electrode. For d.c. potentials this may produce an accumulation of space charge near the hotter electrode. This space charge, q , acted on by the field E produces a body force qE within the liquid. Apparently any non-uniformities in the space charge distribution (in this case caused by thermal variation of resistivity) will cause net body forces, which may produce flows analogous to thermal convection.

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Critical Potential Differences for Charge Transfer between Separated Spheres

MANY workers^{1,2} have measured the voltage difference required for the passage of a spark between spherical electrodes as a function of their radii and separation. Few measurements, however, have been made of the potential difference necessary to effect charge transfer between two spheres by means of a discharge process in the range of separations 5×10^{-3} cm to 10^{-1} cm. This information was required in order to develop the quantitative applications of the calculations of Davis³ (on the electrostatic forces between conducting spheres situated in an electric field) to the atmospheric problems of the coalescence of water droplets⁴ and the inductive theory of electrification of thunderstorms^{5,6}.

A carefully cleaned metallic sphere of radius r was mounted on a rigid support directly above a similar sphere of radius R firmly held in a micromanipulator. The separation X of the sphere could be adjusted with a high degree of precision by use of the fine control of the micromanipulator and could be measured to within $\pm 10^{-3}$ cm using a vernier eyepiece in a telescope mounted on a cathetometer. Electrodes attached to the spheres enabled a continuously variable potential difference of up to 5 kV to be applied between them by means of a high voltage supply. The potential difference could be measured to within ± 1 per cent using a sensitive electrostatic voltmeter. The spheres and electrodes were contained within an approximately cubical shielding box of side 45 cm which was earthed. The box contained holes for illumination and observation of the spheres, which were ventilated with a gentle stream of air free of particles in order to eliminate the settling of dust on the spheres, as this could decrease their separation and create a short circuit. Any discharge current which flowed between the spheres could be detected using a sensitive oscilloscope in circuit with the power supply and electrodes.

The experimental procedure was to bring two selected spheres to a predetermined separation, measured using the cathetometer, and then slowly to increase the potential difference between the spheres until evidence of a discharge was recorded on the oscilloscope, at which point the critical value of potential difference, V , was read. After this operation had been repeated several times the separation X was changed and the corresponding new value of V recorded. Measurements of the critical values of V were made for separations ranging from 5×10^{-3} cm to 10^{-1} cm for spheres of radii ranging from 0.16 cm to 1.20 cm. The local atmospheric pressure was 835 mb.

Fig. 1 shows that for spheres of identical radius ($R=r$) V increased rapidly with increasing X , while the corresponding critical field, V/X , increased as the separation was

Fig. 1. The voltage difference V required for charge transfer as a function of the separation X of spheres of equal radii. $R=r$: (1) $R=0.16$ cm; (2) $R=0.32$ cm; (3) $R=0.64$ cm.

Fig. 2. The voltage difference V required for charge transfer as a function of the separation X of spheres of unequal radii. $r=0.32$ cm: (1) $R/r=3$; (2) $R/r=2$; (3) $R/r=4$.

decreased. The potential difference required for charge transfer at a given separation is seen to be slightly reduced for spheres of larger radius. Fig. 2 demonstrates that when a sphere of radius r was paired with successively larger spheres of radius R the critical value of V at any separation decreased with increasing R/r . The form of these curves agrees reasonably well with those obtained by earlier workers in studies of spark discharges between spheres of various radii. The results obtained in this study were utilized in an experimental investigation⁷ of the computations of Davis; good agreement was found to exist between his theoretical predictions and the experimental results.

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