METHODS

USE OF THE ICh-6 ICh-7 ANALOG FREQUENCY METERS FOR MEASURING THE AVERAGE EEG FREQUENCY

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In experiments and in the clinic, it is frequently necessary to determine the average frequency of the EEG, for example, when studying the effect of drugs on the EEG, when monitoring the course of narcosis, and in other cases. A graphic determination of the average EEG frequency [1] has not been widely used because it is cumbersome and this method has a comparatively low accuracy.

In this work, we will present a method for measuring the average EEG frequency and describe design modifications in the circuit of the ICh-6 and ICh-7 analog frequency meters which are necessary to expand the measurement limits to 1 cps.

These frequency meters, designed to measure the frequency of periodic signals, can be successfully used to measure the average frequency of low-frequency nonperiodic signals, including various biopotentials – EEG, electromyograms, etc. In this case, the average frequency is determined bythe number of alternations of the sign of the signal in unit time.

Certain modifications must be made in the measuring portion of the circuit of these frequency meters to measure the average frequency of low-frequency signals. Figure 1 shows the modified basic circuit of the ICh-7 frequency meter.

The frequency meter consists of a pulse shaper, integrator, and recorder. The circuit of the frequency meter operates in such a manner that each time the signal of the EEG has a positive value, a voltage impulse of a certain amplitude duration is delivered from the pulse shaper to the integrator. The number of impulses per unit time (average frequency) is determined by the integrating circuit. The average frequency is recorded by an automatic potentiometer from the output of the integrating circuit.

The shaper consists of a reservoir capacitor C_r, switch tube L_1, clipper L_2, and a double charging-discharging circuit L_3. When the input signal has a negative voltage, the reservoir capacitor C_r is charged through diodes L_2 and L_3 from the L_4- and L_5-tube voltage regulator.

When the input signal has a positive voltage, the capacitor C_r is discharged through switch tube L_1 and diode L_3 to the integrating circuit R_iC_i.

The average recharging current of the reservoir capacitor is measured by instrument I_1,connected to the integrating system. Since each counted impulse carries a certain charge ($q = C_rU$), the average current passing through the reservoir capacitor and correspondingly through the measuring instrument is proportional to the average frequency of the input signal ($I = qf_{av}$).

The sensitivity of the frequency meter at a constant capacitance of the reservoir capacitor depends on the magnitude of resistance R_i of the integrating circuit. A change of R_i permits smooth regulation of the range of measured frequencies f_{av}. To shift the limits of measurements of the average frequency toward lower frequencies (to 1 cps), the capacitance of the reservoir capacitor in the circuit of the frequency meter is increased to 0.5 μF. In the frequency range above 10 cps, the ICh-6 and ICh-7 instruments can be used without changing the capacitance of the reservoir capacitor.

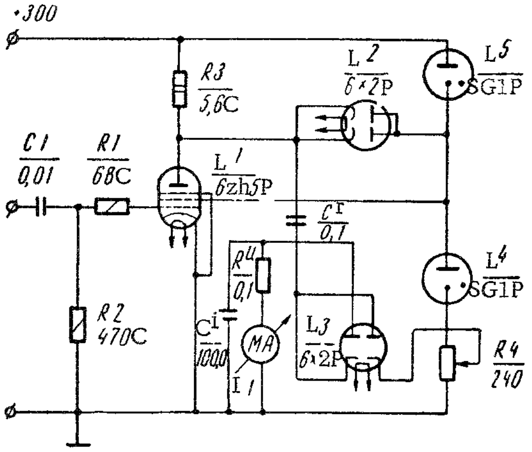

Fig. 1. Basic circuit of frequency meter.

The error of measuring the average frequency by the capacitor frequency meter is determined by the time constant of the integrating circuit. To reduce the error of measuring low average frequencies, the time constant of the integrating circuit is increased to 10 sec by connecting an additional capacitor C_i (EF-1300/300) with a capacitance of 1300 μF. In this case, the root-mean-square error of measuring at a frequency of 10 cps does not exceed 5%.

As a result of these modifications in the circuit of the frequency meter, the range of investigated frequencies was 1-10,000 cps. The output of the frequency meter is connected to an MA recording potentiometer. The amplifying part of the circuit of the ICh-6 and ICh-7 frequency meters is not substantially changed. To reduce distortion at low frequencies, the capacitances of the blocking capacitors (positions No. 1, 22, 31 in the circuit of the ICh-6 instrument) was increased from 0.1 to 1 μF. The circuit of the rectifier was left unchanged.

When measuring the average frequency of the EEG, it is quite important to select correctly the time constant of the integrating circuit (i.e., the time of averaging the readings). As an example, we will give the results of measuring the average frequency of the EEG of a rabbit at two time constants.

Figure 2a shows the graph of the average frequency of the EEG at a time constant of 10 sec, and Fig. 2b at a time constant of 0.5 sec. It is apparent from Fig. 2a that at a very small averaging time, the stability of the readings of the frequency meter drops and the dispersion of the experimental data appreciably increases. The measurement error reaches 40%. When the time constant of the integrating circuit is increased to 10 sec, the readings become more stable and the measurement error drops to 10%. Thus, averaging of the readings over several seconds insures a sufficiently high accuracy of measuring the average frequency of the EEG.

In conclusion, we note that the analog frequency meters can be used not only in experimental but also in clinical electroencephalography. In particular, the output voltage of the frequency meter, which is proportional to the value of the average frequency of the EEG, is conveniently used for automatic regulation of narcosis. The proposed method of utilizing the frequency meters permits using them for measuring the average frequency of electromyograms, electrogastrograms, and certain other types of biopotentials.

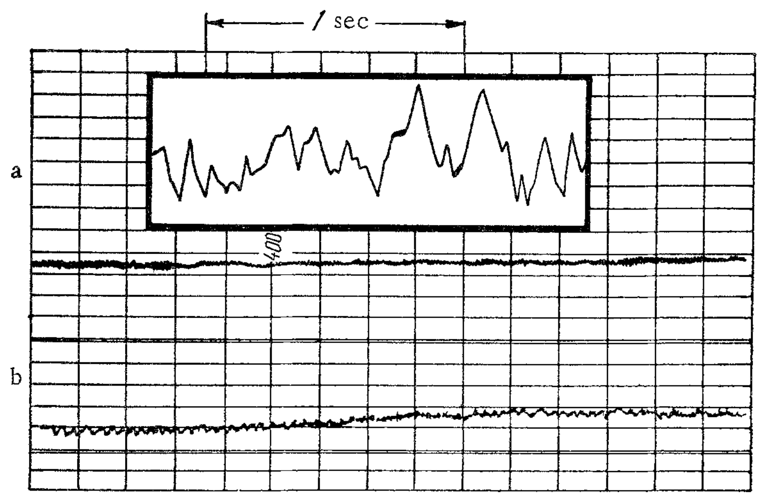

Fig. 2. Portion of the EEG of a rabbit and graphs of the average frequency measured at a time constant of 10 sec (a) and 0.5 sec (b). Time is plotted on the axis of the abscissa and the average frequency (in cps) on the axis of the ordinate.

LITERATURE CITED

1. V. A. Kozhevnikov and R. M. Meshcherskii, Contemporary Methods of Analyzing Electroencephalograms [in Russian], Moscow (1963).