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MOVEMENT INDICATOR FOR BIOLOGICAL OBJECTS WITH ELECTRO-OPTICAL SENSING DEVICE

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In the course of complex electrophysiological investigations, e.g. investigation of muscle activity neuronal control, important information may be gained from recordings showing small movements of biological objects. For practical investigations of this kind, simultaneous multichannel microelectrode recordings and bipolar nerve recordings are applied, so conventional methods are difficult to apply for movement recordings. Conventional mechanical or electromechanical methods have further drawbacks such as their direct mechanical contact with the test object. In most cases, the preparation is damaged at the contact site, resulting in false recordings. Another drawback of conventional movement indicators is the loading of the test object which influences the movement, especially in the case of preparations of small sizes or having small movement energies.

All these problems are solved by electro-optical sensing devices developed during recent years. The movement indicator comprises opto-electronical elements, and operates on the reflection principle. The primary radiator is a light-emitting diode (LED), and the radiation reflected from the moving object is sensed by a phototransistor. This method has the great advantage of not being in direct contact with the test object, thus not loading the object, and is also suitable for recording high-speed movements. As the primary radiator LED operates in the infrared region, recordings may take place both in dark-

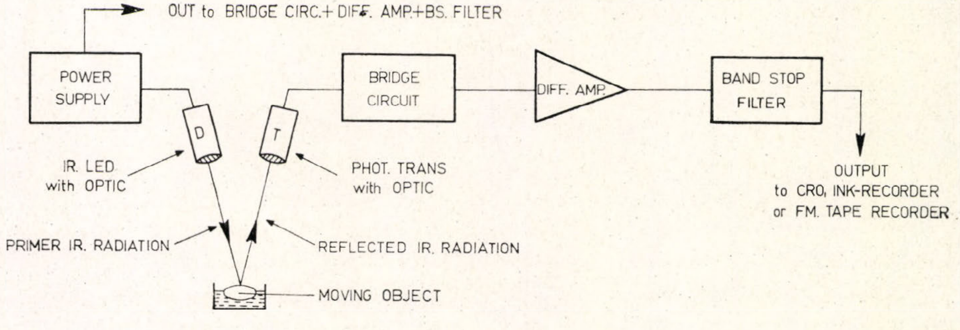

Fig. 1. Movement indicator functional block diagram

ness and during daylight or artificial light conditions. An important feature of the method is the negligible heating effect of the test object which is possible by the use of low intensity light sources, still providing high enough reflection from the preparation.

The functional block diagram of a movement indicator built in our Institute is shown in *Fig. 1.* The infrared radiation of light emitting diode D, which is reflected from the surface of the biological object, is sensed by phototransistor T. The detected signal level is dependent on the movement amplitude. The bridge circuit and the amplifier serve to compensate the constant interfering signals of different levels. Amplifier output is connected to a bandstop filter for eliminating 50 Hz mains interfering signals. The output signal

