HIGH-FREQUENCY GENERATOR TO COAGULATE BRAIN TISSUES

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UDC 615.472.616.831-085.832.74

The circuit of a high-frequency generator intended for coagulating animal tissues is described. Because of the stabilization of the output current and automatic steady build-up, maintenance, and decay of the current load, the apparatus can be used for stereotaxic decerebration of animals with good reproducibility of the results of coagulation and with minor trauma.

KEY WORDS: electrical coagulation; current stabilization.

Generators for diathermy tissue coagulation described in the literature have low output resistance compared with the electrical resistance of the tissues to be coagulated [1-4]. Consequently a change in the electrical resistance of the tissues leads to a change in the volume of the region coagulated, to adhesion of the coagulated tissue to the electrode or, conversely, to incomplete coagulation [3, 5]. These disadvantages are particularly serious when it is impossible to verify the results of coagulation actually during the experiment, for example, in neurophysiological investigations. To overcome these defects a circuit has been developed for a generator with stabilized output current, and work programs and forms of electrodes have been selected experimentally.

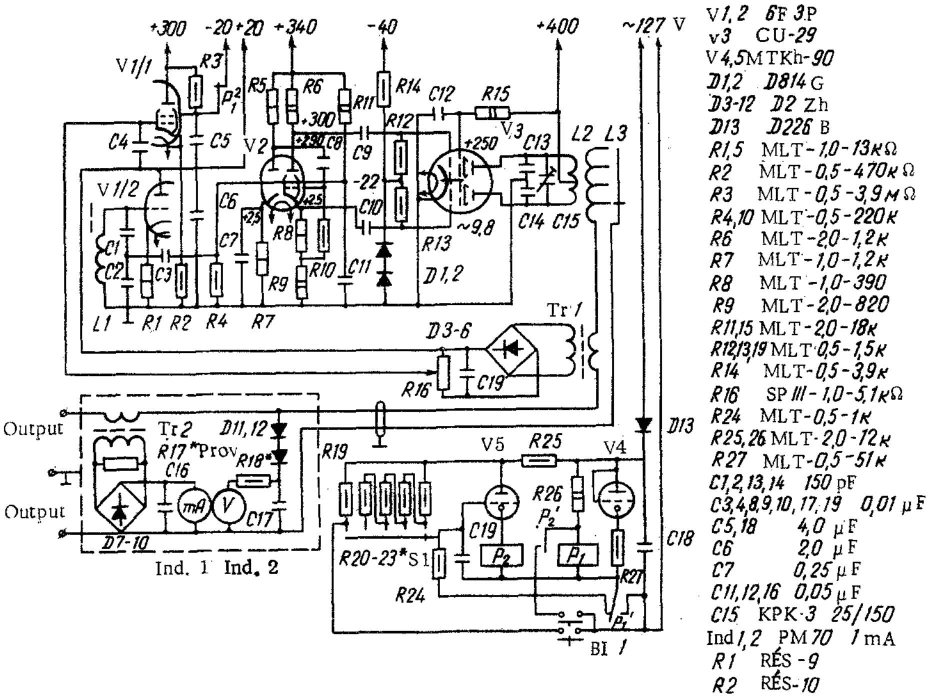

Fig. 1. Electrical circuit of generator. Explanation in text.

Laboratory of Biophysics and Pathophysiology of the Circulation, Institute of General Pathology and Pathological Physiology, Academy of Medical Sciences of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR A. M. Chernukh.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 85, No. 3, pp. 378-380, March, 1978. Original article submitted August 3, 1977.

A distinguishing feature of the circuit described is the feedback from the load current, so that a high output resistance of the generator could be obtained and complete galvanic decoupling of the output circuit provided.

The theoretical circuit of the instrument is given in Fig. 1.

The operating time of the coagulator is assigned by the R 20-23, C 19 circuit and, depending on the position of the switch S 1 is equal to 25, 50, 100, and 200 sec. If S 1 is in the extreme left position the circuit operates all the time the master button B 1 is pressed.

