ELECTRONIC LOW-FREQUENCY ANALYZER AND ITS USE IN ELECTRORETINOGRAPHY

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Accurate frequency analysis is an important problem in electroretinographic and electroencephalographic studies.

A determination of the stimulation rhythms which can still be reproduced by the particular system is of special importance. This ability, as the classical studies of N. E. Vvedenskii showed, characterizes the functional mobility (lability) of the system under investigation.

The ability of the visual analyzer to reproduce a rhythm of photic stimulation has been the subject of numerous investigations, but no one has yet determined exactly what links in the visual organ system govern this ability, which is manifested psychophysiologically in the function of the flicker fusion frequency. The retina is the first link involved in the accomplishment of this function. Until recently the ability of the retina to reproduce a rhythm of photic stimulation was assessed from the electroretinogram obtained in response to flickering light. However, it was difficult to settle the question of the maximum photic rhythm reproducible by the retina since an increase in the flicker frequency led to a considerable reduction in the amplitude of the responses on the electroretinogram and the amplifier noise masked the induced fluctuations of electric potential. The maximum reproduction of a photic rhythm in these conditions did not appear to exceed 50-55 flashes per sec. Henkes et al. [1], who used an electronic frequency analyzer for clarification of this question, succeeded in showing that the human eye could reproduce a flicker frequency of up to 70-75 per sec, and in one case even up to 94 per sec.

Since the maximum flicker fusion frequency in man does not usually exceed 60 flashes per sec, we can infer that the retina is not the link in the visual analyzer system which normally determines the fusion frequency.

Led by V. K. Zhdanov, we constructed in our laboratory an electronic low-frequency analyzer capable of detecting bioelectrical potentials commensurable with the noise level.

The technical data of the instrument were: amplification factor 30, frequency range 8-130 cps, minimum passband at level 0.7 not broader than 4.5% of the frequency of the investigated signal. The instrument can be connected up in an arrangement with a symmetrical and asymmetrical input and output. The operating principle of the selective amplifier was based on the use of negative feed back effected through a twin-T bridge (Fig. 1, a).

In our experiments the instrument was connected between the third and fourth stages of one of the channels of a standard 15-channel electroencephalograph (Alvar firm). A block diagram of the connection is shown in Fig. 1, b.

With this instrument, as distinct from a number of other types of analyzers used in modern electroencephalography, the record of periodic processes on film or on paper does not consist of code marks indicating the

