EEG Analysis with Decatron Toposcope

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Recently the toposcopic procedure by Petsche (1954) has added a unique device to electroencephalographic analysis. Most of the multi-channel EEG recordings which have been generally used for clinical and experimental purposes depend on ink-writing, so that the speed of recording is limited to a considerable extent.

On the other hand, although the cathode ray oscilloscope is generally fit for recording of rapid-moving phenomena, the use of large number of cathode ray tubes (CRT) is usually required for recording of a variety of phenomena. In order to improve these condition, Petsche constructed his first toposcope "Photozellen Toposcop" (1954). However, this apparatus had defects in ability of resolution and in its mechanism using flash light. Later, he presented a report on his experiments with a multivibrator toposcope, and finally succeeded in completing the toposcope (1960).

We contemplated to construct a toposcope for our own EEG analysis and neurophysiological researches. As a result, we adopted a modified device with the purpose of removing a complicated circuit, making the construction easier and increasing the steady action and ability.

MECHANISM AND TECHNIQUE

The decatron toposcope in this paper is in possession of one decatron, as electric switch, instead of numerous multivibrators.

The repeated drive of Y axis (vertical) of CRT by the series of square pulses whose amplitude is stepwise decreased makes it possible to record multi-channel EEG on the single beam of CRT (Fig. 1). These pulses are readily induced from the out-put of the decatron (Figs. 1 and 2).

The out-put from CRT terminal of EEG apparatus is led to the grid of amplifiers corresponding to the respective channels. However, as these vacuum tubes are kept inactive by the attached switch tubes, the EEG signal is not delivered to the anode plate. The cathode of the amplifier tube is maintained...
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Fig. 1. Block diagram of the whole system and schematic signals into the vertical in-put (upper, stepwise square pulses) and the brightness modulator in-put (lower, EEG signals of each channel) of the cathode ray tube (C.R.T.). The single decatron generates all square pulses. Recorded with the continuous recording camera (C.R.C.).

Fig. 2. EEG signal is led into the amplifier tube (upper left) which is kept inactive by the switch tube (right). When the switch pulse from the decatron is induced into the switch tube, the amplifier tube produces the out-put signal of EEG that modulates brightness of C.R.T., and that appears on the top of the corresponding vertical square pulse. Each channel EEG appears successively with varying brightness.
in high voltage by the cathode of the switch tubes. However, as long as square pulses of the first step enter the switch tubes, the amplifier tubes become active whereby momentarily converting the EEG signal into the output. In the meanwhile, the remaining 7 amplifier tubes are inactive. As such an operation takes place successively, the amplitude of EEG of 1–8 leads are shown in sequence in the output common to 8 amplifiers though it lasts for a short duration. These signals modulate the brightness on Z axis of CRT, the brightness intensity corresponding to the amplitude variation of the first channel of EEG is shown on the top of the square pulse of the first step, and those of the other channels are similarly shown on the top of their corresponding pulses. By the repetition of these bright spots, there is seen the shading of light.

The frequency of square pulses in our apparatus is 2,400–40,000 cycles/sec. (maximum frequency of decatron: 40 KC), and the signal frequency in the case of 8 channels is 300–5,000 cycles/sec.

As mentioned above, EEG of 8 channels can be recorded with the variation of brightness on 8 lines as in the case of the ink-writing electroencephalogram. A continuous recording camera was used for recording.

**PRACTICE**

Citing examples, the author wishes to describe briefly the data acquired by us from the obtained electrotopogram (there is a detailed report by Petsche², 4). In this paper the bipolar leading routine EEG of alpha rhythm (Fig. 3a) and its topogram (Fig. 3b) are shown. A band consists of 8 lines, in which the electroencephalograms of 8 leads are shown in downward succession as the variation of brightness. The bright part of each line indicates the positive phase to the base line of alpha waves, the shadow part of it being the negative phase. Accordingly, the brightest part and the darkest part show the positive peak and the negative peak of each alpha wave, respectively. What is of greatest importance is the correlation between brightness and shadow of these 8 lines. The upper 4 leads belong to the left hemisphere and lower 4 leads to the right hemisphere, between which there is seen phase shifting with the occasional occurrence of 180° reversal change (Fig. 3b). Phases of the 4th and 8th leads are obviously different from those of other leads, thus being tempolar leads. As in the case of the routine EEG, alpha blocking phenomena are shown by eye opening and the variation of brightness by alpha waves is restored again by eye closing.

Stripes caused by the phase shift become clearer in the monopolar leading (Fig. 4a) and the topogram (Fig. 4b) in 7 electrodes placed from the nasion to inion.

It is demonstrated that most of these stripes have some gradient; there are the successive inclination of the alpha wave phase from the nasion to the inion.
Fig. 3a. Bipolar leading routine EEG, including alpha wave blocking by eye opening. Recorded simultaneously with topogram (see Fig. 3b).

Fig. 3b. A continuous recording of topogram. Each band consisting of 8 lines shows 1-8 channel EEG in downward succession. The upper edge indicates 20 msec. timer. Film speed: 10 cm/sec.
Fig. 4a. Monopolar leading EEG of normal alpha waves. Electrodes are placed in alignment from nasion to inion except one on the left temporal area. Simultaneous recording with the topogram (Fig. 4b).

Fig. 4b. Dark and bright stripes and their vertical gradients. Timer: 20 msec. Film speed: 10 cm/sec.
and the reversal transference of it from the inion to the nasion.

Granting it to be a spreading in appearance, this would provide a basis for the assertion that alpha waves are spread to a certain direction. It is interesting that the direction of this spreading is reversed with the lapse of time (Fig. 4b). Moreover, the reversal of direction is seen 3–4 times within 10 seconds. In this respect, we agree with the finding by Petsche\(^2\).

Although these facts are not known simply by the routine EEG, they become obvious with the toposcope.

Moreover, not only these notable facts but also the phase shifting is measurable. If the distance between the leading electrodes and the film speed is given, the speed of spreading can be measured without difficulty.

**DISCUSSION**

The decatron toposcope is a polyscope fitted and simplified for our experimental and clinical purposes. This toposcope enables us to observe phenomena of biological electric activity simultaneously and at desirable speed. This observation includes not only the phase correlations among wave forms of multi-channel leading EEG which are hardly observable generally but also the spreading pattern, direction, speed, etc. However, as the decatron toposcope depends on phenomena by brightness modulation, we should pay attention to the fact that the ability of regeneration of oscilloscope screen and the gradation of photo-film or -paper are concerned in the data. Accordingly, the decatron toposcope is not fit for the measurement of wave form and voltage.

The adequate signal frequency for our observation of EEG was 800 cycles/sec., but in case of film speed (10 cm/sec) adapted for that of alpha wave the 8th lead showed always a delay of 10/800 cm for that of the first lead. However, this delay was negligible as compared with other factors.

Prior to recording, it is necessary to adjust the base line to light brightness so that the bottom to peak output voltage of the object phenomena can render pertinent shading.

**SUMMARY**

We designed a decatron toposcope which is simple in structure and easily produced. The result of our practical tests with the apparatus was the same as that by Petsche’s multivibrator.

The use of this apparatus indicates to be useful for researches of EEG and neurophysiology.

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References