

AN APPARATUS FOR CONTINUOUS CALIBRATION AND MONITORING OF BIOELECTRIC POTENTIAL MEASUREMENT SYSTEMS

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During the measurement of bioelectric potentials continuous calibration and control of the measurement system are required.

For this purpose an all solid state externally triggered pulse generator has been constructed. It generates rectangular calibrating pulses (see diagram, Fig. 1).

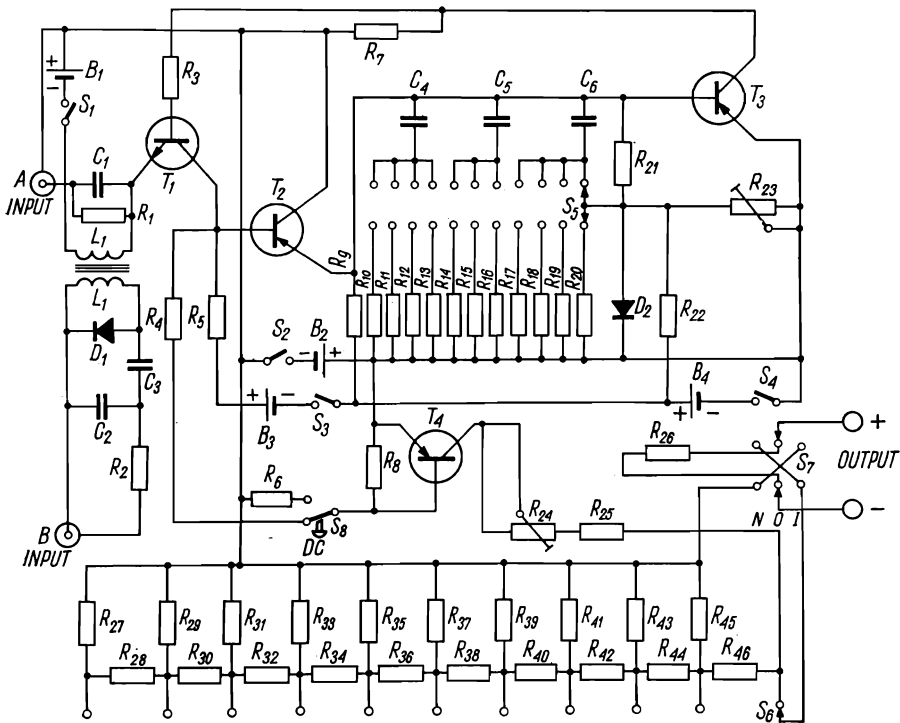


FIG. 1. Circuit diagram of the calibrator.

0.5 w composition resistors

R_1 — 270 k Ω	R_7 — 27 k Ω	R_{13} — 8.5 k Ω	R_{19} — 9.1 k Ω
R_2 — 2.2 k Ω	R_8 — 91 k Ω	R_{14} — 1.8 k Ω	R_{20} — 80 k Ω
R_3 — 13 k Ω	R_9 — 1.5 k Ω	R_{15} — 2.7 k Ω	R_{21} — 75 k Ω
R_4 — 18 k Ω	R_{10} — 350 Ω	R_{16} — 11 k Ω	R_{22} — 3 M Ω
R_5 — 13 k Ω	R_{11} — 600 Ω	R_{17} — 1.6 k Ω	R_{23} — 5 M Ω
R_6 — 18 k Ω	R_{12} — 2.4 k Ω	R_{18} — 4.3 k Ω	

1 w wire resistors

R_{24} — 100 Ω	R_{30} — 105 Ω	R_{36} — 105 Ω	R_{42} — 105 Ω
R_{35} — 50 Ω	R_{31} — 131.3 Ω	P_{37} — 131.3 Ω	R_{43} — 131.3 Ω
R_{26} — 50 Ω	R_{32} — 75 Ω	R_{33} — 75 Ω	R_{44} — 75 Ω
R_{27} — 75 Ω	R_{33} — 150 Ω	R_{39} — 150 Ω	R_{45} — 75 Ω
R_{28} — 75 Ω	R_{34} — 75 Ω	R_{40} — 75 Ω	R_{46} — 450 Ω
R_{29} — 131.3 Ω	R_{35} — 131.3 Ω	R_{41} — 131.3 Ω	

Capacitors

C_1 — 3.3 nF 250v (ceramic)	C_4 — 0.1 μ F 100v (paper)
C_2 — 75 pF 200v (ceramic)	C_5 — 0.5 μ F 100v (paper)
C_3 — 150 pF 200v (ceramic)	C_6 — 3 μ F 100v (paper)
T_1 — BF 504 silicon npn transistor (TEWA) or 2N 918 (TEXAS)	

Germanium pnp transistor

T_2, T_3 — TG 5 (TEWA) or OC 71 ((Philips).

