AN ELECTRONIC DEVICE FOR MEASURING THE SIGNAL/NOISE RATIO ON THE ELECTROENCEPHALOGRAM

E. Ya. Voitinskii

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An electronic device is suggested for automatic measurement of the signal/noise ratio on the electroencephalogram during periodic photic stimulation. The accuracy of measurement of the signal/noise ratio is ±3%.

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The electroencephalogram (EEG) during afferent stimulation can be regarded as a mixture of a useful signal (the brain response) and noise (the background rhythm) [3]. To distinguish the useful signal from noise, several methods are used in electrophysiology: accumulation, filtration, and correlation [2]. Additional information concerning the dynamics of neurophysiological processes during afferent stimulation and the quality of tuning of sensory systems to the acting stimuli can be obtained by measuring the signal/noise ratio of the EEG [1].

In this paper an electronic device is described for automatic measurement of the signal/noise ratio on the EEG during the action of periodic photic stimuli.

The theoretical circuit of the device is illustrated in Fig. 1. It consists of a memory unit based on P_1, type RP-5, and network R_2C_2; a modulator, tube L_1 type 6N1P; a clipper incorporating diode D_1, type D2E, and resistor R_1; an amplifier, tube L_2 type 6N1P; a measuring instrument I_1, type M-24; and an amplifier, tube L_3 type 6Zh1P.

The input voltage from the electroencephalograph is fed via the contact of relay P_1 to network R_2C_2. The relay P_1 works synchronously with the flash stimulator. The bipolar noise signal charges the storage capacitor C_2 alternately. The time constant of the RC-network is so chosen that even very low-frequency signals (0.2-1 Hz) produce virtually no charge on the capacitor. If a response to photic stimuli appears on

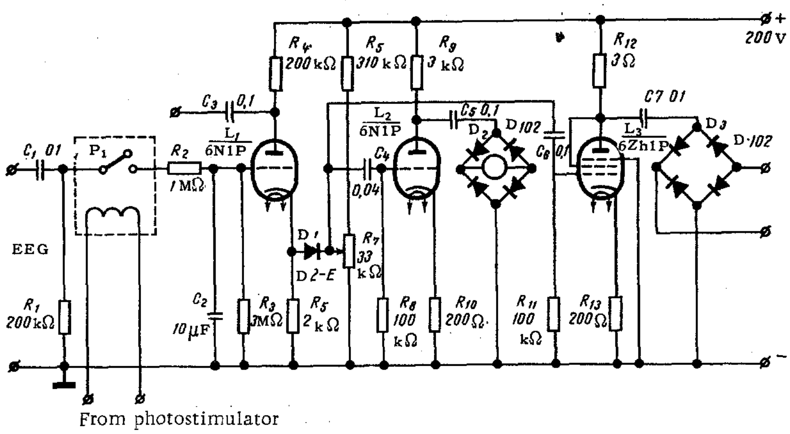

Fig. 1. Theoretical circuit of device for measuring signal/noise ratio on EEG.

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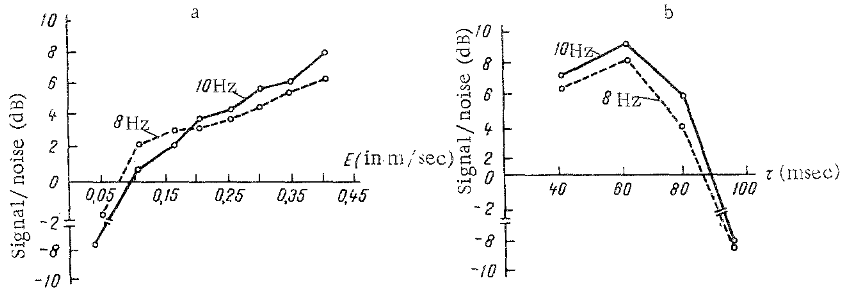

Fig. 2. Graph showing signal/noise ratio on EEG as a function of characteristics of photic stimulation (mean data). a) Abscissa: intensities of flashes; ordinate; signal/noise ratio; b) abscissa: duration of intermittent delay of stimuli; ordinate: signal/noise ratio.

the EEG, a charge begins to accumulate on the capacitor C_2, its magnitude being directly proportional to the power of the signal. The voltage is then transmitted from C_2 to the modulator L_1, designed to transform the dc into ac. In order that the voltage at the modulator output should be zero when no voltage is present at its input, a clipper is used in the circuit, consisting of resistor R_7 and diode D_1, which is blocked by a voltage corresponding to zero voltage on the grid of amplifier tube L_1. If a voltage is present, the grid becomes more positive, and the voltage on the cathode of the tube exceeds the blocking voltage. In this case the diode conducts and an alternating voltage appears at the output of the modulator, whose magnitude depends on changes in the grid voltage. The voltage potential passes from the clipper to the amplifier tube L_2. The load on the amplifier consists of bridge rectifier D_2 and the measuring instrument I_1. This instrument measures the magnitude of the charge accumulating on the capacitor C_2, which is directly proportional to the power of the signal. If the combined power of signal and noise is kept constant, the instrument I_1 can be graduated directly in signal/noise ratio units (in decibels).

To record the results graphically a recording dc potentiometer is used. The voltage potential is fed into it through the amplifier tube L_3 and bridge rectifier D_3.

The device can operate with input signals of 30-100 V and a frequency of 1-200 Hz. Its time constant is 10 sec. The accuracy of measurement of the signal/noise ratio is ±3%.

The device is remarkably simple and reliable in operation, economical and cheap, and convenient in size and weight. It can work with the standard electroencephalograph and photic stimulator.

The suggested device for measuring the signal/noise ratio was used to investigate the EEG of 120 clinically healthy subjects aged 5-25 years and patients with various neurological disturbances. Flashes were applied at different frequencies, intensities, and times of delay.

The investigations showed that the magnitude of the signal/noise ratio on the EEG provides a precise quantitative measure of the conditions studied. Under optimal conditions of photic stimulation the signal/noise ratio in clinically healthy subjects is 7-8 dB (Fig. 2a). With changes in the frequency of stimulation, a decrease in the brightness of the flashes, and an increase in the time lag of the stimuli, a nonlinear decrease in the signal/noise ratio takes place (Fig. 2b).

In cases of brain pathology (encephalitis, trauma, tumors, etc.) the signal/noise ratio may fall to 1-2 dB, and its value is usually significantly lower on the side of the lesion.

The suggested method of analysis and the automatic device can therefore be used with success in clinical as well as experimental electrophysiology.

LITERATURE CITED

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