



Fig. 1.  $Z=38 \dots N=50 \dots Z=50$ . Excess number  $E=N-Z=A-2Z$

Actually, what Durnford has brought to light is the ambiguity of the packing fraction as a parameter. This ambiguity can be avoided simply by using the atomic mass per nucleon ( $m/A$ ) as the parameter for nuclides instead of the packing fraction, thereby freeing the calculations from any dependence on particular standards of atomic masses. Incidentally,  $^{56}_{26}\text{Fe}$  competes with  $^{62}_{28}\text{Ni}$  for the minimum mean nucleon mass value<sup>2</sup>.

The superiority of the mean nucleon mass as a parameter is especially emphasized by plotting ( $m/A$ ) for a nuclide against its atomic number  $Z$  and denoting each point by its neutron excess number  $E = N - Z = A - 2Z$  (ref. 3). Points of equal  $E$  then form straight or 'isoeccess' lines, which break off and start again with new slopes at magic numbers in  $N$  and  $Z$ . The magic numbers occurring here are first of all those discussed fully by Mayer and Jensen<sup>4</sup>, and a set of as many again, which could be called sub-magic numbers, and which are easily fitted into the Mayer-Jensen shell structure.

The plotted points fall on the isoeccess lines with an accuracy of within  $2 \times 10^{-6}$  atomic mass units per nucleon—this being far more accurate than that of any mass formula so far available<sup>5</sup>.

Since the aforementioned system of atomic masses was introduced<sup>3</sup>, it has been used to correct and predict the atomic masses of a number of nuclides to the mentioned accuracy.

A sample plot of isoeccess lines appears in Fig. 1.

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<sup>2</sup> Everling, F., et al., *Nucl. Phys.*, **13**, 529 (1960); **25**, 177 (1961). Bhanot, V. B., Johnson, jun., W. H., and Nier, A. O., *Phys. Rev.*, **120**, 235 (1960).

<sup>3</sup> Klepp, H. B., *A New Nuclear Theory*, Publ. Roy. Norv. Naval Acad., Bergen (1960). *Nucl. Sc. Abs.* 2143-NP9139 (61).

<sup>4</sup> Mayer, Maria G., and Jensen, J. H. D., *Elementary Theory of Nuclear Shell Structure* (Wiley, New York, 1955).

<sup>5</sup> Mozer, F. S., *Phys. Rev.*, **116**, 970 (1959).

## Electric Breakdown in Non-*virgin* Gases

ALTHOUGH the mechanism of the electric breakdown of atomic and molecular gases at low pressure is well understood<sup>1</sup>, most investigations have been confined to gases in the *virgin* state—that is, when the atoms or molecules

are in potential energy states corresponding to the ambient temperature and pressure. However, the collision processes involved are substantially altered if the gas contains species with large potential energy, such as excited atoms or molecules at room temperature.

Recent observations on nitrogen show that the breakdown potential is reduced by  $\leq 10$  per cent when a small number of excited molecules of nitrogen ( $\text{N}_2^*$ ) is added to the *virgin* gas at pressures of about 1–10 mm mercury. To avoid contamination, a long glass tube 4 cm in diameter is filled with spectroscopically pure nitrogen and the breakdown potential at 15 Mc/s is measured with external electrodes at one end of the tube while at the other end, at a distance of up to 60 cm,  $\text{N}_2^*$  with a long free-life (order 1 sec) is produced by an independent auxiliary discharge. By a series of experiments<sup>2</sup>, other factors which could be responsible for the reduction in breakdown potential have been excluded such as impurities, pick-up, diffusing electric charges, light and thermal changes. The reduction observed depends on the strength of the auxiliary discharge, its distance from the region measured, and on the pressure. A similar effect has been observed in exploratory experiments in hydrogen.

The presence of active molecular species carrying potential energy of several eV has been demonstrated by a new detection method:  $\text{N}_2^*$  interacting with a metal oxide can reduce its order by one. For example, the white-yellowish trioxide of molybdenum is changed to the lead-grey dioxide. This and other metal oxides, such as vanadium pentoxide and tungsten trioxide, were exposed to  $\text{N}_2^*$  diffusing from the auxiliary discharge. The time was recorded after which a clearly observable colour change occurred when the powdered oxides are placed at different distances from the auxiliary discharge. These experiments confirm that potential energy carriers diffuse relatively slowly down the tube. From the chemical energy balance, and by assuming that the colour change corresponds to a certain thickness of the de-oxidized layer, a lower value of the concentration of excited particles can be estimated. This is compared with the concentration necessary to account for the reduction in breakdown potential by pre-excitation. The de-activation of  $\text{N}_2^*$  by spontaneous radiation is strongly forbidden and that by collision with nitrogen molecules is a rare process<sup>3</sup>. Since  $\text{N}_2^*$  is produced in a relatively weak discharge, nitrogen atoms can be taken to be absent<sup>4</sup>.

It is concluded that the reduction in breakdown field is due to the presence of a distribution of vibrationally excited molecules in the ground state or in a higher electronic state<sup>5</sup>. These molecules possess virtually lower ionization potentials than nitrogen in the ground state, possibly with larger ionization cross-sections. Also in nitrogen a very small fraction of the electrons have energies above ionization energy and the population of excited molecules produced before breakdown is small, whereas in a pre-excited gas their population is considerably increased so that a large fraction of electrons previously unable to ionize can now contribute to ionization by collision.

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