T_4 — TG 10 (TEWA) or OC 45 (Philips).

D_1, D_2 — DG 20 germanium diodes (TEWA) or OA 5 (Philips).

Tr — Pulse transformer: primary winding (L_1) — 150 turns and secondary winding (L_2) — 250 turns on polystyrene formers (enamelled copper wire 0.15 mm in diameter). The same annular ferrite core 5 mm in diameter.

B_1, B_2, B_3, B_4 — 1.2v nickel-cadmium batteries.

OPERATING PRINCIPLE

The calibrator consists of an input isolation transformer, a monostable multivibrator (flip-flop), an attenuator, an output polarity reversing switch and nickel cadmium batteries.

The isolation transformer (Tr) isolates the calibrator from the input (B) and ground. As a result of this the calibrator is electrically isolated from the trigger source and may be connected in bioelectric potential measurement systems. The trigger pulse delivered from a stimulator or an oscilloscope is transmitted by means of the inductance coupling to the T_1 transistor and then delivered directly to the multivibrator. The task of the T_1 transistor is the adjustment of the resistance of the transformer to the resistance of the input circuit of the multivibrator. The monostable multivibrator contains two TG'5 germanium transistors (T_2 ,

T_3). A $50\ \Omega$ constant resistance attenuator (S_6) selects voltage amplitudes from 0.1 mv to 1 v in decade factors of one, two and five. An eleven position switch (S_5) selects output pulse duration of 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100 and 200 msec. The output pulse can also be turned on and off with a push button switch (S_8). Output pulse rise time is about one microsecond. The calibration pulse polarity is reversed by reversing switch (S_7).

The calibrator has also an input without isolation from the source of the triggering pulses. A 10 v positive going waveform of a maximum of one microsecond rise time will trigger the calibrator with input isolation transformer (input B). A 2 v pulse will trigger the calibrator without the input isolation transformer (input A).

APPLICATION

The calibrator is particularly suitable for continuous calibration and monitoring of functioning of the bioelectric potential measurement systems. This continual monitoring is applicable only when a calibration pulse can be injected into the input of a measurement system without interfering with the information content of the signal. The block diagram (Fig. 2) shows a bioelectric potential measurement system consisting of a biological preparation, preamplifier, oscilloscope and calibrator.

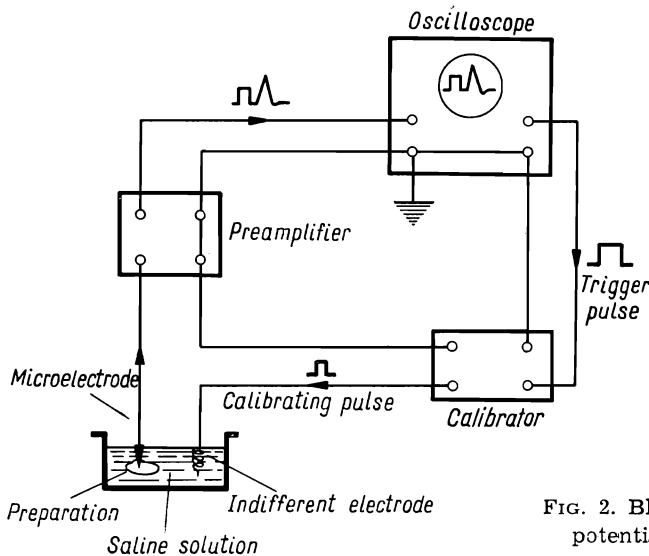


FIG. 2. Block diagram of bioelectric potential measurement system.

A microelectrode penetrates the preparation and connects it to the preamplifier. An indifferent electrode is inserted in the saline solution and is connected to the preamplifier's ground through the low output

impedance of the calibrator. The calibrator is triggered by the delayed gate or the unblanking voltages of the oscilloscope. As a result the calibration pulse is synchronized with the oscilloscope's sweep and can be set to appear at a convenient position of every sweep, for instance at its beginning. Injecting the calibration pulse into a biological preparation — so that the pulse passes through the same circuit as the bioelectric potential — permits continuous calibration and monitoring of the measurement system. The calibration pulse amplitude therefore indicates the amplitude sensitivity of the oscilloscope display; the pulse duration calibrates the time scale of the sweep. In measurements with microelectrodes and a neutralized input capacity amplifier the best pulse shape restoration defines optimum neutralization adjustment. Changes in the waveform and amplitude of the calibration pulse will usually indicate changes in the microelectrode resistance due to tip breakage or clogging.

The calibrator may be also used to calibrate either single ended or differential amplifiers.

A trigger pulse generator which generates a rectangular calibrating waveform is described. The pulse amplitudes range from 0.1 mv to 1 v and pulse durations from 0.1 to 200 msec. The isolated output of the pulse generator makes it applicable for continuous calibration and monitoring of bioelectric potential measurement systems.

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