Simulated unit pulses for calibrating[1]

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A small battery-powered instrument generates sinusoidal pulses of approximately the shape of neuronal pulses. The output consists of alternate positive and negative pulses across a 10 k ohm source resistance. Such a signal allows a quick assessment of the amplification system and indicates possible losses through shunt capacitances along the connections between S and amplifier input.

High source resistance of electrodes used in recording neuronal activity renders an amplifying system sensitive to electric artifacts. The time constant (source resistance x input capacitance) may become sufficiently large to attenuate the signal, especially when the connection between S and preamplifier is complicated by long cables, switches, or commutators. The instrument described is battery operated and can be placed into any test enclosure; it furnishes simulated unit pulses with a high output impedance that permits a quick assessment of possible attenuation through shunt capacitances in the input path of the amplifier. The pulses alternate between positive and negative, thus providing a useful indication of the high-pass characteristics of the amplification system; since high-pass filters have a differentiating effect on pulses, they tend to make positive and negative pulses appear the same in regard to direction of their amplitude peaks.

CIRCUIT

The astable multivibrator (MV) consists of two complimentary grounded base transistors Q_1 and Q_3, which are the two stages of the MV loop (see Fig. 1). The emitter-follower stages Q_2 and Q_4 are used as buffers between collectors of Q_1 and Q_3 and emitters of Q_3 and Q_1, respectively (Pugh, 1965). These emitter followers have modest gain through incorporating collector resistances and are thus driven into saturation. In this way, a fairly sharp square wave is generated at collector of Q_2 and, also, isolation between the timing elements (2.5 microfarad capacitors and 22 k ohm resistors) and the output load is provided.

The MV output is capacitively coupled (0.1 microfarad) to the pulse former, which consists of R, C, and L, whereby L is the inductance of the transformer's primary winding. Capacitive coupling changes the square wave of the MV into differentiated pulses of equal positive and negative amplitude in respect to ground potential. The differentiated waveform can be regarded as consisting of voltage steps, since the droop of the spikes is small when compared to the short duration of the generated sinusoidal pulse. The pulse former generates damped sinusoidal pulses. The wave shapes are indicated in Fig. 1, and the shape of the sinusoidal pulse is shown in Fig. 2. Output is taken from the secondary transformer. Two attenuating networks reduce the pulse amplitude to 100 microvolts$_{peak}$ with a source resistance of 10 k ohm, which approximates a situation of recording unit activity with a thin wire electrode (Olds Mink, & Best, 1969).

The sinusoidal pulse is a damped oscillation generated by applying a step voltage to the R-L-C resonant circuit. The period of oscillation without damping would be $T_o = 2\pi(LC)^{1/2}$. Damping is introduced by means of the finite value of R, the resistive load across the secondary winding and the low Q-value of the transformer inductance. The damped period T thus becomes dependent on the circuit's Q: $T = T_o[1 - (4Q^2)^{-1}]^{-1/2}$, a lower Q producing a longer period (Millmann & Taub, 1965). The Q of the resonant circuit has been chosen to give a pulse with some overshoot to keep the pulse narrow and well defined (see Fig. 2). The frequency content of the pulse reaches from 500 Hz to 1300 Hz (−1 dB). The inductance of the transformer's primary winding was measured to be 2.9 H with a Q of 2 (secondary winding open).

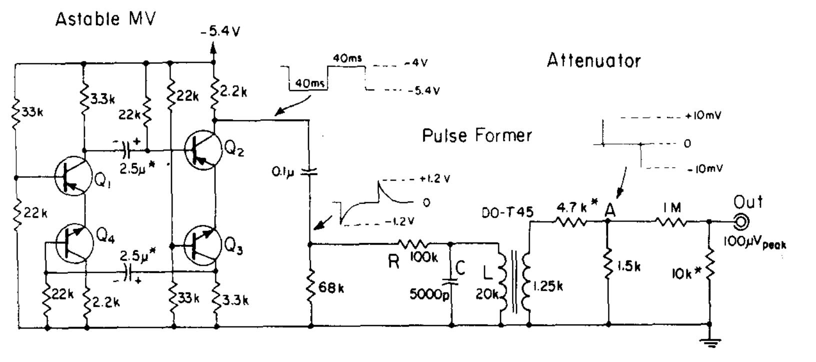

Fig. 1. Circuit Diagram. The transformer is made by United Transformer Corp., New York, N. Y. Components marked * must be selected to achieve required timing and amplitude of output pulses. Power is supplied by a Mallory Type 302904 Mercury battery. Transistors are Texas Instrument Types 2N3702 (PNP) and 2N3704 (NPN).

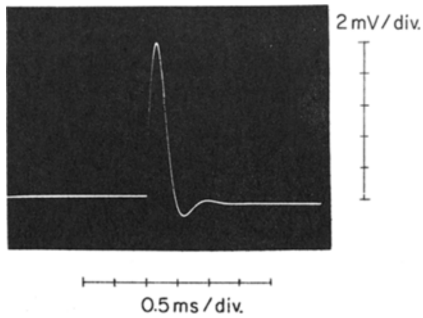

Fig. 2. Output pulse at Point A.

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NOTE

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