AUTOMATIC DEVICE FOR MEASURING DURATION OF EEG DISCHARGES

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Statistical methods of investigating the time characteristics of the EEG [4] are of great practical and theoretical interest. Several different systems of automatic analysis of these characteristics are in use, especially devices for measuring the number of zeros on the EEG and the intervals between them [2, 5]. Additional information on the time properties of the EEG can be obtained if the EEG is investigated not only along the zero line, but also at other levels. This task is partly accomplished by means of an apparatus designed to count the mean number of intersections of various levels of analysis by the EEG signal [1]. In this paper an automatic device for measuring another time characteristic – the mean duration of the EEG discharges at different levels of analysis – is described. The error of the measurements does not exceed 5%.

The duration of the EEG discharge means the time during which the EEG signal exceeds a given level of analysis X [3]. The level of analysis may be either the zero line of the EEG or other horizontal lines above or below it.

Description of the Device. The suggested device can be used to measure the mean durations of the EEG discharges at 10 levels of analysis. Its functional scheme is indicated in Fig. 1. The device consists of a converter of durations into amplitude, a type AADO-1 amplitude analyzer, and a type PP-6 counter.

The EEG signal, recorded on magnetic tape, is fed via a cathode follower into a device for converting durations into amplitude (Fig. 2). The cathode follower is assembled on the left half of the type 6N1P tube T_1. From the output of the cathode follower the signal enters the analysis level selector, consisting of the relay R_1-R_{13} and a type D103 diode D_1. The analysis level selector allows only the apices of the EEG pulses to pass, cutting off the EEG signal at its base. The cutoff level is determined by the relay R_1-R_{13}. From the analysis level selector the signal passes to an amplifier assembled on the right half of the tube T_1. From the output of the amplifier the signal is fed via the capacitor C_3 into the input of a Schmitt trigger. From here a signal whose duration is proportional to the duration of the EEG pulse at the chosen level of analysis is taken. From the left anode of a type 6N1P tube T_2 the rectangular signal is fed into the input of a sawtooth potential generator assembled on the type 6Zh5P tubes T_3 and T_4. For every pulse arriving from the anode of tube T_2, the generator generates a pulse of sawtooth potential, its amplitude proportional to the duration of the rectangular pulse and, hence, to the chosen time interval of the EEG.

However, these sawtooth pulses cannot be analyzed by a standard amplitude analyzer, for these instruments are designed to record pulses with a duration of 1-15 μsec and steep rising fronts. Special shaping of the trailing edge of the sawtooth pulse therefore becomes necessary.

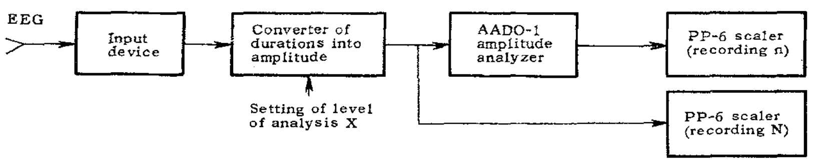

Fig. 1. Functional scheme of the apparatus.

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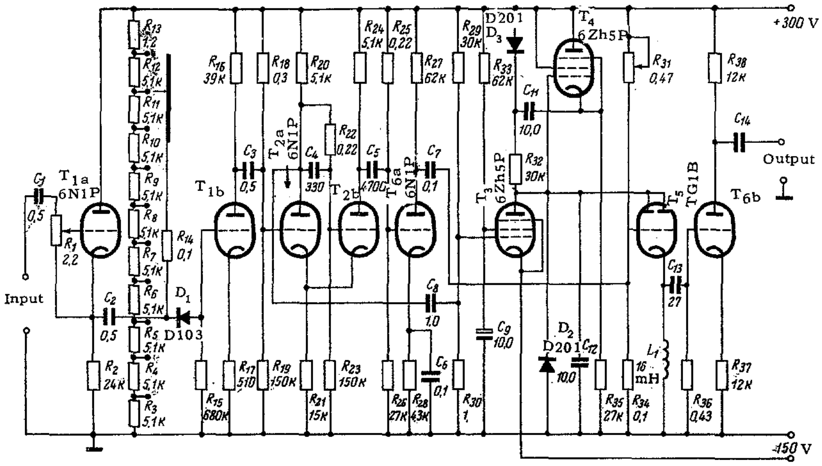

Fig. 2. Theoretical circuit of converted durations into amplitude.

