to the University of Oregon next fall. During his absence Dr. H. C. Hicks has served as assistant professor of mathematics at the University of Oregon. Dr. Hicks has recently been elected professor of mathematics and aeronautics at Texas Technological College.

R. A. ROBERTSON, reader in botany in the United College, St. Andrews, has been appointed to the newly established chair of botany in the University of St. Andrews, which places him at the head of the departments of botany in the United College, St. Andrews, and in University College, Dundee.

# DISCUSSION

## ATMOSPHERIC ELECTRICITY DURING SAND STORMS[1]

THE observations of Canfield[2] that sand storms cause atmospheric electrical disturbances and that during the storm an arc will pass between the points of an aerial wire and a ground wire may be explained as analogous to the "Dorn effect"[3] in liquid systems.

Colloid chemists have recently devoted considerable attention to methods for the study of the electrokinetic potential, *i.e.*, the absolute magnitude of the electrical charge on the surface of colloid particles. The methods usually employed are cataphoresis or electroendosmosis. Cataphoresis is the migration of a suspended particle through a liquid under an impressed electrical potential, the particle migrating toward the electrode having the opposite sign to the electrical charge on the particle. The rate of migration under a constant electrical potential is proportional to the magnitude of the electrokinetic potential on the surface of the particle, or

$$\zeta = \frac{4\pi V \eta}{E \varepsilon} \qquad (1)$$

where $\zeta$ = the electrokinetic potential; $V$ = the velocity of migration; $\eta$ = the viscosity of the medium; $E$ = the applied E.M.F. per unit length between electrodes, and $\varepsilon$ = the dielectric constant of the medium.

Electroendosmosis is similar to cataphoresis except that in this instance the material under investigation is a gel or a porous membrane. When the pores of such a membrane are filled with liquid and electrodes are inserted in the liquid on opposite sides of the membrane, a streaming of liquid takes place through the membrane toward the electrode having the same sign as the charge on the surface of the membrane. The rate of flow of liquid through the pores of the membrane under a constant electrical potential is proportional to the magnitude of the electrokinetic potential on the surfaces of the capillaries, or for a bundle of capillaries of cross-section q,

$$\zeta = \frac{4\pi v \eta l}{q H \varepsilon} \qquad (2)$$

where $v$ = the volume of liquid transported in unit time and $l$ = the length of the capillaries, the other quantities having the same values as in equation (1).

The streaming potential is the converse of electroendosmosis and has been studied by Freundlich,[4] Kruyt[5] and Briggs.[6] It must be obvious that if an electrical potential produces streaming through a membrane, then streaming a liquid through a membrane by hydrostatic pressure will set up an electrical potential difference between electrodes immersed in the liquid on the opposite sides of the membrane. This potential difference may be of considerable magnitude. Thus, Martin[7] has observed a potential difference in excess of 1.25 volts when nitrobenzene was streamed through a cellulose membrane under a hydrostatic pressure of approximately 19 cm of mercury.

The electrokinetic potential at the interface of such a system may be calculated by the formula,

$$\zeta = \frac{4\pi \eta \varkappa_s H}{P \varepsilon} \qquad (3)$$

or

$$H = \frac{\zeta P \varepsilon}{4\pi \eta \varkappa_s} \qquad (4)$$

where $\varkappa_s$ = the specific electrical conductivity of the liquid as it exists in the pores of the diaphragm; $H$ = the E.M.F. developed between the electrodes, due to the streaming of the liquid, and $P$ = the hydrostatic pressure under which the liquid flows through the diaphragm, the other quantities being as in equations (1) and (2).

The Dorn effect is the converse of cataphoresis, *i.e.*, if an electrical potential gradient will cause the movement of charged particles through a medium, then the movement of charged particles will set up an

[1] Published with the approval of the director as Paper No. 870, Journal Series, Minnesota Agricultural Experiment Station.

[2] R. H. Canfield, SCIENCE, 69: 474–475, 1929.

[3] E. Dorn, *Ann. Physik.*, 5: 20–44, 1878; 9: 513–552, 1880; 10: 46–76, 1880.

[4] Freundlich and Rona, *Sitzber., preuss. Akad. Wiss.*, 20: 397–402, 1920.

[5] H. R. Kruyt, *Koll. Z.*, 22: 81–98, 1918; 45: 307–319, 1928.

[6] D. R. Briggs, *J. Phys. Chem.*, 32: 641–675, 1646–1662, 1928; *J. Am. Chem. Soc.*, 50: 2358–2363, 1928.

