, 295 (1924).

[4] E. P. Lewis (*Astrophys. Journ.*, 20, 49, and 58 (1904)) has shown that the γ bands are, without much doubt, due to NO; and Birge finds that the β and γ bands have a common final state. Also, their simple structure indicates a diatomic emitter.

however, consisting of a small proportion of N_2' and NO′ molecules in a medium chiefly of unexcited and so inert nitrogen, and with no continuous exciting discharge, this ratio may well be reversed, especially in view of the probable mode of formation of BO.′

In some experiments with a carbon arc,[5] the anode of which contained BN, B_6C, or B_2O_3, I have found that in all three cases the BO (and the B_2O_3) bands appear, in moderate intensity, when an atmosphere of oxygen or air is used, but that they are completely absent in nitrogen. In the latter case BN is doubtless formed, but does not emit a spectrum. No doubt B_2O_3 is partly dissociated into BO at the high temperature of the arc. In the lower temperature of the flame only the B_2O_3 bands are known to occur.

The final piece of evidence is the very close agreement of the vibrational isotope effect with theory for BO, and its definite disagreement for BN. In view of the strength of the theory, this by itself makes BO very probable. If the bands were due to BN, the agreement of experiment with theory would become qualitative only; and if this were the case, the chance is very small that the deviation of the theory from quantitative correctness would be just such as to correspond to an exact but illusory quantitative agreement for BO. The following empirical equations represent within experimental error the positions of all the measurable BO band heads:[6]

$$\begin{array}{llllll}
\mathrm{B^{10}O}: & \nu_\alpha=\left\{\begin{matrix}23652\cdot2; & 23638\cdot9;\\ 23526\cdot0; & 23512\cdot7\end{matrix}\right\} & +1285\cdot6n' & -11\cdot7n'^2 & -1926\cdot8n & +12\cdot21n^2\\
\mathrm{B^{11}O}: & \nu_\alpha=\left\{\begin{matrix}23661\cdot6; & 23648\cdot3;\\ 23535\cdot4; & 23522\cdot1\end{matrix}\right\} & +1247\cdot9n' & -10\cdot6n'^2 & -1873\cdot2n & +11\cdot68n^2\\
\text{Ratio}: & (\textit{Difference}=-9\cdot4) & 1\cdot0302 & 1\cdot104 & 1\cdot0286 & 1\cdot045\\
\mathrm{B^{10}O}: & \nu_\beta=42874\cdot6-0\cdot19nn' & +1304\cdot6n' & -10\cdot43n'^2 & -1927\cdot9n & +12\cdot66n^2\\
\mathrm{B^{11}O}: & \nu_\beta=42880\cdot9-0\cdot17nn' & +1268\cdot8n' & -9\cdot98n'^2 & -1872\cdot9n & +11\cdot84n^2\\
\text{Ratio}: & (\textit{Difference}=-6\cdot3) & 1\cdot0282 & 1\cdot045 & 1\cdot0294 & 1\cdot069
\end{array}$$

For the coefficients of the linear terms, the theoretical ratio is 1·0292 for BO and 1·0276 for BN; for the quadratic terms, 1·0593 for BO and 1·0560 for BN. The mean of the four experimental values is $1\cdot0291 \pm 0\cdot0004$ for the former, $1\cdot066 \pm 0\cdot010$ for the latter.—The coefficients of n and n^2 indicate a common final state for the α and β systems.

A remarkable feature of the BO bands is the non-coincidence, for the bands having the vibrational quantum numbers n and n' both zero, of corresponding heads of the two isotopes. For the centres of these bands an approximate correction, based on measurements of band structure, increases the differences recorded above to $-10\cdot0$ and $-7\cdot2$ for the α and β systems respectively. According to the theory as now accepted, these corrected differences must represent electronic isotope effects, of much greater magnitude than have been found in line spectra. Since this is highly improbable, the following alternative explanation is decidedly to be preferred. If one assumes that the true values of the vibrational quantum numbers are not n and n', but each $\frac{1}{2}$ unit greater, the apparent isotope effect for the true vibrational zero point is reduced to $-2\cdot2$ for the α and $+2\cdot4$ for the β system. These differences are now small enough to have resulted from inaccuracies in the determination of equation coefficients. It is then probable that the minimum vibrational energy of BO (and doubtless of other) molecules is $\frac{1}{2}$ quantum. In the case of molecular rotational energy, the necessity of using half quanta is already well established. Analogous relations appear in line spectra; *e.g.* Heisenberg[7] has successfully used half-integral radial and azimuthal quantum numbers in explaining the structure and Zeeman effect of doublets and triplets.

