PRODUCTION OF EXPERIMENTAL SLEEP IN CATS BY THE ACTION OF A LOW-FREQUENCY MODULATED ELECTROMAGNETIC FIELD

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The action of a low-frequency modulated pulsed electromagnetic field with a frequency of 5-7 Hz and intensity up to 300 Oe induces a state of drowsiness or sleep in cats. Analysis of the electrocorticogram, work of the heart, respiration, and constant polarization potential of the animals' brain indicates changes in the body similar to those observed during physiological sleep.

The central nervous system has been shown to play an active part in the formation of physiological responses of the body to electromagnetic fields (EMF) [5, 6, 10, 11]. The cerebral cortex and structures of the diencephalon, especially the hypothalamus, are most sensitive to a low-frequency EMF [10, 11]. It is these structures which are responsible for the central regulation of physiological processes, notably sleep and waking [1, 2, 4, 7, 8, 12].

The object of the present investigation was to produce sleep in cats with the aid of weak rhythmic modulated pulses of EMF.

EXPERIMENTAL METHOD

To produce a low-frequency modulated EMF a radiotransmitter consisting of antenna, solenoid, and power units was built. The shape, duration, and frequency of the pulses were assigned by a type UÉI-1 universal electric pulse generator.

A square magnetic pulse with constant high-frequency components of 5 GHz was formed at the output of the transmitter on the amplitude-pulse modulation principle. The coefficient of modulation was 0.8. Modulating waves varied in frequency from 0.5 to 100 Hz, and in pulse duration from 5 to 100 msec. With a change in the frequency and duration of the magnetic pulse, its off-duty factor also changed. The intensity of the EMF during the pulse was controlled to between 10 and 1,000 Oe.

Experiments (384) were carried out on 10 cats. To assess the state of the animals' functions in the EMF, the electrocorticogram was recorded through bipolar and monopolar electrodes inserted into the sensomotor cortex [3] by means of a 4-channel UBNK-V biopotential amplifier; the ECG was recorded through a type VÉKS-01 vectorelectrocardioscope on an N-102 loop oscillograph. The steady polarization potential of the brain (SPP) was recorded on a self-writing instrument (N-372) with dc amplifier [9]; the respiration rate was recorded on another self-writing instrument (N-370) through the UBNK-V amplifier.

Each experiment was carried out in the following order: all physiological indices were recorded before the EMF was activated (this record also acted as the control). The physiological indices were then recorded during the action of the EMF (3 min), and the aftereffect was recorded after every 2-3 min for 18-20 min. After each experiment an interval of up to 1 h was kept in crder to prevent the superposition of one EMF effect on another.

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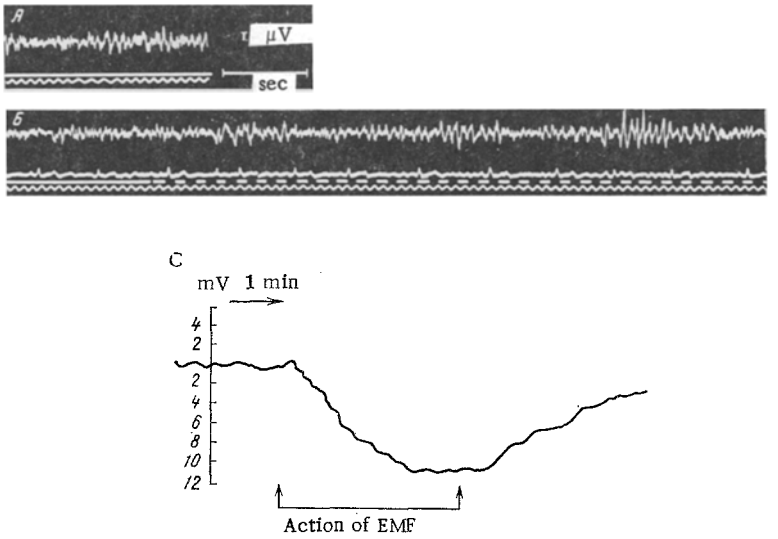

Fig. 1. Effect of modulated pulsed EMF on electrocorticogram (A and B) and SPP (C): A) background; B) action of EMF. From top to bottom, in A: electrocorticogram, marker of stimulation, time marker 0.1 sec; in B: electrocorticogram, ECG, marker of stimulation, time marker 0.1 sec.

The first part of the experiment consisted of selection of the strength parameters of the EMF (the intensities of the electric and magnetic fields, the off-duty factor of the magnetic pulse), and the optimal frequency and duration of the pulse at which the animals developed sleep.

The second part of the experiment consisted in exposure of the animals to the action of individually selected strength parameters of the EMF and also of the frequency and duration of the pulses. The time during which the animal remained in a state of sleep on activation of the EMF varied from 1 to 2 h.

EXPERIMENTAL RESULTS

Analysis of the results showed that a low-frequency modulated pulse EMF with an intensity of up to 300 Oe and with a pulse duration of 10 msec and frequency 5-7 Hz induces a state of drowsiness or sleep in most cats. The similar state induced in animals by the action of electromagnetic waves has been called radiosleep [4].

Starting from the second minute of action of the EMF and throughout exposure, spindles with a frequency of 14 Hz or synchronized activity, characteristic of deeper sleep, will be seen in every case on the electrocorticogram. The appearance of spindles with a frequency of 14 Hz on the electrocorticogram of cats is connected with the development of sleep inhibition in the cortex [12]. In the study of the SPP during radiosleep, stable hyperpolarization reaching to −12 mV was observed (Fig. 1). A similar electroencephalographic picture, accompanying hyperpolarization of the SPP, is typical of physiological sleep [7, 8]. The pulse rate was reduced from 120-150 to 80-90 beats per minute and the respiration rate to 11-12 per minute.

The parameters of the EMF inducing sleep in cats are of average magnitude, for during the selection of parameters of the pulsed field to produce sleep they could vary individually for each animal.

LITERATURE CITED

1. P. K. Anokhin, The Biology and Neurophysiology of the Conditioned Reflex [in Russian], Moscow (1968).
2. I. S. Beritashvili, The Structure and Function of the Cerebral Cortex [in Russian], Moscow (1969).
3. J. Bures, M. Petran', and I. Zakhar, Electrophysiological Methods of Investigation [in Russian], Moscow (1962).
4. K. A. Ivanov-Muromskii, The Sleeping Brain [in Russian], Kiev (1966).
5. F. P. Petrov, Trudy Inst. Fiziol. Akad. Nauk SSSR, 1, 369 (1952).

6. A. S. Presman, Electromagnetic Fields and Life, Plenum Press, New York (1970).
7. G. N. Sorokhtin, The Response of Excitable Systems to a Deficit of Excitation [in Russian], Moscow (1968).
8. G. N. Sorokhtin, in: A Deficit of Excitation and Stimulation [in Russian], Petrozavodsk (1967), p. 7.
9. M. Kh. Starobinets, in: A Deficit of Excitation and Stimulation [in Russian], Petrozavodsk (1967), p. 82.
10. Yu. A. Kholodov, in: Bionics [in Russian], Moscow (1965), p. 278.
11. Yu. A. Kholodov, Effect of Electromagnetic and Magnetic Fields on the Central Nervous System [in Russian], Moscow (1966).
12. L. A. Fedotova, Zh. Vyssh. Nervn. Deyat., No. 3, 537 (1969).