Compensation of low-pass filter properties of the current measuring internode in voltage clamped myelinated nerve fibres

H. Schumann and E. Koppenhöfer
Physiologisches Institut der Universität, D-2300 Kiel, F.R.G.

In conventional voltage clamp configurations for single Ranvier nodes the membrane current is measured as a voltage drop across the impedance of the current measuring internode located in compartment E of the recording chamber (1,2). From one dimensional linear cable theory the impedance is given by $Z \tanh(\gamma L)$, where $Z = \sqrt{R/j\omega C}$, $\gamma = \sqrt{j\omega RC}$ and L represents the length of the internode. R is the axoplasmic resistance and C the radial myelin capacity, both per unit length, ω and j have their usual meanings. The internode acts as a low-pass filter and cuts down the high frequency components of the current records. For a mean fibre from the sciatic nerve of Rana esculenta (diameter: 14 µm; L = 2 mm) the cut off frequency (-3db) is about 6 KHz (3).

To increase this figure we grounded a segment of the internode via an additional compartment E'. As a result the low-pass filter properties of the rest of the internode (remaining in compartment E) was compensated by the grounded segment which acted as a high-pass filter. In the modified configuration the impedance of the internode is given by

$Z \cosh(\gamma l_{E'}) [\tanh(\gamma l_{E'}) + \tanh(\gamma l_E)]$, where l_E' and l_E denote the fibre lengths in the corresponding compartments ($l_E' + l_E = L$). If about 35 % of the internode was grounded and a waviness of ± 3db was allowed for, the cut off frequency increased by a factor of about 40.
In voltage clamp experiments (4) the duration of the so-called capacity currents, I_C, was cut down to about 7 µs. This facilitated fast Na^+-current measurements since in many cases corrections of current records for I_C became superfluous.

1. Dodge, F.A., Frankenhaeuser, B. (1958) J. Physiol. 143, 76-90
2. Nonner, W. (1969) Pflügers Arch. 309, 177-192
3. Nonner, W., Rojas, E., Stämpfli, R. (1978) Pflügers Arch. 375, 75-85
4. Koppenhöfer, E., Schumann, H. (1981) Pflügers Arch. 390, 288-299

This study was supported by the Arbeitsamt Kiel (54/80 - 131).