LETTERS TO THE EDITOR

PLANETARY SCIENCE

Electrical Effects of the Harmattan Dust Storms

EACH year, from December to March, an area of a million square miles or so in West Africa is periodically subjected to a very dry dust-laden atmosphere (the Harmattan), which rises in the Sahara desert and is carried south by winds from that area. The dust particles are thought to consist predominantly of quartz, with diameters of the region 0·1–1μ, and the dust layers are known to rise to heights in excess of 10,000 ft. Visibility can be reduced to less than a mile and the intensity of the radiation from the Sun is severely reduced at the surface of the Earth.

Measurements of the electric field at ground level, and of the electric current from the air to ground, have been made at Zaria during the present Harmattan season. During fair weather conditions there is a positive electric field perpendicular to the surface at any position on the ground, normally about 100 V/m, because the upper conducting layers of the atmosphere are at a positive potential with respect to the ground. This electric field is accompanied by an electric current into the ground from the atmosphere of about 10^{-12} amp/m^2. These fair-weather values are severely modified by the presence of thunderclouds, when the electric field may be reversed in polarity and increase to many thousands of volts/m, as a result of the proximity of the negatively charged lower regions of the thunderclouds.

Some interesting electrical effects have been observed during the recent periods of intense dust concentration at Zaria. The electric field has been measured by two independent methods. In one, the field-mill method, insulated plates are alternately covered and exposed to the electric field by an earthed rotor and the resultant alternating current is amplified and measured. In the other, a radioactive electrode is mounted a short vertical distance from the ground and its potential measured with respect to Earth. The former instrument is calibrated by imposing a known electric field, and the latter is calibrated under steady conditions against the field mill. A continuous record is taken of the measurements using a chart recorder.

Fig. 1 shows the variation in the measured vertical electric field at ground level over a 24 h period during a period of severe Harmattan at Zaria. The different scales for the positive and negative fields should be noted. During the night period the field has a value which is typical for the fair weather field at ground level, but in the early morning the field reduces to zero and then reverses in polarity, reaching a magnitude of several thousand volts/metre which is sustained for a period of several hours.

It has long been known that electrical effects can result from dust storms, but the measurements show both the polarity and the intensity of the effects for the particular conditions in this part of the world. Continuous measurements have been made over a prolonged period, and the results obtained during the Harmattan period are consistent for both methods of measurement in the polarity of the field recorded, the time of onset early in the morning, the peak being reached in mid-morning and the gradual decay of the effect during the remainder of the day. The commencement of the effect possibly results from the heating of the surface of the Earth by the early Sun and the consequent turbulence of the air layers.

The current to a horizontal metal plate electrode close to ground level has also been measured, with a measuring

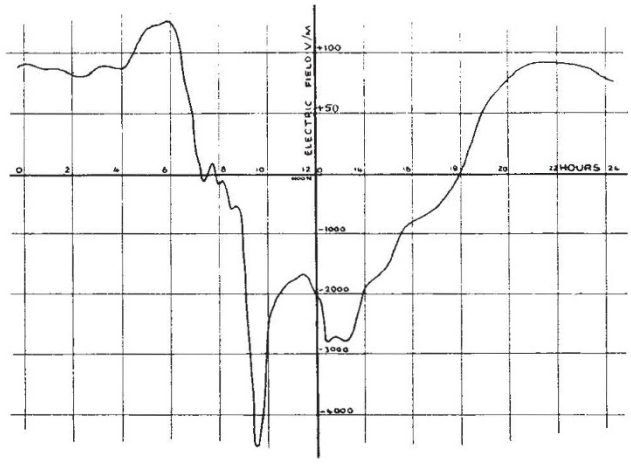

Fig. 1. Variation of the Earth's electric field at Zaria, Northern Nigeria, on February 4, 1967.

time constant of 10 min to minimize displacement current effects. Currents recorded follow a similar pattern to the variation of electric field, with a steady positive current of about 10^{-12} amp/m^2 during the night and a maximum negative current greater than 10^{-11} amp/m^2 during the mid-morning. Because the area covered by the Harmattan dust haze in West Africa alone may be one hundredth of the surface of the Earth. this negative current effect may be of some significance in the current balance between the Earth and the upper atmosphere.

D. J. HARRIS

Department of Electrical Engineering,
Ahmadu Bello University, Zaria,
Northern Nigeria.

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PHYSICS

Flow Characteristics of Complex Soap Systems

THIS communication describes some preliminary experiments on flow through pipes using a dilute solution of cetyltrimethylammonium bromide (CTAB) and 1-naphthol.

Nash[1,2] has shown that when mixtures of CTAB and derivatives of naphthalene are dissolved in water highly viscoelastic gels are formed; however, the proportions and method of mixing are fairly critical. The possibility of using these additives to reduce turbulent friction has recently been suggested by Gadd[3].

Measurements have been made of the axial pressure gradients for fully developed flow in a range of circular pipes using an aqueous equi-molar solution of CTAB and 1-naphthol at a total concentration of 508 w.p.p.m. Fluid was drawn from a small sump and supplied to one of the pipes by a centrifugal pump through suitable control valves. The flow rate was measured by timing the discharge from the pipes into a volumetric measuring tank, the contents of which were finally returned to the sump for recirculation. The solution was prepared by dissolving the CTAB in water, and then adding the naphthol drop by drop which had previously been dissolved in alcohol. It was found that when the viscosity of the resulting complex solution was measured in a capillary viscometer it was only slightly greater than that of water.

The results of these experiments are presented in Figs. 1 and 2. It can be seen that the additives result in a considerable reduction in pipe friction, and there is no evidence of a threshold stress effect which occurs with many dilute high polymer solutions[3,4].