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Strength-Duration Curve of Nerve Excitation by Electrical Fields Associated with Discharge of Condensers.

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In a previous report[1] it was shown that when the sciatic of the frog is placed between the plates of a condenser separated by a distance of 7 inches, it is stimulable by the electrical field associated with a 60 ~ potential difference of 10,000 volts between them.

In the present experiments the plates were 7″ x 5″ and were separated by a distance of 2 5/16 inches. These plates were connected in parallel with condensers of various values and the system charged by a DC power supply capable of yielding a maximum potential difference of 2,000 volts.

The preparation, consisting of the sciatic and the attached gastrocnemius, was laid upon a carefully cleaned glass slide between the large plates of the condenser system in such wise that the nerve was parallel to the electrical lines of force of the field, and the long axis of the muscle at right angles to them. The edges of the glass slide were each 3 mm from the plates of the condenser. To keep the preparation from becoming desiccated a strip of cloth 3 mm wide was laid across the nerve some 2 mm from the cut end and moistened with Ringers.

It was found possible to stimulate the nerve both during the charging of the condenser as well as during the discharge. The thresholds were not equal, however, and their value was determined by altering a non-inductive resistance which was connected in series with the condenser until the gastrocnemius ceased to contract. It was found by this means that stimulation was more readily obtained on the discharge of the condenser than on the charge.

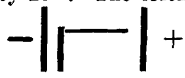
The determination of the strength-duration curve was made with the discharge of the condenser, and we utilized both varying capacities and varying resistances. The preparation was arranged as shown in the legend of Table I. The table gives the results from 5 series of experiments. In the first 4 series the resistance is fixed and the capacity is varied; in the fifth series the capacity is fixed and the resistance is varied. The values of E represent averages of from

[1] Gengerelli, J. A., and Holter, N. J., PROC. SOC. EXP. BIOL. AND MED., 1941, **46**, 532.

TABLE I.

C	R	CR	E	No. of determinations
.00025	20	.0050	1675	
.00033	"	.0066	1487	
.00050	"	.010	1312	
.0009	"	.018	1237	
.0066	"	.132	1162	6
.0196	"	.392	1312	
.0909	"	1.818	1650	
.10	"	2.00	1675	
.00025	"	.0050	1093	
.00033	"	.0066	888	
.00050	"	.010	791	
.0009	"	.018	769	
.0066	"	.132	719	8
.0196	"	.392	894	
.0909	"	1.818	1625	
.10	"	2.00	1831	
.00025	"	.005	1894	
.00050	"	.010	1350	
.0050	"	.10	1156	
.01	"	.20	1144	10
.05	"	1.00	1792	
.10	"	2.00	1925	
.00025	"	.0050	1063	
.00050	"	.01	869	
.0050	"	.10	791	
.01	"	.20	831	8
.0196	"	.392	1013	
.05	"	1.00	1656	
.10	"	2.00	1900	
.0099	20	.198	1266	
"	40	.396	1325	
"	60	.594	1300	
"	80	.792	1345	8
"	100	.990	1326	
"	500	4.950	1377	
"	1000	9.90	1456	
"	1950	19.30	1550	
"	5000	49.50	1725	

C is expressed in microfarads; R in ohms. To obtain CR in mscs, it is necessary to multiply the values in the table by 10^{-3}. The orientation of the preparation,



6 to 10 readings with not less than 2 preparations for each experiment; these were taken by the technic of reversed series, in order to eliminate the influence of any systematic time factor.

It will be noted from the first 4 segments of the table that the strength-duration curve presents an interesting inversion. The results of these experiments are shown graphically in Fig. 1. The

locus of the inversion region is uniformly indicated by x's. It will be observed, furthermore, that the fifth experiment did not yield sufficiently small values of CR to include the inversion, hence the obtained strength-duration curve shows E as an increasing negatively

