

PRODUCTION OF BALANCED SQUARE WAVES FOR ELECTRONIC STIMULATION

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INTRODUCTION

It is generally recognized that integrated organisms have definite reactions to electronic currents. Animal reactions to electrical stimulation are related to the strength of the stimulus (voltage); the quantity of the stimulus (amperage), and the nature of the stimulus (wave form). Instantaneously interrupted electron currents have proven to be quantitatively applicable to behavior studies. The spaced sudden shock type of Hill (1934) or the controlled interruptions of direct current described by Ritchie (1944) are the conventional methods of current application for this type of work. The several devices which we present below produce a balanced square wave, i.e., an instantaneous interchange of cathode and anode at a controlled tempo. With such electrical mechanisms it is possible through synchronization of movement with wave form to quantitatively interpret reactions to electron stimulation.

In the biological laboratory this instantaneous interchange may be accomplished by a double pole double throw (dpdt) hand switch. In a physics laboratory an electronic switch or square wave generator is used to accomplish the same result. With these types of mechanisms it is possible to effect an electrical stimulation, the electro-chemical results of which are equal and opposite.

METHODS OF PRODUCTION

With the common dpdt switch, the interchange is made at as slow a tempo as may be desired. Although we have the human element herein, it would be negligible in frequencies of one interchange every several seconds. This method of production is shown in Fig. 1. It was determined, however, that frequencies beyond the accuracy range of the dpdt switch were required in the behavior laboratory.

To produce controlled frequencies accurately between .25 and 5 cycles per second, a special mechanism was designed. This consists of a variable speed motor with an external commutator which excites a dpdt electric relay. With such a device voltage as well as frequency may be varied. See Fig. 2 for details.

To produce controlled frequencies of a higher range (5 to 100,000 cycles per second) a variable square wave generator is used. With such a device it is also possible to accurately control both frequency and output voltage. An oscillograph when employed in the circuit provides a visual check on wave form, frequency and voltage. See Fig. 3 for details.

INTERPRETATION

The variable speed motor with an external commutator activating a dpdt relay produces an instantaneous interchange with satisfactory accuracy at lower frequencies. The calculation of frequency output from this mechanism is based upon the revolutions per minute of the commutator. At low speeds this can be reasonably determined by a stop watch, higher speeds requiring either a RPM meter or an oscillograph for visual observation.

As previously stated, a variable square wave generator provides with accuracy variable frequencies in the higher range. A relatively accurate check of the

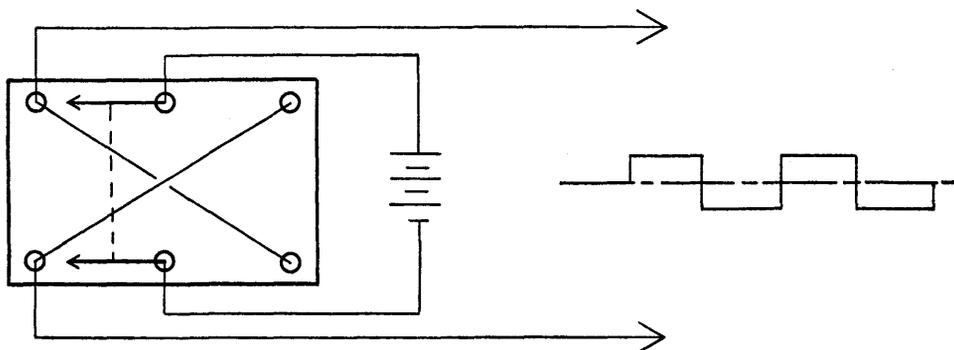
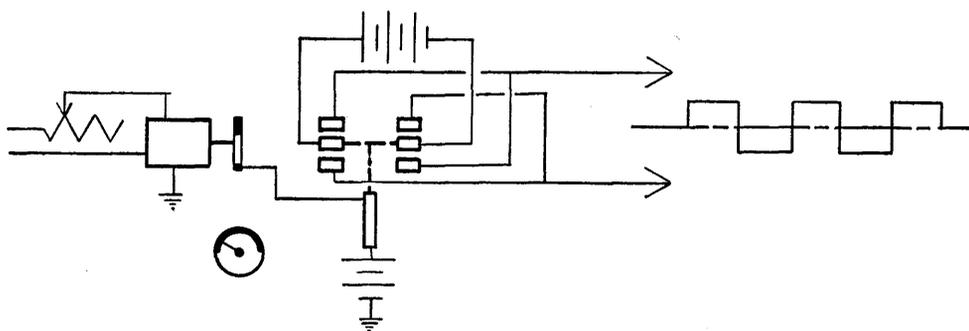
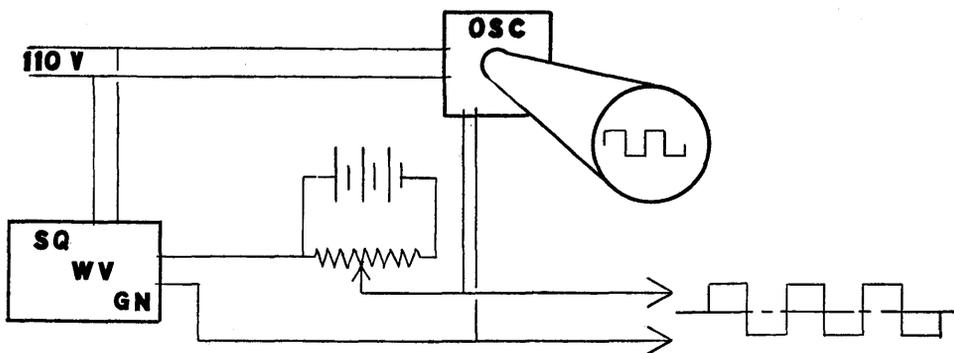
**FIG. 1****FIG. 2****FIG. 3**

FIG. 1. Hand operated double pole double throw switch.

FIG. 2. Variable speed motor with external commutator exciting a double pole double throw electric relay.

FIG. 3. Variable square wave generator, with balancing batteries and oscilloscope.

calibrated output may be made through the use of an oscillograph after synchronization with a known frequency. Utilization of the direct deflection plates of the oscillograph makes it possible to visually determine voltage reference level and output. The reference level may be set to ground through the use of balancing batteries (Fig. 3).

The oscillograph employed in the above circuit has its sweep synchronized to a known frequency. Interpretation of any higher harmonic is then possible by direct count of cycles shown on the screen of the cathode ray tube.

APPLICATION

The above described apparatus provides a means of applying electrical stimulation of known frequencies. Interesting results were obtained using Protozoa as test organisms and will be reported in an early issue of this Journal.

REFERENCES

- Hill, A. V. 1934. Repetitive stimulation by commutator and condenser. *Jour. Physiol.*, 82: 4.
Ritchie, A. E. 1944. A simple variable "square wave" stimulator by biological work. *Jour. Sci. Instruments*, 21: 4.
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