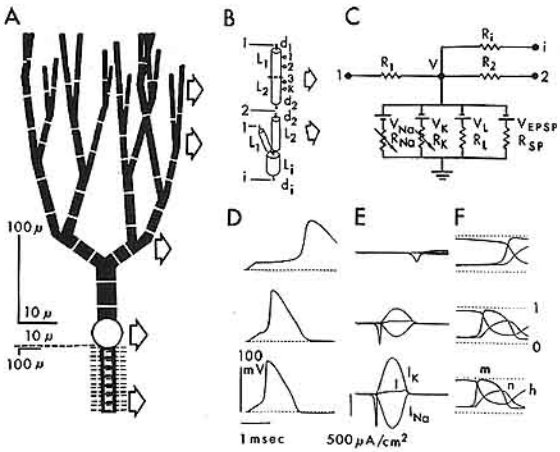

FIG. 2. Multicompartmental model of the Purkinje cell. The model consists of 31 dendritic branches, 15 bifurcation points, a soma, an initial segment and 7 nodes and myelinated segments. Each of these 62 compartments are represented by a cylindrical spatial segment of uniform diameter; or, for the branching compartments, a combination of three cylinders as shown in B. The equivalent electrical circuit is shown in C, where R_i represents the longitudinal resistance of the cylindrical compartment and the rest represents the electrical equivalent of the membrane as described by HODGKIN & HUXLEY (1952), all of the parameters being set individually for each compartment. D–E–F show the assumed electrical properties of three representative compartments: a low excitability branching point (upper row in D–E–F), the soma (second row) and nodes of Ranvier (lowest row) being of increasing excitability. Numerical solutions expressing the waveform of membrane potential change (D), the membrane currents (E), and the m, n, h variables in Hodgkin–Huxley equations (F) are shown as a function of time following the brief current pulse injection illustrated in F.

90 mV respectively), V_L is the e.m.f. (0 mV) for 'leakage' current. The neighboring compartmental potential values are denoted by V_i.

The R_{Na}, R_K and R_L cross-membrane resistance values for Na$^+$, K$^+$ and leakage currents are determined as follows:

$$1/R_{Na} = g_{Na}.s$$
$$1/R_K = g_K.s$$
$$R_L = R_m/s$$

where S is the combined surface area of the i cylinders involved in one compartment:

$$s = \sum_{n=1}^{i} \pi d_i L_i.$$

While the specific cross-membrane resistance (R_m) is assumed to be constant (normally taken as 6000 Ω/cm²), the Na and K conductances follow those of HODGKIN & HUXLEY (1952), in which the actual g_{Na} and g_K values are at all times determined by the average $\bar{g}_{Na}$ and $\bar{g}_K$ but are changing with the V membrane potential and time as determined by the equations:

$$g_{Na} = m^3 h\, \bar{g}_{Na}$$
$$g_K = n^4\, \bar{g}_K.$$

Here the dimensionless variables of $k = m$, n and h follow the equation

$$dk/dt = \alpha_k(1 - k) - \beta_k \cdot k.$$

The α and β constants are deduced from those in FRANKENHAEUSER & HUXLEY (1964) with only minor modifications:

$$\alpha_m = 0.36\,\frac{V - 22.0}{1 - \exp(22.0 - V)/3}$$
$$\beta_m = 0.40\,\frac{13.0 - V}{1 - \exp(V - 13)/30}$$
$$\alpha_n = 0.02\,\frac{V - 35.0}{1 - \exp(45.0 - V)/10}$$
$$\beta_n = 0.25\,\frac{10.0 - V}{1 - \exp(V - 10.0)/10}$$
$$\alpha_h = 0.35\,\frac{-10.0 - V}{1 - \exp(V + 10.0)/7}$$
$$\beta_h = 0.05\,\frac{V - 45.0}{1 - \exp(45.0 - V)/10}.$$

These sets of parameters were established through the procedure of requiring an adequate rising time and propagation of the action potential (see HARDY, 1973) and also a capability of firing with a frequency exceeding 500 Hz, as it can be recorded experimentally (LLINÁS, BLOEDEL & HILLMAN, 1969). Since the morphological and electrical properties of any of the 62 compartments could be adjusted independently, this provided the possibility of studying the significance of the different parameters in overall integrative properties. Especially important were