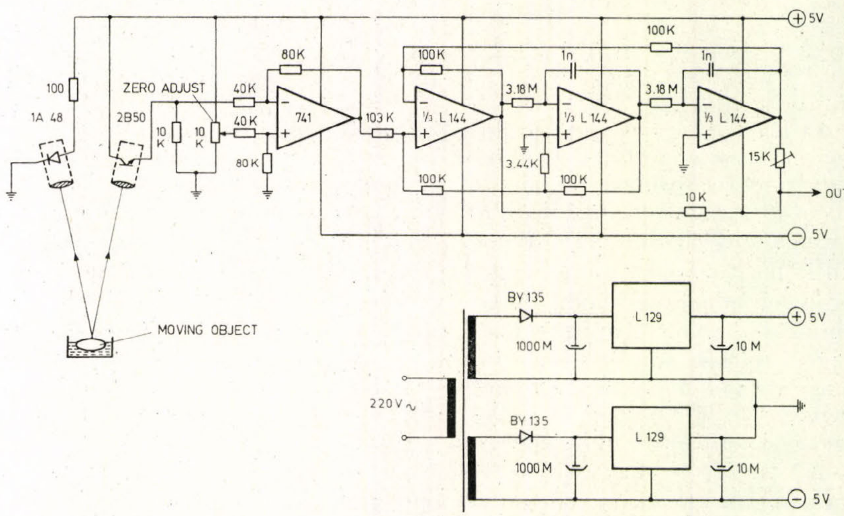

Fig. 2. Movement indicator circuit diagram

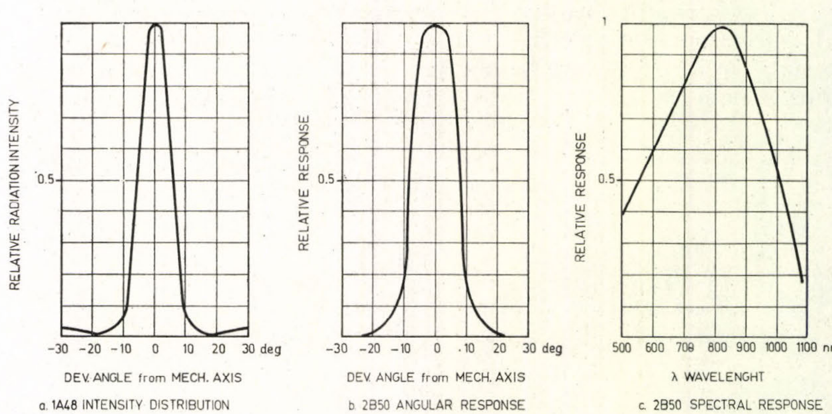

Fig. 3. Light emitting diode and photo transistor characteristics. *a)* Intensity distribution of 1A48 light emitting diode, *b)* angular response of 2B50 photo transistor, *c)* spectral response of 2B50 photo transistor

of the band-stop filter which is proportional to the movement amplitude is connected to an oscilloscope, a stripchart recorder or a tape recorder. A common power supply serves all circuits.

The detailed circuit diagram of the movement recorder is shown in *Fig. 2*. The primary radiator of the indicator is a GaAs light-emitting diode which emits light of wave length $\lambda = 940$ nm. The light-emitting diode is equipped

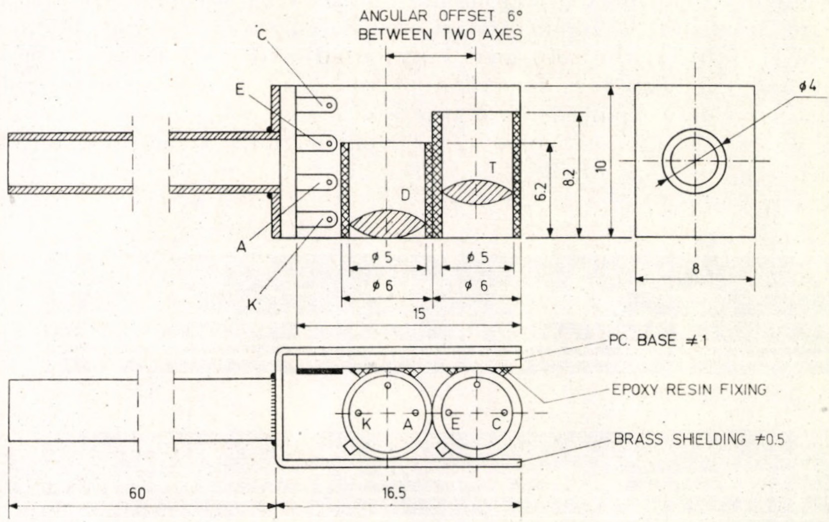

Fig. 4. Layout of the movement indicator sensing head, with principle dimensional outlines