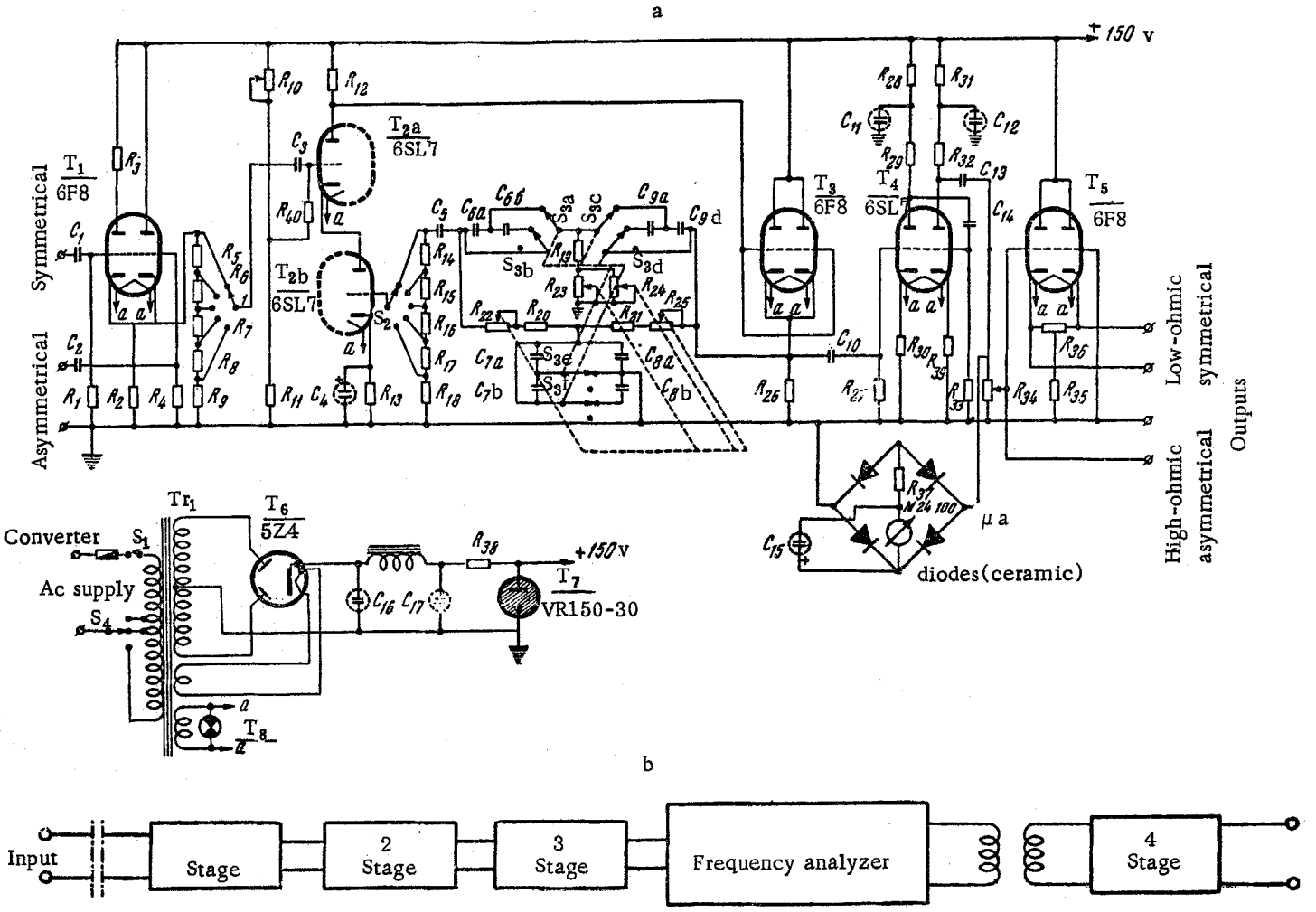

Fig. 1. Low-frequency analyzer. a) Circuit of amplifier of low-frequency analyzer; b) block diagram of connection of analyzer in amplifier channel.

