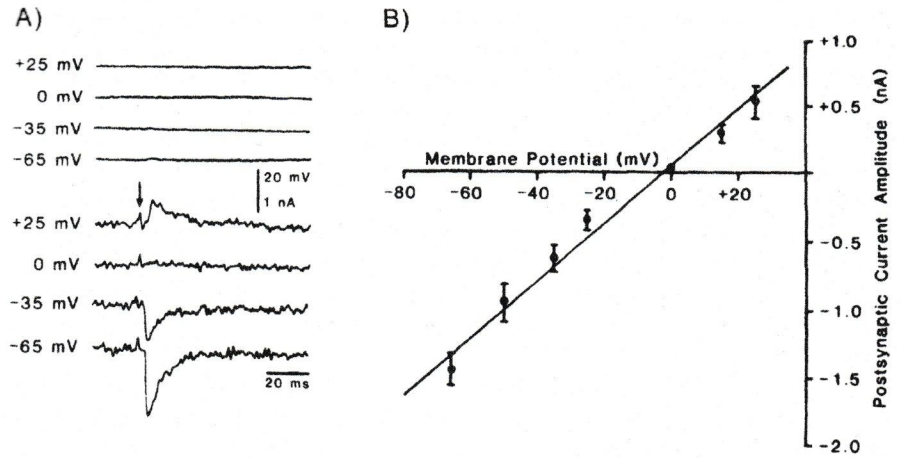

Fig. 1.6 A Fast Excitatory Synaptic Input Excitatory postsynaptic current (EPSC) caused by the simultaneous activation of synapses (arrow) made by the mossy fibers onto CA3 pyramidal cells in the rodent hippocampus (Brown and Johnston, 1983). This classical experiment showed how a central synapse can be successfully voltage clamped. **(A)** The voltage-clamp setup stabilizes—via electronic feedback control—the membrane potential at a fixed value. Here four experiments are shown, carried out at the holding potentials indicated at the left. The current that is drawn to keep the membrane potential constant, termed the clamp current, corresponds to the negative EPSC. It is maximal at negative potentials and reverses sign around zero. The synaptic current rises within 1 msec to its peak value, decaying to baseline over 20–30 msec. The experiments were carried out in the presence of pharmacological agents that blocked synaptic inhibition. **(B)** When the peak EPSC is plotted against the holding potential, an approximately linear relationship emerges; the regression line yields an x-axis intercept of -1.9 mV and a slope of 20.6 nS. Thus, once the synaptic reversal potential is accounted for, Ohm's law appears to be reasonably well obeyed. We conclude that synaptic input is caused by a transient increase in the conductance of the membrane to certain ions. Reprinted by permission from Brown and Johnston (1983).

pyramidal cell.[3] The figure is taken from an experiment by Brown and Johnston (1983), which demonstrated for the first time how a synapse within the central nervous system could be voltage clamped. The *voltage-clamp* technique was previously used on the very large synapse made between the axonal terminals of motoneurons and the muscle, the so-called *neuromuscular junction* (Katz, 1966; Johnston and Wu, 1995). It allows the experimentalist to stabilize the membrane potential (via a feedback loop) at some fixed value, irrespective of the currents that are flowing across the membrane in response to some stimulus. This allows the measurement of EPSCs at various fixed potentials (as in Fig. 1.6). The EPSC has its largest value at a holding potential of -65 mV, becoming progressively smaller and vanishing around 0 mV. If the membrane potential is clamped to values more positive than zero, the EPSC reverses sign (Fig. 1.6A). When the relationship between the peak current and the holding potential is plotted (Fig. 1.6B), the data tend to fall on a straight line that goes through zero around -1.9 mV and that has a slope of 20.6 nS.

What we can infer from such a plot is that the postsynaptic event is caused by a temporary increase in the membrane conductance, here by a maximal increase of about 20 nS

3. It should be pointed out that we are here looking at a population of synapses, made very close to the soma of the pyramidal cell, thereby minimizing space-clamp problems.

(due to simultaneous activation of numero
reversal battery or potential, $E_{syn} = -1.$
for a particular class of ions). Spiking act
complicated cascade of biophysical event
change in the membrane of the postsyn
transiently increases within less than 1 ms
The equivalent electrical circuit diagram
membrane is shown in Fig. 1.7A. It is in
postsynaptic point of view, a synapse doe
that case the slope of the I–V curve in Fi
increase in the membrane conductance. A
basic feature of the neuronal hardware has

Because of the existence of the synaptic
is the difference between E_{syn} and the me
to a single such synapse is given by Ohm's

$$I_{syn} = g_{syn}(t$$

Inserting this synapse into a patch of me
ordinary differential equation (on the basis

$$C\frac{dV_m}{dt} + g_{syn}(t)(V_m$$

or, with $\tau = CR$, the passive membrane ti
we can transform this into

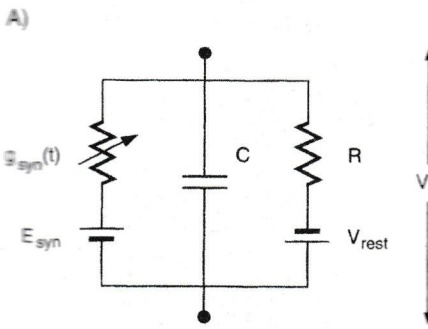

Fig. 1.7 Equivalent Electrical Circuit
model of a fast voltage-independent chemical
occurring at the neuromuscular junction by Ka
the central nervous system, with the exception
complex, operate on the same principle. Activa
ionic channels, selective to certain ions. This
conductance $g_{syn}(t)$ in series with the synaptic
passive membrane patch. **(B)** If the evoked pote
potential, the synapse can be approximated by
however, this will not be the case and synaptic
that has important functional consequences.