LETTER TO THE EDITOR

Improved Electrode System for Point-discharge Current Measurement in Trees

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The simple electrode by-passing arrangement of Milner and Chalmers (1961) which diverts part of the point-discharge current in a tree through a low resistance galvanometer connecting two metal electrodes in the tree suffers from two major defects:

Firstly, owing to relaxation effects between the electrodes (Ette, 1966a) the electrode current response when a constant current derived from a laboratory point-discharger is injected into the tree (Ette, 1966b) is not constant, but shows a steady asymptotic decay. In consequence—as noted by Jhawar and Chalmers (1967)—the by-passed current is not a fixed fraction of the injected current; the calibration curve being determined by personal and instrumental response characteristics.

Secondly, investigations reveal that where, as is often the case, a residual current in excess of some limiting value (determined largely by the nature and dimensions of the electrodes) flows in an electrode system the electrode contacts acquire rectifying characteristics; the system exhibiting a higher by-passing efficiency, for calibration currents flowing in the same (‘forward’) direction as the residual current than for calibration currents in the opposing (‘reverse’) direction. This effect is illustrated by the calibration curves shown in Fig. 1 for a Palm tree with nearly passive mercury electrodes (no residual current) between which residual currents were simulated by the use of a 1.5 volt dry cell in series with the electrode meter.

The current response of a passive Milner-Chalmers electrode system to an injected current impulse consists of a sharp current peak in the direction of the impulse followed by a broad secondary peak of smaller magnitude in the opposite direction. An enhancement of a secondary peak (when in the ‘forward’ direction of an electrode system with a large residual current) relative to the primary peak can therefore lead to occasional loss of similitude between the by—passed and injected current waveforms, where the currents are large and impulsive. Using a recording system with a sluggish response an attenuated primary peak in ‘reverse’ direction may fail to be registered; the electrode and injected currents appearing to flow in opposite directions immediately after an impulse—as was probably the case in the response recorded by Chalmers (1962) after the third lightning discharge.

The average rate of decay of the electrode current response to a step current input a tree decreases when a resistance is connected in series with the electrode meter; being
sensibly zero for a length of time which increases with the magnitude of the resistance. Under this condition the disturbing higher relaxation modes of the tree—electrode network are effectively suppressed, with consequent linearization of the calibration curve over a wide range of currents—as shown in Fig. 2.

A series resistance in the electrode circuit decreases the magnitude of the current passed by the electrode contacts and, if high enough to reduce the residual current below the limiting value for the electrode system, can also eliminate asymmetry in the electrode response. The pen oscillograms reproduced in Fig. 3a of by-passed and injected currents lasting over 30 min indicate that the loaded electrode system may be relied on to provide satisfactory and unambiguous measure of point-discharge currents in trees under natural conditions. As may be seen in the oscillograms of Fig. 3b, the electrode response remained satisfactory even when very large currents flowing as sparks passed between the discharging tips of a small casuarina plant and the calibrating plate (Ette, 1966b), were injected into the tree.

The only significant effect of a small residual current in an adequately loaded electrode system is a steady drift of the electrical zero in the direction of the residual current (see Fig. 3a). To minimise this, the short-circuit residual current must be kept low by making the electrodes identical in structure, and siting them fairly close together—about 2 or 3
Fig. 2 Calibration curves for the electrode system in the Palm tree in the absence of residual current,
(a) with virtually no resistance load between the electrodes,
(b) with a 650 kΩ load between the electrodes.

Fig. 3 Pen oscillograms of by-passed and injected currents lasting over 30 minutes for another Palm tree with mercury electrodes loaded to reduce residual current below 0.005 μA, the limiting value for the system. The wave forms in (a) were obtained by interrupting the discharge from a metal point; and those in (b) by arranging for sparks to pass between the tips of a discharging casuarina plant and the charged plate above.
metres apart—in the middle section of the tree where differences in bioelectrical characteristics of the plant cells are likely to be minimal.

References