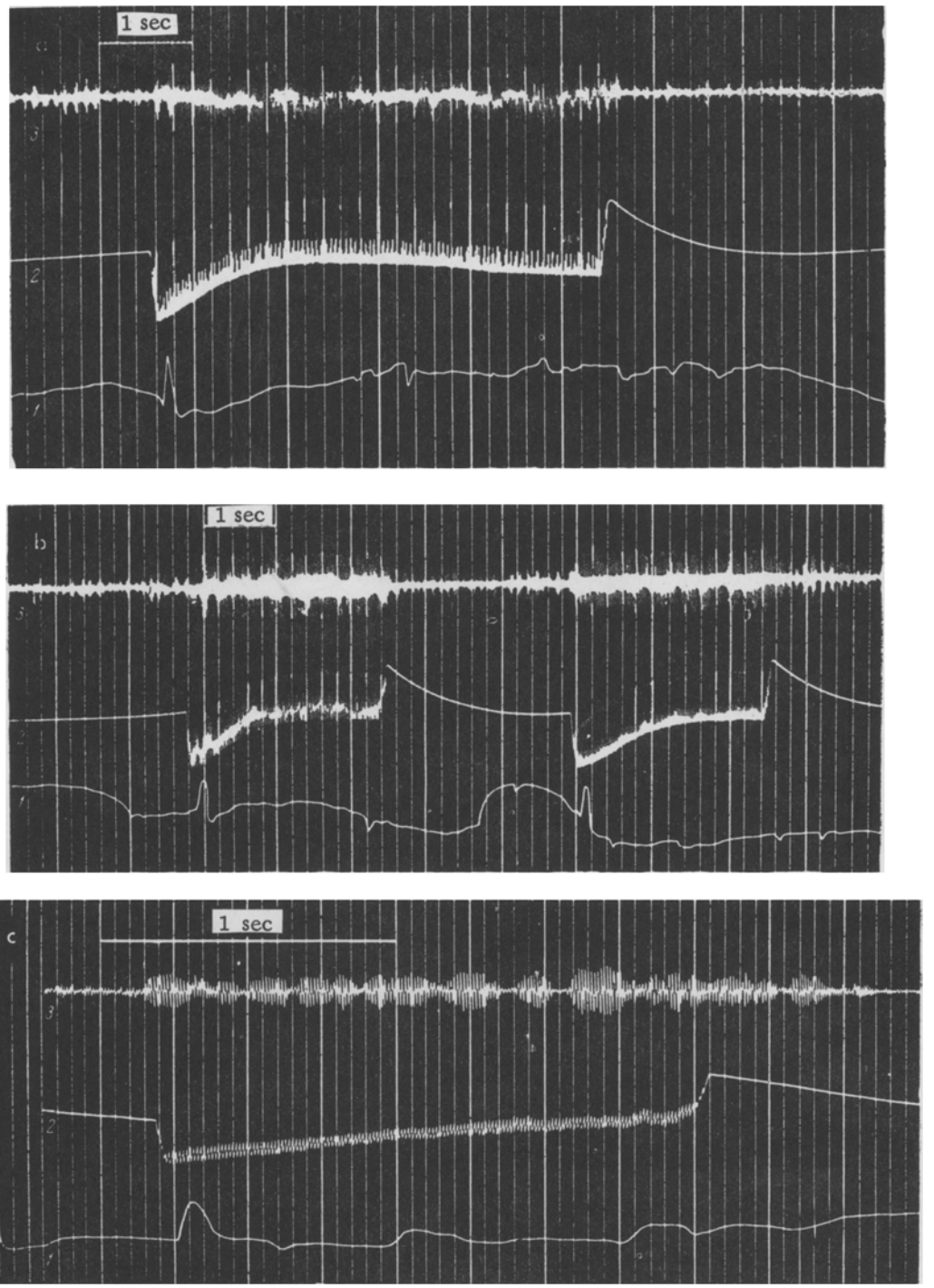

Fig. 2. Analysis of frequencies reproduced by human retina on stimulation by interrupted light. a: 1) Electroretinogram; 2) stimulation marks, 40 cps; 3) frequency analyzer reveals frequency of 40 cps reproduced by retina, but indetectable on electroretinogram; b) as above, analyzer reveals frequency 60 cps reproduced twice by retina; c) as above, analyzer reveals frequency of 100 cps reproduced by retina with after-effect of about 0.5 sec duration.

presence and amplitude of a component of particular frequency, but is a direct reproduction of the response to a rhythm of photic stimulation. This was made possible by the high selectivity of the amplifier. Narrowing of the passband enabled a considerable reduction in the noise level at the amplifier output. Low-capacity capacitors were connected at the channel input to eliminate the effect of slowly varying potentials.

Our observations were made on two normal human subjects. Our aim was to discover the maximum flicker frequency reproducible by the retina on the electroretinogram when our low-frequency analyzer was used.

The electroretinograms were recorded by means of a chlorided silver electrode mounted in a contact lens fitted on the eye. The space between the lens and eye was filled with physiological saline. The indifferent electrode was placed on the ear lobe. The subject was placed in a screened cabinet. Dark-adaptation took 5 to 10 min. For the photic stimulation we used a 500 w projection lamp, which gave an intensity of about 800 lux at the eye level, and a light chopper.

Our investigations showed that the normal human retina can reproduce a rhythm of up to 100 cps (Fig. 2). This cannot be established in the usual electroretinogram without the use of the analyzer.

We must mention that the reproduction of such a high flicker frequency in the electroretinogram was not obtained in every case, even in the same subject. For instance, one of our subjects, A. P., whose electroretinogram usually revealed the reproduction of a photic rhythm of up to 100 cps, could only reproduce a rhythm not exceeding 45 cps in one of the experiments. We learned that on the day before he had been engaged in electric welding for several hours and was very tired. This observation is in accordance with the established fact of a relationship between the electroretinogram and the general state of the organism.

SUMMARY

The electronic analyzer of low frequencies suggested by V. K. Zhdanov, may be successfully used for frequency analysis of electric biopotentials, particularly to analyze the electroretinogram. With the aid of this apparatus the authors recorded the reproduction of light rhythm in electroretinogram, equal to 100 cycles per sec.

The authors were the first to record such rhythms in humans.

LITERATURE CITED

1. H. E. Henkes et al., Ophthalmologica 132, 14 (1956) p. 140.*

* Omitted in original and inserted by translator.