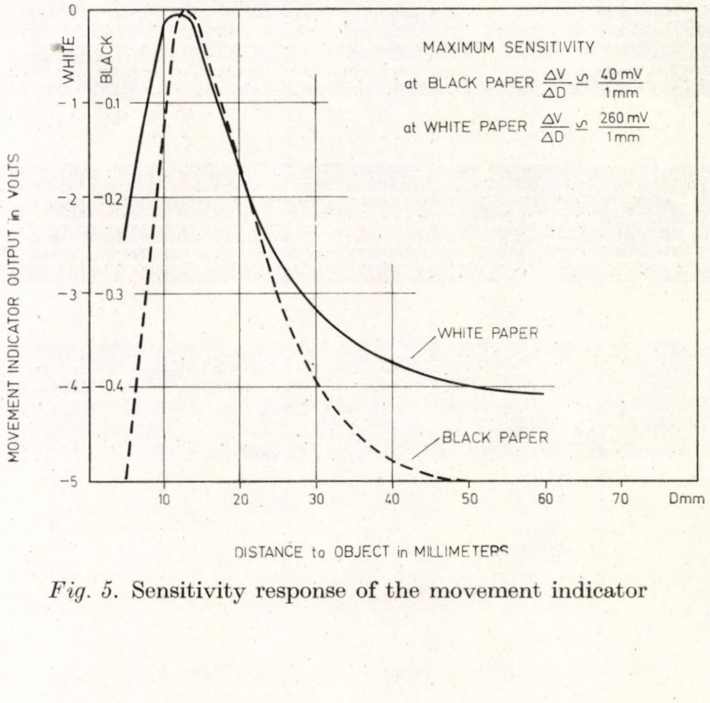

Fig. 5. Sensitivity response of the movement indicator

with an optical system limiting the radiation to a small area. *Fig. 3* shows the spatial distribution of the radiation in case of the applied type 1A48 IR-LED (ASEA-HAFO). The infrared radiation reflected from the object is sensed by a Si phototransistor. The directivity of the type 2B50 phototransistor (ASEA-HAFO) is provided by a built-in optical system resulting in an angular response as shown in *Fig. 3b*. The spectral response of the 2B50 phototransistor as a function of the wave length is shown in *Fig. 3c*. The phototransistor is operating in an emitter follower circuit, and the output signal is given through a bridge circuit on the input of a differential amplifier. During the quiescent state of the object, the zero level may be adjusted by means of the bridge circuit and the amplifier, for different reflecting surface and for different external interfering light effects of constant level. Zero level has to be adjusted before every measurement in order to avoid amplifier saturation during high amplitude movements of the object. The amplifier output is connected to an active band-stop filter which has the circuit of the universal active filter of

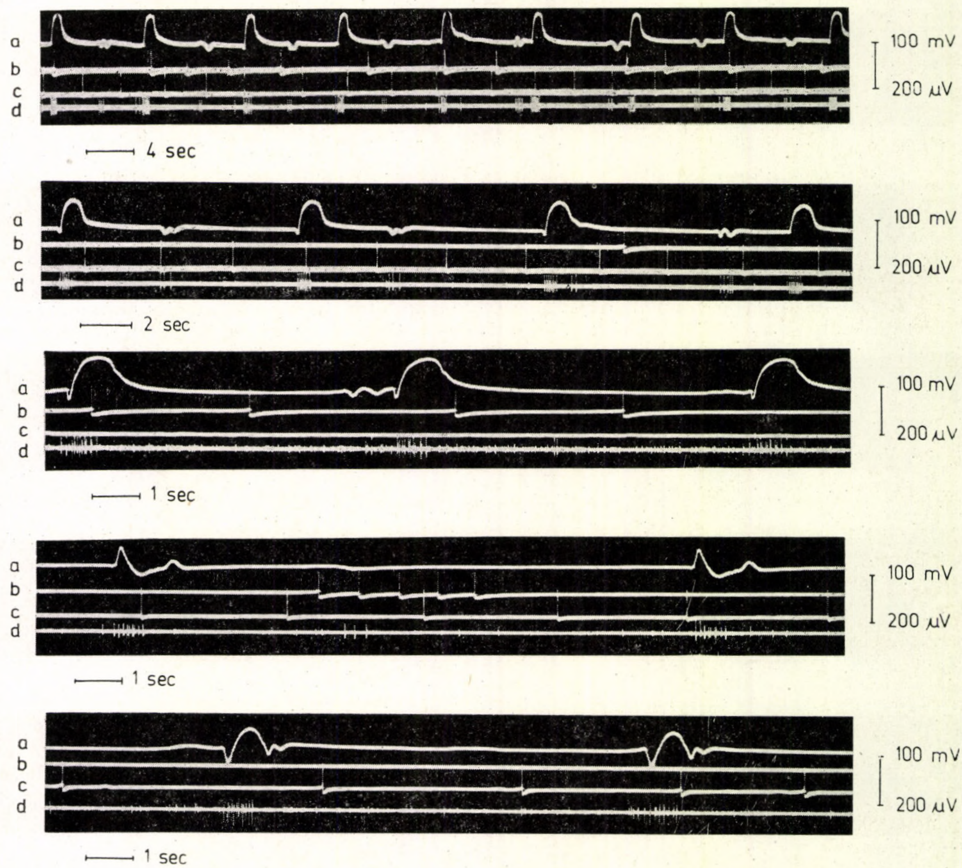

Fig. 6. Typical multichannel records from snail (*Helix pomatia* L). Trace *a)* — heart contraction, traces *b)* and *c)* — action potentials of two neurons, trace *d)* — nerve activity. The 100 mV calibration refers to traces *a*, *b*, *c*, the 200 µV calibration refers to trace *d*

type UAF 11/15 (Burr-Brown Res. Corp.). In the filter built in our Institute, a triple op-amp of type L 144 (Siliconix Inc.) is used, based on the data sheet of the UAF circuit (PSD-295A and AN-61 Application Note). Using the basic UAF 11/15 active filter, the suitable choice of four resistors yields a band-stop filter at a given frequency having small dimensions (but is equally applicable for band-pass, low-pass and high-pass purposes).

