

The possibility of investigating the electroencephalogram of workers in industry by a radiotelemetric method was studied. The radioelectroencephalogram (REEG) was recorded in the left fronto-occipital lead in 18 polishers while at rest and during work. The investigation showed that the REEG can be recorded under natural industrial working conditions, even involving considerable physical effort, with the eyes both closed and open.

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There is evidence in the literature [7, 8, 10-12] of the importance of electroencephalography during muscular activity. All the investigations cited were carried out with the use of wire connections and of laboratory loads. However, the character of changes in the EEG during physical and mental work under actual conditions of industrial activity has received inadequate study, mainly because of the technical difficulties involved.

The object of the present investigation was to determine whether the human EEG can be investigated under industrial working conditions by the use of radiotelemetric methods. First attempts to record the radioelectroencephalogram (REEG) in a person able to move freely gave positive results [2, 3], and these were followed up in the present investigation.

## EXPERIMENTAL METHOD

The investigation was carried out at a factory manufacturing electromedical apparatus, in the department for polishing and glazing large and small components. The area of the department was 550 m<sup>2</sup> and it contained several dozen polishing benches and other benches for glazing articles.

The dust concentration in the air at the working places within the zone of inhalation of the workers was low, the overall intensity of illumination was 50 lx, but the general noise level in the department was high (about 100 dB). The vibration level of the polishing bench was within the prescribed health limits.

The REEG was recorded by means of a radiocommunication system consisting of a type REE-2 radio-electroencephalograph, weighing 120 g and designed by R. V. Unzhin and S. V. Suzdalova, a modified receiver from an ARS-2 automobile radio station, and a recording instrument consisting of a type EKPSch ink-writing electrocardiograph. Recordings were made principally at a speed of 25 mm/sec. By the use of this system the REEG could be recorded from places in the department at different distances.

Lead cup electrodes 12 mm in diameter and the REE instrument were fixed to the subject's head by rubber straps. The hair beneath the electrodes was brushed to the side, the skin was treated with Nikiforov's mixture, and a layer of cotton wool soaked in soap shampoo solution containing potassium chloride was applied between the electrodes and the skin, as a result of which the interelectrode resistance did not exceed 6 kΩ. The REEG was recorded by a bipolar method in the left fronto-occipital lead, both at relative rest before and after periods of work (the subject remaining at the work bench, near the bench which was still in operation, with the component in his hand, but not actually at work), and also while actually engaged on the work. In both cases the recordings were made with the eyes closed and open. During the tests the workers were seated (in one case the subject stood).

This paper describes the results of 22 tests on 18 workers (2 men and 16 women) aged from 20 to 45 years, employed on that particular job for between 6 months and 16 years. Further clinical investigations

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Department of Work Physiology and Functional Diagnosis, Research Institute of Work Hygiene and Occupational Medicine and Regional Dispensary for Occupational Diseases, Sverdlovsk (Presented by Academician A. A. Letavet, Academy of Medical Sciences of the USSR.) Translated from *Byulleten' Éksperimental'noi Biologii i Meditsiny*, Vol. 68, No. 7, pp. 13-16, July, 1969. Original article submitted January 22, 1968.

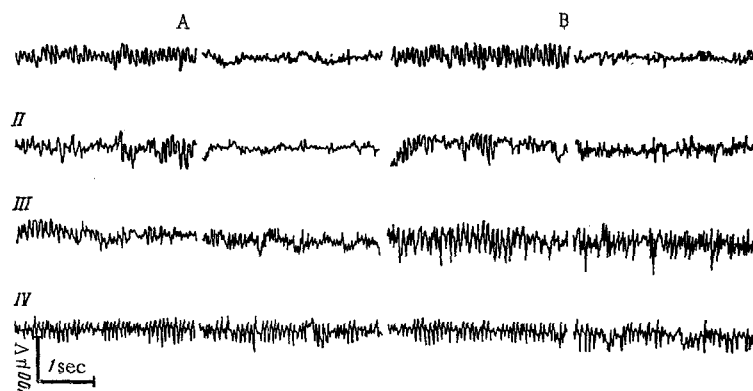


Fig. 1. REEGs recorded in left fronto-occipital lead in 4 subjects while sitting at the working place. A) In resting state with eyes closed (on the left) and open (on the right); B) during work with eyes closed (on the left) and open (on the right); I) subject M, polisher, female aged 32 years; II) subject K, polisher, female aged 32 years; III) subject S, polisher, female aged 35 years; IV) subject A, polisher, male aged 25 years. Recording speed 25 mm/sec.