[7] W. McK. Martin, unpublished data taken from Ph.D. thesis filed in Library of the University of Minnesota, June, 1929.

electrical potential. Those systems which have been somewhat studied have all been solid-liquid systems in which the particles were allowed to fall through the liquid under the force of gravity. This is true of Dorn's original observations, as well as the later work of Stock,[8] who obtained "sedimentation potentials" of the order of 80 volts, when quartz powder was allowed to fall through a 2-meter column of toluol. No formula has as yet been devised whereby the $\zeta$-potential can be calculated from the observed and measured "sedimentation potential" difference which exists across the electrodes. A study designed to develop a correct formula is already in progress in our laboratories.

From the foregoing there can be but little doubt but that the "atmospheric electricity" effects observed by Canfield during the sand storms are analogous to the sedimentation potential observed in liquid-solid systems. In the sand storms the force moving the particle is the wind instead of gravity, the viscosity of the air is much lower than that of a liquid system ($\eta = ca.\ 1900 \times 10^{-7}$ at 20°), the specific conductivity of dry air is extremely low, the dielectric constant of air is low (*ca.* 1.0), so that if a formula similar to (4) should hold, the system is such as to favor the production of high potentials, the magnitude of the potential which is developed being influenced by the force of the wind (P) and the magnitude of the electrokinetic potential ($\zeta$) on the surface of the sand particles. Of course, relative humidity will be a factor, since this would affect the dielectric constant, the viscosity and the conductivity of the air.

It is surprising that this source of "atmospheric electricity" has not been earlier recognized. Falling rain drops or the rapid motion of any charged particles through any medium which is a poor conductor of electricity should produce this effect. Probably the "static electricity" which occasionally causes explosions in sugar refineries, flour mills, starch factories, etc., may result from similar causes, for a relatively high electrical potential should be generated whenever dry powders are allowed to flow at high velocity through dry air.

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## WRECK OF THE ARCHEOLOGICAL DEPARTMENT OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA

THE sale of the Clarence B. Moore collection by the trustees of the Academy of Natural Sciences of Philadelphia and the concomitant destruction of the academy's archeological department call for explanation. The Clarence B. Moore collection is the finest, most comprehensive and best documented assemblage of Indian antiquities from the mounds and cemeteries of the southern states. It is now in the possession of the Museum of the American Indian, Heye Foundation, of New York City.

The facts, as far as known, are these.

On December 1, 1928, it was announced that Mr. Charles M. B. Cadwalader, a trustee of the academy, had been made managing director of the academy—an office not created until new by-laws were passed on January 15, 1929. The managing director was without museum experience, and his first official inspection of the archeological department revealed him as ignorant of the value and importance of its collections. He summoned Mr. Moore to a conference, ostensibly to discuss the cleaning of his cases, which, according to his contract with the academy, were not to be opened in his absence. Owing to his departure for Florida, Mr. Moore was unable to meet Mr. Cadwalader.

Some weeks later, the managing director began inquiries as to the donors of the academy's archeological and ethnological collections—their residence, if living, their heirs, if dead.

On February 28, notice was served to the scientific staff that the academy's stock of publications was being moved to the top of the book-stack—one hundred copies of each part of the "Proceedings" and seventy-five of each part of the *Journal*—and the remaining "surplus stock," amounting to several tons, would be destroyed.

The editor, Mr. W. J. Fox, called Mr. Cadwalader's attention to the fact that Mr. Moore's "Reports," making twenty issues of the *Journal*, had been paid for entirely by Mr. Moore. To this, Mr. Cadwalader replied: "Mr. Moore is in Florida and we can not reach him. We will say nothing about it." At Mr. Fox's suggestion, the present writer sent Mr. Moore an offer of as many sets of his "Reports" as he should wish to request. To this, Mr. Cadwalader later agreed.

The "surplus stock" of the academy's publications was saved from burning or defacement only by the protest of the united scientific staff, and they are being sent out to scientific institutions.

In March, the entire east end of the archeological hall was ordered cleared. Archeological and ethnographic material from thirty cases was sent to storage in the rather leaky old museum. This was to make space for proposed groups of sheep and goats. At this time, the managing director stated that the entire archeological hall would be used for mammal groups and that no other exhibition space would be provided

[8] M. J. Stock, *Bull. intern. acad. sci. Cracovie*, 1913, p. 131; *Anzeiger Akad. Wiss. Krakau* (A), 1914, p. 95–106.