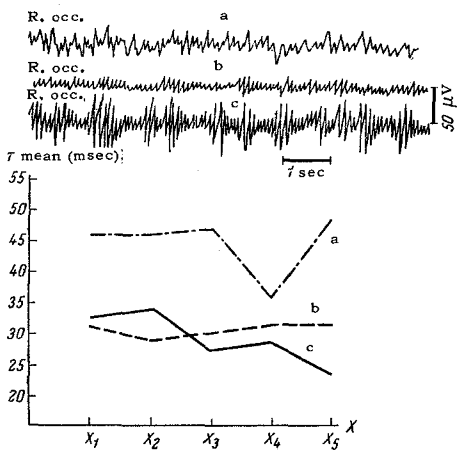

Fig. 3. Graphs of mean duration of discharges in EEG (a, c) of two subjects with a dominant Θ-rhythm (a) and a regular α-rhythm (b). Abscissa – levels of analysis; ordinate – time (in msec).

A thyratron TG1B, cut off in normal conditions by a negative bias on the grid, is connected in parallel with the capacitor C_{10}. The pulse of positive polarity, taken from the right anode of the Schmitt trigger, is differentiated by a circuit consisting of capacitor C_5 and the input circuit of an amplifier built on the left triode T_6. Two series of pulses are taken from the output of the amplifier. The first series, negative in polarity, corresponds to the leading edge of the rectangular pulse and, consequently, to the beginning of generation of the sawtooth pulse. The second pulse, positive in polarity, corresponds to the trailing edge of the rectangular pulse and, consequently, to the end of generation of the sawtooth pulse. A sequence of pulses from the resistor R_{27} passes to the grid of the thyratron TG1B. The cutoff thyratron TG1B is insensitive to pulses of negative polarity. Hence, at the moment that capacitor C_{10} begins to discharge through the internal resistance of tube T_3, the positive pulse from R_{27} fires the thyratron. The cathode circuit of the thyratron incorporates an inductance L_1, from which a pulse with a duration of the order of 10 μsec and with a short rise time is taken. This pulse is readily recorded by the amplitude analyzer, the one used being a type AADO-1 industrial analyzer.

The thresholds of the analyzer are calibrated from 0.01 to 0.17 sec to correspond to the measured durations.

The durations of the discharges are recorded by means of a type PP-6 industrial scaler. The readings are taken in the PP-6 instrument from neon lamps and from decatrons. The instrument includes an electronic seconds counter automatically stopping the counting at the end of time intervals ranging from 4 to $4 \cdot 10^3$ sec or after a given number of pulses has been monitored (from 10^3 to $4 \cdot 10^6$ pulses).

The standard error of the measurements does not exceed ±5%. The apparatus is comparatively simple, reliable, and convenient in operation. The analysis can be speeded up by using multichannel amplitude analyzers of the AI-100 or AI-128 types.

To measure the mean duration of the discharges experimentally, the EEG was recorded simultaneously on paper and magnetic tape (with the aid of amplitude modulation). Altogether, 69 cuts of the EEG with different background activity were analyzed: with a regular α-rhythm, with dysrhythmia of the waves, with dominant fast activity, with dominant fast waves, etc. The duration of the EEG segments analyzed was 2 min.

As an example, graphs of the mean duration of the discharges at five levels of analysis obtained from three subjects are shown in Fig. 3. Two had an α-rhythm of similar frequency, but differing in shape and amplitude (b, c), while on had dominant Θ-waves (a).

It will be clear from Fig. 3 that the longest duration of the discharges, associated with maximal information, is not found at the zero level of the EEG (X_1), but at other levels of analysis. The fine differences between the mean durations of the discharges in two cuts of the EEG with a normal α-rhythm can be seen in detail. Finally, essential differences are seen in the distribution of the durations of the discharges depending on the dominant frequencies of the EEG.

The proposed method of machine analysis provides more complete data on the time characteristics of the EEG than the periodometric method, in which the durations are measured at only one level of analysis [5]. The method and the apparatus for measuring the mean durations of the EEG discharges can be used in both experimental and clinical electroencephalography, and for studying both the background EEG curves and their changes caused by various stimuli and pharmacological agents.

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