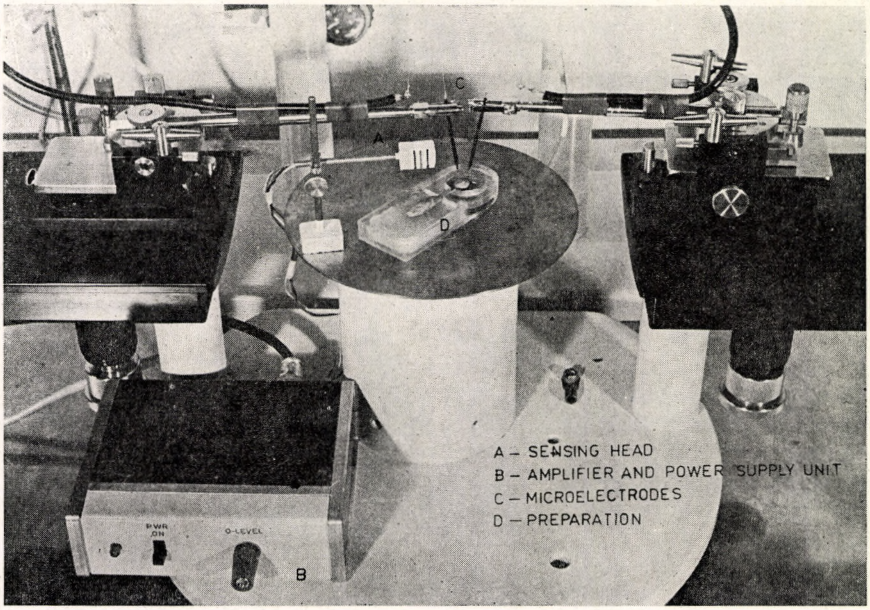

Fig. 7. Photograph of a measurement set-up showing the movement indicator and a test preparation with microelectrodes

A common ± 5 V power supply serves the light emitting diode, the phototransistor, the amplifier and the active filter. The supply voltages are regulated by 5 V voltage regulators of type L 129 (SGS-ATES) providing suitable low hum voltage needed by light-emitting diodes.

Layout of the movement indicator sensing head is shown in *Fig. 4*. The light-emitting diode and the phototransistor are fixed on separate stands in two assemblies and are adjustable by magnets near the test preparation. The sensing probe is connected by a cable to the amplifier and filter unit and to the power supply.

Fig. 5 shows the sensitivity reponse of the movement indicator as a function of distance to the object. The reference zero level has been adjusted in the focal point of the sensing part (F = 12.5 mm). The response has been traced by using black and white paper for reflecting surface, so the voltages generated by reflecting surfaces during practical measurements fall between the two curves. The *Figure* shows that a relatively high level signal is available even with surfaces having low reflection factors, thus insuring a suitable signal-to-noise ratio during movement indication.

Fig. 6 shows typical multichannel records of a snail (*Helix pomatia* L.): heart contraction, action potentials recorded by microelectrodes from two central neurons, and bipolar recording of the heart nerve activity have been simultaneously investigated. On the recording of the heart movement, the movement effects are clearly visible, and at some parts, even the amplitude-time function of the auricle and ventricle contractions may be observed.

Fig. 7 shows a photograph of a measurement set-up including the movement indicator assemblies, the test preparation and the microelectrodes used for the recording. According to the experiences of our Institute, the movement indicator described is easily applicable to complicated multichannel electrophysiological measurements, and facilitates long-time recordings without damaging the preparation. Additionally to the applications mentioned, it may also be used for other kinds of investigations such as the recording of insect wing movements.

Summary

An electro-optical sensing device for recording movements of biological objects is presented, making possible considerable simplifications during recordings of small object movements. It is especially suitable for simultaneous multichannel recordings. In the paper, details are given from the electrical parameters and mechanical arrangement of the sensing part, and auxiliary circuits and their functions are described. The sensitivity response of the movement indicator and a practical recording prove that the output signal proportional to the movement shows high enough signal-to-noise ratio during measurements on actual biological test objects.

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MOZGÁS-INDIKÁTOR BIOLÓGIAI OBJEKTUMOKHOZ ELEKTRO-OPTIKAI ÉRZÉKELŐVEL

Véró Mihály

Összefoglalás

A biológiai objektumok mozgásának regisztrálásához készült elektro-optikai érzékelő jelentősen egyszerűsíti a kisméretű objektumok mozgásának regisztrálását, mely különösen előnyös szimultán, több csatornás elvezetésnél. A dolgozat részletesen ismerteti az érzékelő rész elektromos paramétereit, mechanikai elrendezését, valamint a kiegészítő áramköröket és azok funkcióit. A mozgás-indikátor érzékenységi görbéje és gyakorlatból vett regisztrátum jól szemlélteti, hogy a mozgással analóg kimenő jel, megfelelő jel/zaj viszony mellett biztosítja a regisztrálást a biológiai gyakorlatban előforduló méréseknél.