and the leaders to subsequent discharges along the same track. While the latter are of a continuously-moving, dart-like character followed by fainter luminosity, the first leader is a luminous streamer extending in a discontinuous step-by-step manner from cloud to ground. The length of each step is about 50 metres, and, after completing a step, the streamer luminosity practically disappears for a time of the order of 10^{-4} seconds. After this extinction period, the streamer travels downwards over the old track without developing much light, but as it enters virgin air at the end of the old track it blazes a fresh step very brightly and appears to stop. Since it is difficult to photograph much more than the bright fresh step at the tip of each streamer, the record of this type of leader is usually only a series of elongated dots extending from cloud to ground and separated considerably from one another along the time axis by the camera motion during the extinction period.

This 'stepped' leader is shown on 22 out of the 55 first strokes on our records and is so difficult to see that we consider it must have been present in many other cases. It is shown on 74 per cent (14/19) of our better records. It has not been found associated with any strokes other than the first of a series along the same track. Conversely, no continuous dart-like leaders have been found blazing the way for first strokes.

Owing to numerous pauses in its progress, a stepped leader takes a comparatively long time to reach the ground, sometimes more than one-hundredth of a second, though the velocity of the extending streamer itself is very high. Electromagnetic radiation from such steps would be on a wave-length of approximately 30 km., which is that of the ripple on many atmospherics. The sound waves emitted would have a frequency of about 10,000 and could produce the sound of tearing linen sometimes reported for a close discharge.

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[1] NATURE, **132**, 407, Sept. 9, 1933.
[2] *Proc. Roy. Soc.*, A, **143**, 654; 1934.

Constitution of Carbon, Nickel and Cadmium

DURING recent years considerable controversy has taken place over the atomic weight of carbon, the values obtained by chemical methods and by density determinations ranging from 12·000 to 12·010. At the same time, the abundance of the rare isotope C13 first supposed to be about 1 in 400, has recently been estimated to be as high as 1 per cent.

I have now applied the methods of photometry of mass-spectra to the problem. This could only be done by the use of the comparatively weak second order lines of the element at 6 and 6·5. With alternating exposures of 15 minutes against 5 seconds consistent results were obtained but unfortunately three corrections due to the position of the lines, photographic efficiency and a background effect were all large and rather uncertain. After applying these the most probable ratio of abundance appears to be 140 ± 14. Allowing for the packing fraction of C12 and change of scale we get:

$$\text{Atomic Weight of Carbon} = 12{\cdot}0080 \pm 0{\cdot}0005.$$

The analysis of nickel by means of its carbonyl has been repeated, and the more intense mass-spectra obtained reveal two new isotopes 62 and 61. Lines at 56 and 64 present to less than 1 per cent are probably due to isotopes, but this is not yet certain.

Further work with cadmium has yielded much more intense mass-spectra. These confirm mass-numbers 114, 112, 110, 111, 113, 116 and reveal three new faint ones 106, 108, 115 in this order of intensity.

Svensson[1] has already claimed to have demonstrated the presence of isotopes 118 and 108 by observations on the band spectra of cadmium hydride. The new mass-spectra show that the former cannot be present even to the extent of 0·3 per cent. This discrepancy, and his failure to detect the more abundant isotope 106, suggest that the arguments on which his claim is based are not strictly valid.

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[1] NATURE, **131**, 28, Jan. 7, 1933.

A General Equation for Induced Polarity

ORGANIC reactions, of which the speed can be affected by the presence of a 'polar' substituent in a molecule, have been classified into two groups[1], for each of which Nathan and Watson[2] have suggested, from analysis of experimental data, an empirical equation to correlate the energy of activation with the dipole moment of the polar substituent. For Class *A* reactions, accelerated by electron access to the point of attack, they suggest $E = E_0 - C(\mu - \alpha\mu^2)$, and for Class *B* reactions, accelerated by electron recession from the point of attack, they suggest $E = E_0 + C(\mu + \alpha\mu^2)$.

I have pointed out[3] that the *field* of a dipole operating on any other pole or dipole, whether in the same or any vicinal molecule, will bring about an energy change ΔE varying as $\mu\mu'$ or as μe, and that *induction* of a secondary dipole in a covalent link will bring about an energy change ΔE varying as μ^2.

If the sign of the energy changes enumerated above be considered, it will be seen that the effect of electrostatic induction in a molecule will be to reduce the energy content of the covalent links, since electrons, etc., will tend to move from their unperturbed states to an environment of lower potential energy in the field of the neighbouring dipole. Hence the induction term will always be positive in the activation equation, in which $+E$ represents energy that must be gained before the requisite activation can occur. In contrast, the energy change due to the field of the dipole can be of varying sign, according as the terms $\mu\mu'$ and μe give a positive or negative product. One general equation $E = E_0 + a\mu\mu' + b\mu e + c\mu^2$, in which $a\mu\mu'$ and $b\mu e$ represent vector sums, will therefore fit all cases of induced polarity.

For Class *A* reactions, $(a\mu\mu' + b\mu e)$ becomes negative; and for Class *B* reactions it remains positive. Qualitative study of general induced polarity has shown how, in the majority of cases,