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[5] Similar experiments by Jevons (*l.c.*) on a boron arc were inconclusive, although favouring the nitride origin of the BO bands.

[6] It can be shown that no appreciable error is introduced here in the isotope ratios by using data on heads. The nn' terms are due to the fact that the data are for heads.

[7] W. Heisenberg, *Zeit. für Physik*, 8, 273 (1922).

Effect of Length of Day on Flowering and Growth.

AN attempt has been made to confirm the work of Garner and Allard[1] done in America, under the conditions prevailing in Britain at the Welsh Plant Breeding Station, and to test particularly the behaviour of various strains of herbage plants under different lengths of day.

The plants, equal propagants, or pure line plants, were grown in pots or boxes placed on trucks which were run in and out of a three-sectioned hut so that they received 12, 9, and 6 hours' daylight. Control plants received the full natural daylight. Equal soil, water, and temperature conditions were provided so far as possible.

The results obtained fall into three divisions, namely:

I. EVER-BLOOMING TYPE.—Plants of *Poa Annua* flowered normally under all light periods.

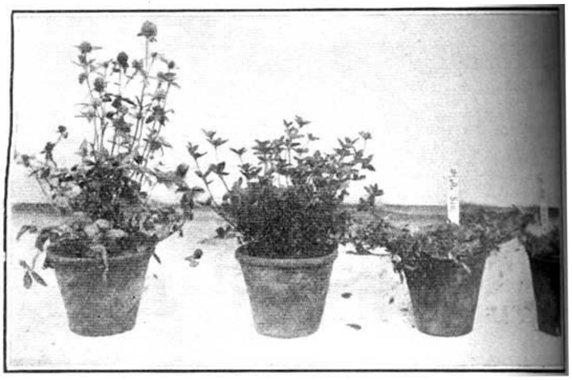

FIG. 1.—American Red Clover, photographed on July 29, showing, left to right, control (many heads ripening), 12-hour plant (with small flowers), 9-hour plant (almost prostrate, with a few small heads), and 6-hour plant (prostrate, in winter habit).

II. SHORT-DAY PLANTS—*Chrysanthemums* (var. Mrs. William Buckingham): Subjected to treatment on May 9. Short-day plants, flower buds July 26, open in early August. Controls, no buds August 12. *Phaseolus vulgaris* (Runner Bean, Sutton's "Best of All"): Treated plants were small and bushy, with thick nodes and swollen roots. Height of control plants 50 in., height of 6-hour plants 9 in. Treated plants flowered 4 days earlier than control plants.

III. LONG-DAY PLANTS—(1) *Broad Red Clover* (ex. Suffolk): Control plants started flowering May 21, attained flowering zenith June 6; 12-hour plants started flowering June 28, attained flowering zenith July 26; 9-hour plants started flowering July 6, attained flowering zenith July 31; 6-hour plants have remained entirely in the winter habit. (2) *Montgomery Variety*: Controls flowered freely from July 16, reaching their flowering zenith about July 26. The 12-, 9-, and 6-hour plants were quite prostrate and in the winter habit on August 10.

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[1] "Effect of Relative Length of Day and Night and other Factors of the Environment on Growth and Reproduction in Plants," W. W. Garner and H. A. Allard (*Journ. Agric. Res.*, vol. xviii. No. 11, p. 553); "Further Studies in Photoperiodism, the Response of the Plant to Relative Length of Day and Night," W. W. Garner and H. A. Allard (*Journ. Agric. Res.*, vol. xxiii. No. 11, p. 71, 1923); "Photoperiodism in Relation to Hydrogen ion Concentration of Cell Sap and Carbohydrate Content of the Plant," W. W. Garner, C. Bacon, and H. A. Allard (*Journ. Agric. Res.*, vol. xxvii. No. 3, p. 119, 1924).