work-like and flocculent appearances so often observed in the froth which is formed when the tide breaks on the seashore may be explained in a similar manner.

HAROLD WAGER.

West Park, Leeds, April 14.

An Extension of the Spectrum in the Extreme Ultra-Violet.

THE researches of Schumann led him to extend the spectrum to the neighbourhood of wave-length 1250. His limiting wave-length was determined by the absorption of the fluorite which formed a necessary part of his apparatus. In 1904 I succeeded in pushing the limit to wave-length 1030 by the use of a concave diffraction grating.

Recently I have renewed the attack on the problem, with the result that I have succeeded in photographing the spectrum of hydrogen to wave-length 905. The extension is due, not so much to any fundamental change in the nature of the apparatus as to an improvement in technique consequent on an experience of ten years.

It is a characteristic of the region investigated by Schumann between wave-lengths 1850 and 1250 that, while hydrogen yields a rich secondary spectrum, with the possible exception of one line, no radiation has been discovered belonging to the primary spectrum. On the other hand, in the new region between the limit set by fluorite and wave-length 905, a disruptive discharge in hydrogen produces a primary spectrum of great interest made up of perhaps a dozen lines. These lines are always accompanied in pure hydrogen by members of the secondary spectrum, but they may be obtained alone if helium containing a trace of hydrogen is employed.

Results obtained from vacuum tubes when a strong disruptive discharge is used, must always be interpreted with caution since the material torn from the tube itself sometimes furnishes impurities. In the present case, it will be some time before the effect of such impurities can be estimated. However, it may be stated with some degree of certainty that the diffuse series predicted in this region by Ritz has been discovered. The first member at 1216 is found to be greatly intensified by the disruptive discharge, and the next line at 1026 appears also, though very faintly. This diffuse series bears a simple relation to Balmer's formula. Following the same kind of argument, a sharp series corresponding to the Pickering series might be expected. The new region appears to yield two lines belonging to such a relation at the positions demanded by calculation.

THEODORE LYMAN.

Harvard University, April 20.

The Structure of Atoms and Molecules.

SINCE in an elaborate criticism of Bohr's theory on the constitution of atoms and molecules, Prof. J. W. Nicholson, as in his letter to NATURE (February 5, p 630), comes to the conclusion (*Phil. Mag.*, xxvii., p. 560, 1914) that the valencies of lithium, beryllium, boron, etc., on Bohr's theory are not in accord with experience, and if the electrons in the atoms are to be in one plane, we must either abandon Bohr's method of calculating valency—and (generally) Bohr's theory of the atoms more complex than hydrogen and helium—or give up van den Broek's hypothesis, that the charge of the nucleus of Rutherford's atom is equal to the atomic number (which hypothesis was accepted by Bohr as one of his fundamental assumptions), I may be allowed to add some remarks to my previous letter on this subject (NATURE, March 5, 1914).

For these atoms at least this hypothesis is a mere expression of experimental facts. The hydrogen atom is known to lose never more than one electron, and the helium atom never more than two, and, of course, never one to form an electrolytic ion, while lithium, beryllium, boron, and carbon can lose, or, in chemical combination, dispose of 1, 2, 3, 4 electrons respectively. Further, the number of electrons per atom has been proved to be nearly equal to half the atomic weight (Rutherford, Barkla), and in the case of carbon to be six (Rutherford, *Phil. Mag.*, vol. xxvi., p. 711, 1913). Since the number of electrons per atom must be an integer, here, at least, no other solution seems to be possible than that the number of electrons per atom surrounding the nucleus, and hence the nuclear charge, is equal to the atomic number.

Further mentioning Moseley's previous experiments on high-frequency spectra (undertaken for the express purpose of testing the atomic number hypothesis), and criticising the theoretical deductions, derived by Moseley from these experiments, Nicholson concludes that they have shown no relation to Bohr's theory (*loc. cit.*, p. 564). Now in another paper Moseley, from further experiments on high-frequency spectra, proves (*Phil. Mag.*, vol. xxvii., p. 703, 1914) that the frequency of any line in the X-ray spectra is approximately proportional to $A(M-b)^2$, where A and b are constants for each series, and M, the atomic number (called by Moseley N) of the element, is identified with the number of positive units of electricity contained in the atomic nucleus, so that these experiments "give the strongest possible support" to this atomic number hypothesis (*loc. cit.*, p. 712). The number of rare-earth elements as given by Moseley is the only exception.

That b is much larger for the "L" lines than for the "K" lines suggests, according to Moseley (in agreement with my own views, NATURE, December 25, 1913) that the "L" system is situated the further from the nucleus. If so, b = the number of electrons nearest the nucleus, and not $=\sigma_n$, the term arising from the influence of the electrons in a ring on each other, and, for the "K" lines, n, like b, must be unity, as calculated by Nicholson on Bohr's theory. For the "L" lines, according to Moseley, $b=7\cdot4$, but it can easily be seen from the tables that if $(M-b)$ be here augmented by 0·8 per cent., all values are integers ($\pm0\cdot2$), and $b=7$ and $n=1$ again, but perhaps the factor 5/36 in Moseley's interpretation cannot be retained.

Hence, though this number 7 requires confirmation, principally, for the "K" line at least, Bohr's theory is here in agreement with Moseley's experiments, and with the atomic number hypothesis. Not only the frequencies, but also the minimum velocity of electrons required to excite this radiation, and the absorption of it (in aluminium) have been proved (*loc. cit.*) to depend on the atomic number very nearly, and Nicholson's conclusion that the atomic numbers are not correct does not hold, for $(M-b)$, not M, is one unit less for the K radiation than the corresponding atomic number. But, from analogy, Bohr's lithium atom, as well as Nicholson's ring of three electrons, must be given up, for of three, one electron (b) must be very near the nucleus, one (n) near but outside this first one, and one as electron of valency must be peripheric.

Further, the velocity of electrons, required to excite this radiation, according to Widdington equal to $10^8\times$atomic weight cm./sec., is more accurately equal to $2\cdot24\times10^8(M-1)$ cm./sec., than for Cr, Fe, Ni, Cu, Zn, and Se; the last formula gives for the constant reduced to unity 0·99, **1·04**, 1·02, 1·00, **0·97**, 1·00, while the first gives 0·99, 1·05, **1·06**, 0·99, 0·98, **0·94** respectively. Since the absorbability of the excited radia-