The automatic generator is assembled in accordance with a Hartley oscillator circuit and satisfies the condition of soft self-excitation and is tuned to a frequency of 500 kHz. The working frequency, and the build-up and decay time are chosen in accordance with Wyss' recommendations [3].

The inductance coil L 1 is mounted on an SB 12 core and has 240 turns of PEV 0.1 wire. The inductance coil L 2-L 3 has 2× 120 and 4× 15 turns respectively of PEV 0.51 wire, wound on a transparent plastic frame (diameter 50 mm); L 3 is wound between the two sections of L 2. The transformers Tr 1 and Tr 2 are wound on K 20× 10× 5 M 1000 rings. Tr 1 has two turns of PEV 0.51 wire in the primary and 50 turns of PEV 0.1 wire in the secondary winding. Tr 2 has three and 100 turns of the same wire respectively. For visual control of the load current and voltage in the instrument, pointer indicators of the PM 70 type are used. To increase the accuracy of the readings the indicator head is brought out to the working place through high-frequency RK 75 cable 1 m long.

As Fig. 1 shows, the generator consists of a closed system with feedback from the load current, for which the following relationships between the amplitudes of the currents and the voltages under steady-state conditions are valid:

$$I_l = I_0\frac{DG}{1+DG}, \quad I_0 = \frac{U_{C5}K_0}{K_2}, \qquad (1)$$

where

$$G = |G_i + G_l|, \quad D = K_1K_2, \quad K_1 = \frac{dU_{out}}{dU_a},$$

$$K_2 = \frac{dU_a}{dI_l}, \quad K_0 = \frac{dU_a}{dU_{C5}} \Big/ U_{C4} = \text{const}.$$

U_{out} denotes the open-circuit output voltage; U_a the anode voltage of the tube V 1/2; U_{C4} and U_{C5} the voltage on the capacitors C5 and C4; G_i, G_l the output conductance of the generator and load respectively; d the differentiation operator. Differentiating (1) with respect to G we obtain the function of sensitivity:

$$\frac{dI_l}{I_0} = \frac{dG_l}{G}\frac{DG}{(1+DG)^2}. \qquad (2)$$

When $DG \gg 1$ we can write approximately:

$$\frac{dI_l}{I_0} \approx \frac{dG_l}{G}\cdot\frac{1}{DG}. \qquad (3)$$

Equation (3) shows that at high values of DG (100-1000) $\frac{dI_l}{I_0} \to 0$, and the generator current is virtually independent of the load. Under these circumstances, the equation:

$$I_l \approx I_0 = \frac{U_{C5}K_0}{K_2}$$

is satisfied with great accuracy.

In the circuit illustrated in Fig. 1 the value of K_2 is regulated by the potentiometer R16, by means of which the output current of the generator can be varied by a factor of about 10 within each range. A smooth change of current when the master button B1 is switched on and off is ensured by the choice of time constants of charge and discharge of the capacitor C5. With the above values of the components of the circuit the instrument has the following characteristics: maximal output power 25 W, maximal output voltage 150 V, minimal output current 10 mA, maximal output current 150 mA, number of ranges 4, frequency 500 kHz, exposure time for automatic coagulation 25, 50, 100, and 200 sec, build-up time of output current from 0 to assigned value 10 sec, decay time of current 2 sec, load range 0-10 kΩ, stability of current during a twofold change in load not less than 2%.

More than 80 successful decerebrations have been carried out on cats by means of the apparatus. These results were obtained by the use of a steel electrode 0.4 mm in diameter with varnish insulation and uninsulated tip 2.5 mm long, with an output power of the generator of 600 mW. The electrode displacement speed was 10 mm in 90 sec. Under these circumstances a column of coagulated tissue 3.5 ± 0.5 mm in diameter was formed around the electrode. The mean blood pressure of the animals during the 8-12 h after the decerebration exceeded 100 mm Hg, reflecting the relative absence of trauma associated with the method.

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