

and consequently the progression is undisturbed by the modification of the directional differences for the same salt, which are relatively so much more important in the case of the thermal constants.

The net effect of the replacement of one metal by another has, however, been shown to be clearly demonstrated by the progression of the coefficients of the cubical expansion and their increments.

The final conclusion of the investigation, therefore, is that :

The thermal deformation constants of the crystals of the normal sulphates of potassium, rubidium, and caesium exhibit variations which, in common with the morphological, optical, and other physical properties previously investigated, follow the order of progression of the atomic weights of the alkali metals which the salts contain.

“On the Reflex Electrical Effects in Mixed Nerve and in the Anterior and Posterior Roots.” By Miss S. C. M. SOWTON. Communicated by A. D. WALLER, M.D., F.R.S. Received December 12, 1898,—Read February 16, 1899.

The following experiments were made during the months of May, June, and July, 1897, in the Physiological Laboratory of Leipzig, under the guidance of Professors Hering and v. Frey, to test whether in the frog, reflex electrical changes could be demonstrated at the central end—

- I. Of a mixed nerve.
- II. Of anterior roots alone.
- III. Of posterior roots alone.

As regards the first two heads, the end in view was simply the actual verification of an extremely probable phenomenon, preparatory to an examination of the third head, viz., reflex electrical effects propagated down the posterior roots, which, in 1891,* were pointed out by Gotech and Horsley, and offered as proof of the passage of centrifugal nerve impulses in normally afferent nerve channels. The results obtained in the present experiments being somewhat difficult to interpret, the notes were laid aside until opportunity should offer for carrying the investigation further. Professor Bernstein having, however, quite recently† discussed the question of the reflex negative variation of the nerve current, the moment seemed opportune for submitting these results as they stand to the attention of those interested in the subject.

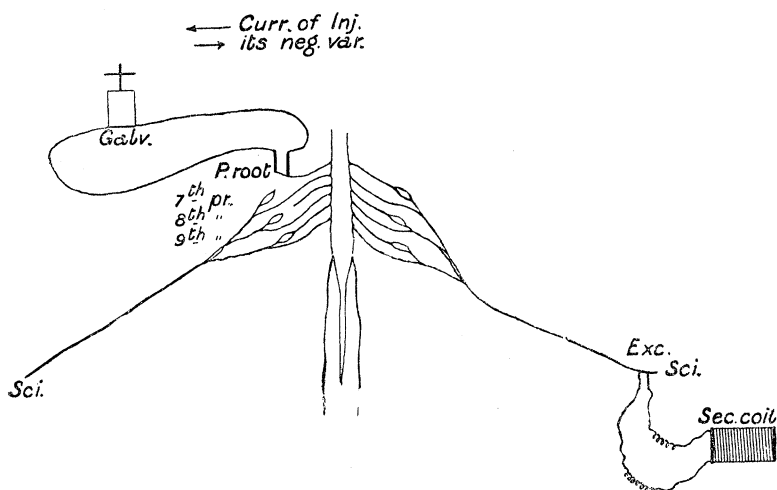
The galvanometer used was on the lines of Thomson's reflecting instrument, with modifications by Carpentier. The leading-off electrodes had finely pointed camel's hair brushes inserted in the plug

* ‘Phil. Trans.’ B, vol. 182.

† ‘Pflüger's Archiv,’ vol. 73, p. 374, 1898.

of refined clay, the brushes being moistened with normal saline. The current of injury was compensated in the usual way. In the exciting circuit, the Du Bois Raymond induction coil was supplied by a single Daniell cell, the stimulating electrodes were of platinum wire, and had an extra loop of wire (Hering's pattern) to guard against unipolar effects.

Frogs of the Esculenta species were used ; they were cooled, *i.e.*, kept for six or seven days on ice to ensure a high degree of excitability. The frog was prepared with as little loss of blood as possible, the brain above the medulla being destroyed by insertion of a small peg of wood. For experiments under head I, the frog having been firmly secured, the two sciatics were exposed, cut at the knee-joint, and isolated in their full extent. The nerve of one side was then raised, supported by a glass hook, and connected at transverse and longitudinal surfaces with the galvanometer electrodes—the hook was so arranged as to obviate any possible shifting of contacts. The sciatic of the opposite side was then also raised, and its lower end laid across the stimulating electrodes. In one or two preliminary experiments, one branch only of the sciatic was divided at the knee and led off to the galvanometer, the other branch being left in connection with its muscles to serve as a control ; under these conditions, on stimulating the sciatic of the opposite side, the electrical and muscular effects corresponded, both sometimes failing to appear.



I.—Experiments showing Reflex Electrical Changes at the Central End of a Mixed Nerve.