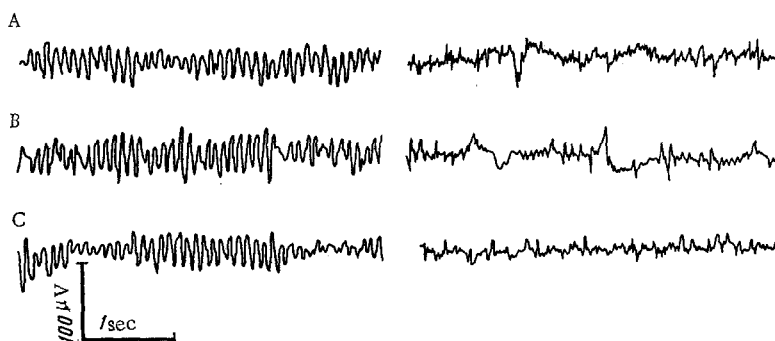


Fig. 2. REEG recorded in left fronto-occipital lead from subject B, polisher, female aged 29 years, when standing at the work place. A) In a resting state with eyes closed (on the left) and open (on the right); B) during work, at beginning of shift, with eyes closed (on the left) and open (on the right); C) during work at end of shift, with eyes closed (on the left) and open (on the right). Recording speed 25 mm/sec.

showed that the initial manifestation of vibration disease has been diagnosed previously in 5 subjects, one of the women polishers suffered from essential hypertension and one had rheumatic disease of the heart.

## EXPERIMENTAL RESULTS

Six of the 18 workers tested both at rest and during work, with their eyes closed, still retained on their REEG a distinct "spindle" type of  $\alpha$ -rhythm with a well-marked response to opening the eyes, in the form of depression of the  $\alpha$ -activity (Fig. 1, I).

An irregular rhythm, consisting of discrete groups of  $\alpha$ - and  $\beta$ -waves, was observed in 8 subjects at rest, and in half of them it showed no significant change during work (Fig. 1, II); in the other half its frequency and amplitude increased considerably during physical exertion (from 12 to 30 waves/sec and from 60 to 100  $\mu$ V) and many muscle potentials appeared (Fig. 1, III). In three cases a rhythm which, in Sologub's terminology [9] can be described as a spike-like rhythm, was recorded on the REEG during work. In two of these cases its frequency was 13-14 waves/sec and amplitude 60  $\mu$ V and it consisted of "spindles" with pointed waves (Fig. 1, IV), while in one case it was regular with a frequency of 26 waves/sec and amplitude 40-50  $\mu$ V, and was readily distinguished at a recording speed of 50 mm/sec. A characteristic feature

of all three cases was that this rhythm remained regular with the eyes closed or open throughout the period of work, and in two subjects while at rest also. An irregular  $\alpha$ -rhythm was recorded from one of the three subjects at rest. When the eyes were opened, only a very slight increase or decrease in amplitude of the waves could be observed, indicating prolonged preservation of latent changes in the functional state of the cortical cells. All three subjects polished small parts, resulting in much greater nervous tension because of the increased precision of the operation and risk of injury than when polishing large parts (as the other subjects did). A spike-like rhythm was previously recorded on the EEG of a person performing muscular activity and was fully described by Sologub in the paper cited above; the cortical character of its origin was proved and it was shown to be associated with certain stages of training, with the level of working capacity of the cortical cells, and with the character of innervation of the working muscles.

Special mention must be made of the REEG recorded in a male polisher while polishing tubes. This worker, standing by the bench, holds in his hands a metal tube 1.5 m long and 4 cm in diameter, which he constantly turns by his fingers which perform horizontal sideways movements. Despite the instruction given in the textbooks on methods of recording the EEG [5, 6], stating that when brain potentials are recorded from subjects even in a sitting position it is essential to use a support for the head so as to exclude the superposition of muscle potentials (in particular, from the cervical muscles), in this case the performance of such considerable physical exertion in a standing position caused no marked changes or interference in the REEG. Whether at rest or at work, at the beginning and end of the working day a distinct and regular  $\alpha$ -rhythm was preserved, consisting of "spindles" with a frequency of 11 waves/sec and amplitude 60-70  $\mu$ V. During work with the eyes open,  $\beta$ -activity with a frequency of 22-24 waves/sec and amplitude 20-30  $\mu$ V and single muscle potentials (Fig. 2) were predominant.

The work done by the polishers, who had been engaged on this job for at least 6 months, used in these tests can be regarded as habitual or, to use Vinogradov's [1] terminology, with the character of stage III of practice, i.e., the stage of a stable motor stereotype, when the electrical activity of the brain remains constant both in rhythm and in amplitude throughout the duration of the work and is almost indistinguishable from that at rest.

As was shown above, this was the pattern observed in most workers tested. The appearance of a spike-like regulatory rhythm in workers engaged on polishing small parts likewise indicates that the subjects were trained in this work, because the spike-like rhythm appears at certain stages of practice.

Considering that under normal conditions, when standard methods are used to record the EEG, an  $\alpha$ -rhythm is usually found in not more than 70% of cases in healthy persons [4], the prospects for studying the EEG by means of the method used, in which an  $\alpha$ -rhythm was observed during work in almost half of the cases (and 5 subjects, moreover, had nervous or physical abnormalities), must be regarded as very good.

These investigations demonstrated the possibility of recording the REEG in man while engaged on industrial work, even involving considerable physical exertion, with the eyes closed or open, and they showed that adequate physiological information can be obtained by this means.

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