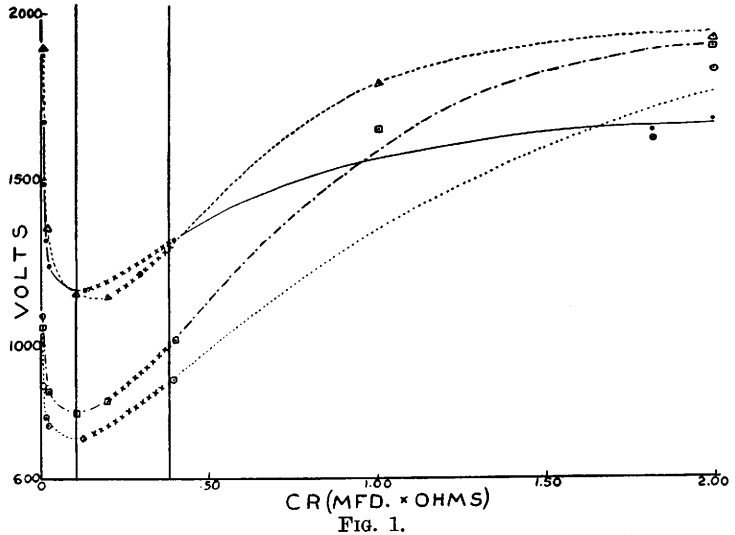


FIG. 1.

Graphs giving the results of 4 series of experiments (the first four segments of Table I). The inversion point may be considered as occurring between .0001 and .00038 mscs. These limits are indicated by the two vertical lines.

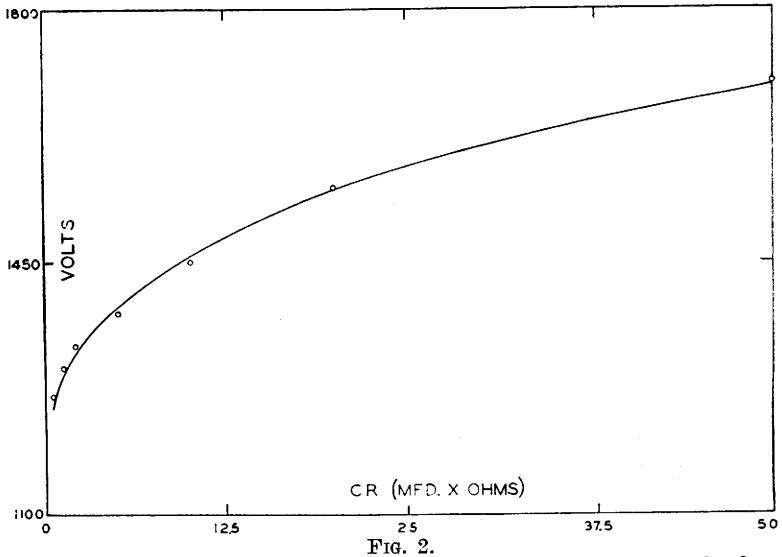


FIG. 2.

The graph illustrates the fifth segment of Table I. The experimental values for R=40 and R=80 are not shown in the graph.

accelerated function of the time. This is shown graphically in Fig. 2. The two irregularities occurring at 40 and 80 ohms, respectively, are not indicated in the curve.

Summary. 1. Stimulation of nerve by electrical fields associated with the charging and discharging of condensers has been obtained, although the efficacy of increasing and decreasing fields is not identical; 2. a strength-duration curve of excitation with diminishing electrical fields associated with the discharge of condensers has been determined wherein E is at first a decreasing and then an increasing negatively accelerated function of the time. The region of inversion is between .0001 and .00038 mscs; 3. the curve is in marked contrast with those obtained by discharging condensers through nerve tissue, in that these (a) are not characterized by an inversion, (b) show E as a *diminishing* negatively accelerated function of the time;[2] 4. there are great differences in the stimulability of preparations.

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An Automatic Electron Tube Stimulator and Recorder.*

H. V. CONNERTY AND W. H. JOHNSON. (Introduced by T. Koppanyi.)

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As a result of the development of radio apparatus and of new types of vacuum tubes, it became possible to devise stimulators having desirable features impossible to inductorium or neon tube stimulators, *i. e.*, greater range of frequency of stimulation, greater range of intensity of each shock, and methods for recording the frequency of the stimulation. Many instruments, incorporating some or all of these features, have been devised, outstanding examples being those of Scheminzky,[1] Schmitt,[2] Nicolai,[3] and Bouman.[4] Although these instruments can be considered as great improvements

[2] Katz, B., *Electrical Excitation of Nerve*, Oxford Press, 1939, p. 5.

* The authors are indebted to Dr. Reginald A. Cutting, director of the Department of Physiology, for the use of his personal electrical apparatus and for stimulating the investigation in many ways.

[1] Scheminzky, F., *Arch. f. d. ges. Physiol.*, 1930, **225**, 303.

[2] Schmitt, H. A., and F. O., *Science*, 1932, **76**, 328.

[3] Nicolai, L., *Pflügers Archiv.*, 1930, **225**, 131.

[4] Bouman, H. D., *Arch. Neérl. Physiol.*, 1935, **20**, 155.