APPARATUS FOR MEASURING DISPERSION OF THE ELECTROENCEPHALOGRAM

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During statistical analysis of the electroencephalogram (EEG) valuable information can be obtained by measuring the dispersion or the mean square of the signal voltage at the output of the electroencephalograph. Existing electrical measuring instruments give only the mean or the peak value of the signal voltage [2]. Such instruments can be graduated in values of the mean square of the voltage only for a sinusoidal or other periodic voltage, but when measuring the mean square of an aperiodic voltage of complex form, graduation of this sort is impossible. In this case the instrument used must have a square-law detector and must be capable of yielding the square-law characteristics of the relationship between the output voltage or current and the input voltage.

A comparatively simple analogue computer is described below by means of which the dispersion of the EEG signal can be measured with the use of a standard commercial electroencephalograph.

Description of Apparatus

The signal from the output of the electroenceophalograph or magnetic recording instrument is fed into the input cascade of the computer, which consists of a cathode repeater on a tube L_1, the purpose of which is to remove interaction between the quadrating circuit and the output cascade of the electroencephalograph.

The input device contains a voltage divider, enabling the required sensitivity of the apparatus to be selected.

As a quadrating circuit a multiplier on a type 6I1P multigrid tube was used. The square-law characteristics of such a circuit are obtained by using the principle of dual control by the anode current of the tube.

The complete circuit of the computer is shown in Fig. 1. The advantage of such a circuit lies in the considerable magnitude of the square-law area of the characteristic curve. The negative feedback

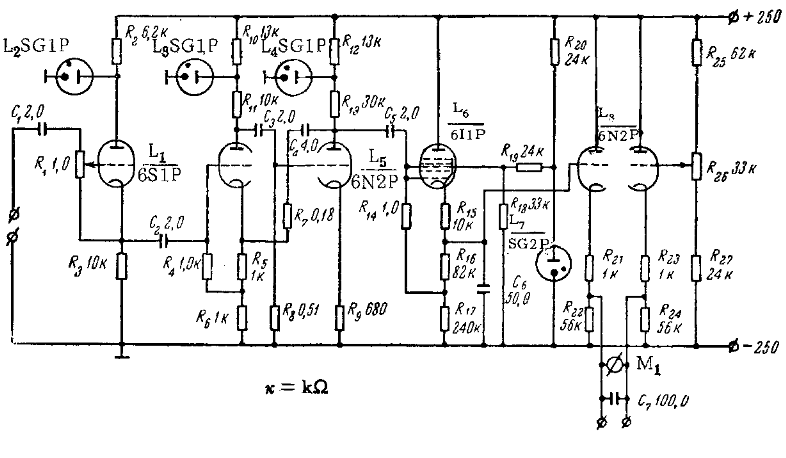

Fig. 1. Theoretical circuit of the apparatus for measuring dispersion of the EEG.

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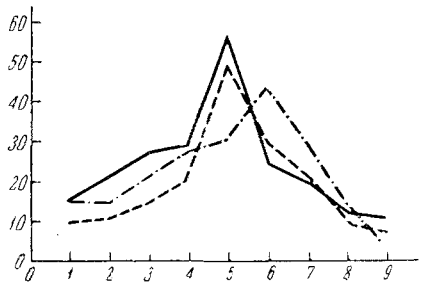

Fig. 2. Curves showing the increase in dispersion of the EEG during hyperventilation. Observations on three subjects. Along the axis of abscissas) time (in min), along the axis of ordinates) dispersion (in %).

due to the cathode resistor R_{15} increases the stability of the circuit considerably. The voltage is amplified by means of a two-cascade amplifier on the tube L_5, covered by deep negative feedback through the resistor R_7 and the capacitor C_4. The intermediate capacitors and the feedback circuit were selected so as to obtain a uniform frequency characteristic of the detector in the range from 0.5 to 1000 cps. Type SG1P gas-filled voltage stabilizers were used and decoupling filters in the anode circuit.

From the output of the quadrating circuit the signal passes to the output voltage meter on the type 6N2P tube L_8. The output voltage is measured by the apparatus M_1 and can be recorded by means of a type N-105 or EPP-09 self-writing potentiometer.

The range of measurable frequencies is 0.5-1000 cps and the limits of measurement 0.1-10 V. The degree of error of the measurement is ± 3%.

The dispersion can be measured for long periods of time without the need for recording the EEG.

EXPERIMENTAL RESULTS

The apparatus described above was used for calculating the dispersion of the EEG in the rabbit and man, when recorded in various experimental conditions – in a resting state, during exposure to a rhythmic light, to hyperventilation, and also under the influence of certain drugs: chlorpromazine, sodium amytal, amphetamine, etc.

The results of the measurements showed that the dispersion calculated over a long period remained approximately stable for each individual. The various function tests had consistent effects on the magnitude of dispersion. During exposure to the rhythmic light, for instance, the dispersion decreased while during hyperventilation it always increased.

As an example the results obtained with three clinically healthy persons are given below. The dispersion was calculated in a resting state and during hyperventilation (Fig. 2). It is clear from Fig. 2 that the dispersion increased by 50-60% over its background level. The initial values were restored 2-3 min after discontinuing the hyperventilation.

The method of measurement of the dispersion of the EEG closely resembles the method of determining the total bioelectrical activity by means of automatic integrators [1, 3, 4]. However, when integrators are used, they also take account of the higher harmonic components formed during detection of the alternating current. This, in turn, introduces errors into the results of the measurements, and if the duration of analysis (i.e., the time of averaging) increased, so also does the degree of error. During measurement of dispersion, the higher harmonic components are absent, thus enabling more accurate measurements to be made.

The instrumental method of measuring dispersion can be used with advantage for studying the dynamics of changes in biopotentials over a period of time in experimental and clinical electroencephalography.

LITERATURE CITED

1. V. A. Kozhevnikov and R. M. Meshcherskii, Modern Methods of Analysis of the Electroencephalogram [in Russian], Moscow (1963).
2. K. D. Osipov and V. V. Pasynkov, Reference on Radio Measuring Instruments [in Russian], 4, 1, Moscow (1959).
3. Z. Drohocki, Rev. neurol., 8 (1948), p. 619.
4. J. Faure, R. Dalleas, and R. Pierre, Rev. neurol., 2 (1962), p. 243.