Electrical Discharge Between a Stationary and a Rotating Electrode

A visual and photographic study has been made of electrical discharges between a stationary and a rapidly rotating electrode in dry air at reduced pressure. The rotating electrode was a 4″ solid tapered disk made of Duralumin ST14 mounted on the flexible shaft of an inverted vacuum-type ultracentrifuge, which has been previously described.[1] The usual metal vacuum chamber was replaced by one of glass, with a brass electrode mounted in the side of the wall, as shown in the photographs. The gas pressure could be varied from atmospheric down to the vapor pressure of the vacuum-pump oil, and the rotational speed of the electrode was limited only by the bursting strength of the rotor in the gas pressure range used (maximum peripheral speed of 7.5×10^4 cm/sec.). Contact to the rotor was made outside the vacuum chamber by dipping the end of the supporting shaft into a metal cup containing concentrated $CuSo_4$. Fig. 1 shows nonoscillating discharges of a 0.5-microfarad condenser with a spark gap (2.8 mm), 350-ohm resistance, and the two electrodes in series. The air pressure in the vacuum chamber was 1.4 cm Hg and the periphery of the rotor was moving 4×10^4 cm/sec. In addition to the light from the discharge, the apparatus was illuminated by auxiliary light to bring out the details of the electrodes and vacuum chamber. Fig. 1A shows a single discharge when the rotating electrode was anode, while Fig. 1B shows a single discharge when the rotating electrode was cathode.

In Fig. 1B it will be observed that the luminous column is carried around the periphery of the rotor. For a given discharge circuit and gas pressure, the length of this column is approximately proportional to the rotational speed. For example, we have observed this length to increase from a very slight displacement to approximately the circumference of the rotor as the rotational speed is increased. After stopping the rotor, it was found to have roughly circular pitts on its surface, which we interpret as cathode spots of the single discharges. None of the pitts were elongated into lines, indicating that the cathode spot remained fixed on the rotor surface as it moved.

On the other hand, when the rotating electrode was the anode, only a comparatively small displacement was observed. While a more detailed report of these experiments will be made later, it is apparent that the difficulty of moving the cathode spot on the rotor surface is much greater than the resistance to the extension of the discharge length in this type of discharge.

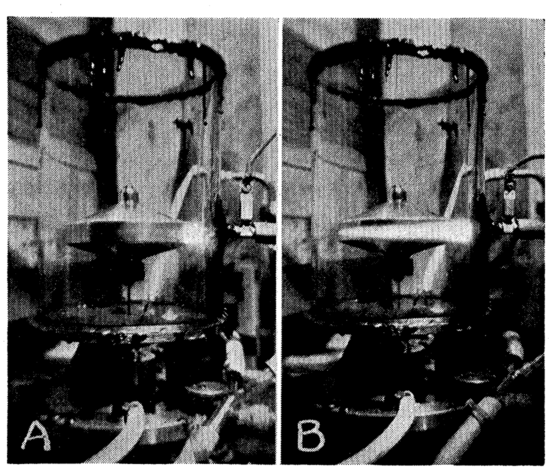

FIG. 1. Discharge between a stationary and rapidly rotating electrode. A, Rotating electrode as anode. B, With rotating electrode as cathode.

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[1] J. W. Beams and F. W. Linke, Rev. Sci. Inst. **8**, 160 (1937); J. App. Phys. **8**, 795 (1937).

On the Shape and Stability of Heavy Nuclei

The surface energy of a nucleus has its minimum value for the spherical shape if nuclear matter is assumed to behave like an incompressible fluid. Under the same assumption, the Coulomb energy is larger for the spherical shape than for any nearly spherical distribution. A heavy nucleus in its normal state will take the form of a sphere if for any small departure from sphericity the increase in surface energy is greater than the decrease in Coulomb energy.

To obtain a quantitative condition for the stability of the spherical shape I calculate the surface and Coulomb energies of a nucleus bounded by the ellipsoidal surface

$$x^2+y^2+(z/a)^2=R^2/a^{\frac{2}{3}}. \qquad (1)$$

A sphere of radius R has a volume equal to that enclosed by the surface (1). For the sphere the energies are

$$E_s^0=\gamma A^{\frac{2}{3}} \text{ (surface)}, \qquad (2)$$

$$E_c^0=\frac{3}{5}\frac{Z^2e^2}{R} \text{ (Coulomb)}.$$

The calculation yields

$$E_s=E_s^0\{1+8/45\ (a-1)^2+\cdots\}, \qquad (3)$$
$$E_c=E_c^0\{1-4/45\ (a-1)^2+\cdots\}.$$

A necessary condition for stability against small departures from the spherical shape is

$$2E_s^0/E_c^0>1. \qquad (4)$$

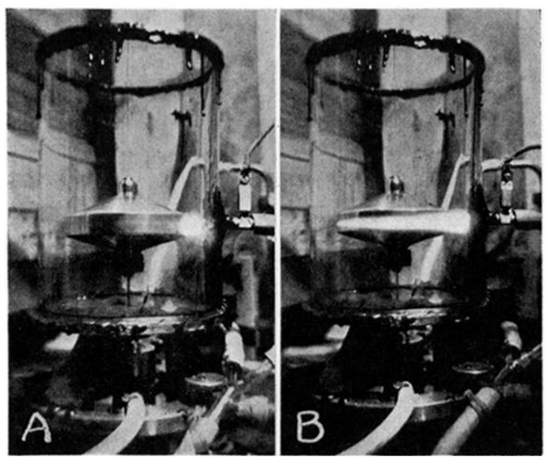
The quantities γ and R have been determined by fitting a semi-empirical energy formula[1] to the experimental mass defects[2] in the mass range $100\leqq A\leqq 238$. One finds

$$\gamma=26\ mc^2, \qquad (5)$$
$$R=1.39\times 10^{-13}A^{\frac{1}{3}}\text{ cm}$$

and

$$E_c^0=1.22\ Z^2/A^{\frac{1}{3}}mc^2, \qquad (6)$$
$$2E_s^0/E_c^0=42.6\ A/Z^2.$$

Values assumed by the quantity $2E_s^0/E_c^0$ are given in Table I. The stability condition is satisfied for all known nuclei.



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