An inherent problem in certain constant-current stimulators^{1,2}

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A basic and potentially dangerous problem that may occur in the use of triggered constant-current generators for stimulation is discussed in the general case. A solution with schematic illustration is presented for one specific constant-current generator, the CCS-1A manufactured by Electronics of Life Sciences, Inc.

The use of constant-current generators for electrical stimulation in electrophysiological and behavioral experiments has increased greatly in recent years. Increased experimental control and greater safety makes constant-current generators superior to so-called constant-voltage systems (Gibson, 1968). This laboratory, however, after several years' experience with constant-current generators, has found a basic design problem that can create a safety hazard, particularly in clinical brain stimulation. Although the following discussion of the problem is presented with reference to a particular constant-current generator, the principles apply in general to any generator that is triggered by a pulse source. The suggested modification, however, applies only to the specified generator.

The constant-current generator to be discussed is the CCS-1A, manufactured by Electronics for Life Sciences, Rockville, Maryland. This unit must be triggered "on" and "off" by square-wave pulses, such as those produced by a Grass S4 stimulator. The generator produces a constant-current pulse of the same duration as the input pulse and provides complete electrical isolation between input and output pulses. This isolation is accomplished by coupling the input signal to the constant-current circuit via a pulse transformer, which in effect differentiates the input pulse: The leading (positive-going) edge of the pulse turns the generator "on," and the trailing (negative-going) edge turns it "off." According to the manual for the ELS CCS-1A, the rise time of the input pulse must be 1 microsec or faster, and it is this requirement that creates a problem: If the rise time of the input pulse (or some other transient) meets the 1-microsec requirement, and the fall time (or negative-going rise time) does not, the generator may be triggered "on" and left "on" until a pulse arrives with the required fall time to turn it "off." If this happens, a relatively large amount of power is

transmitted to the S in an inconvenient and often dangerous situation.

The modification shown in Fig. 1 permits the CCS-1A generator to be "on" only when an input pulse is present; when there is no input, there will be no current output. In making this modification, the electrical isolation between the input and output circuits is lost, and some method must be used to isolate the input pulse from ground if the constant-current pulse is to be isolated. A Grass stimulus isolation unit, or the equivalent, is a convenient solution to this problem.

The modification suggested has been found to be simple to make, both electrically and mechanically. Switch S_m , which enables the user to operate the generator in either the original triggered mode or the drive mode, can be mounted directly above the input jack. Resistor R_6 is easily identified on the circuit board, and can be properly connected by unsoldering the end connected to the collector of Transistor Q_3 from the circuit board and soldering this free end to the wire going back to Switch S_m . The ground for the output circuit can be located by tracing the wire connected to the negative terminal of the 90-V battery back to its termination on

the circuit board. In the driven mode, the generator requires a negative pulse of about -4 V peak to be driven "on," but it has not been damaged by the inadvertent application of a -150-V pulse from a Grass SIU4.

Investigators in this laboratory, after examination of changes in the behavioral and electroneurological characteristics of experimental animals, feel that several have been irreversibly damaged by relatively long applications of power from unmodified generators. For this reason, we feel that the suggested modification is highly desirable and, in clinical instances, should be mandatory.

REFERENCES

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Fig. 1. Modification for Electronics for Life Sciences constant-current generator, Model CCS-1A.

Notes: (1) dotted lines: connections to be removed; (2) light solid lines: original circuit; (3) heavy solid lines: modification; (4) S_m : three pole-two position switch; (5) CR_m : IN660 or equivalent silicon signal diode; (6) switch S_m shown in triggered mode position.