	Part stimulated.	Part led off.	Deflection of galvanometer.
May 8, 1897. Coil at 30 cm.	Central end of right sciatic.	Central end of opposite sciatic.	5° and rather more.
May 17. Frog curarised. Coil 30 cm.	Do. (Effect the same sciatic.)	Do. from left to right	10—30°.
May 20. Frog curarised. Coil 30 cm.	Do.	Do.	Trace.
Coil at 30 cm. Effect much the same with coil at 12.	Do.	Do.	40—50°.
May 22	Do.	Do.	10—15°.
	Strychnia injected	subcutaneously.	
	Do.	Do.	40—90°. Also clonus effects 120—130° at highest, in response to a light tap on the table.
May 24	Central end of right sciatic.	Central end of opposite sciatic.	10—20°.
	After	strychnia.	
	Do.	Do.	Slight increase up to 30°.
2nd Frog	Do.	Do.	10°.
	After	strychnia.	
	Do.	Do.	30—70°.
May 29. Frog etherised.	Do.	Do.	No deflection either way across.
	After	strychnia.	
	Do.	Do.	20—35°.
June 18. Coil 15 cm.	Do.	Do.	10—15°.
June 23. Coil 10 cm.	Do.	Do.	4—10°.
2nd Frog	Do.	Do.	5°.

In these experiments the negative variation was reflex in character, effects could not be obtained in rapid succession, but a pause of a

minute or two was necessary before repeating the stimulation, and the latent period was very marked—to be reckoned often in seconds.

In experiments where the nerve roots were to be led off to the galvanometer, the frog was always curarised. A sciatic having then been prepared as before for stimulation, its nerve roots (7th, 8th, and 9th pairs), or the corresponding pairs of the opposite side, were exposed by opening up the lower part of the spinal column; the roots were then carefully separated and those to be led off to the galvanometer were cut as far as possible from the cord (just above the ganglion, in the case of posterior roots). Two roots were usually taken together and their central ends connected with the brush electrodes.

In cases where the bulb was stimulated, the brain and upper half of the cord were exposed, and the brain cut off at the bulb. The cord having then been severed from its attachments, was carefully raised and the bulb laid upon the stimulating electrodes.

II.—(1) Experiments showing Electrical Changes at the Central End of Anterior Roots alone. Excitation of Sciatic of same side.

	Part stimulated.	Part led off.	Deflection of galvanometer.
May 12. Coil 30 cm.	Central end of left sciatic.	Central end of 2 anterior roots of same side.	10—40°.
June 21. Coil 15 and 10 cm.	Do.	Central end of 1 anterior root of same side.	5—10°.

II.—(2) Ditto, ditto. Excitation of Bulb.

	Part stimulated.	Part led off.	Deflection of galvanometer.
June 25. Coil 10 cm.	Bulb.	Central end of 2 anterior roots.	20—100°.
June 29. Coil 10 cm.	Do.	Do.	5—10°.

III.—(1) Experiments showing Electrical Changes at the Central End of Posterior Roots alone. Excitation of Sciatic of same side.

	Part stimulated.	Part led off.	Deflection of galvanometer.
June 21. Coil 30 cm.	Central end of left sciatic.	Central end of 2 posterior roots of same side.	5—8°.
June 22. Coil 10 cm.	Do.	Do.	4—10°.
July 10. Coil 10 cm.	Do.	Do.	5—6°.
July 12. Coil 10 cm.	Do.	Do.	10—20°.
July 15. Coil 10 cm.	Do.	Do.	2°
July 16. Coil 10 cm.	Do.	Do.	3°

III.—(2) Ditto, ditto. Excitation of Sciatic of opposite side.

	Part stimulated.	Part led off.	Deflection of galvanometer.
June 21. Coil 10 cm.	Central end of right sciatic.	Central end of 2 opposite posterior roots.	2—3°
July 10. Coil 10 cm.	Do.	Do.	8—9°
July 12. Coil 10 cm.	Do.	Do.	8—15°

In these last nine experiments where the lead-off was from posterior roots the deflection had not the characters of a reflex deflection—viz., delay and exhaustibility; the negative variation followed at once on stimulation and could be repeated without the pause necessary in the case of an ordinary reflex. The same thing was also observed on one occasion in the case of anterior roots (experiment of June 29). In the remaining experiments III (3) where, the bulb being stimulated, the posterior roots were led off to the galvanometer, this non-reflex effect was observed in certainly two cases (June 29 and 30).

III.—(3) Ditto, ditto. Excitation of Bulb.

	Part stimulated.	Part led off.	Deflection of galvanometer.
June 25. Coil 10 cm.	Bulb.	Central end of 2 posterior roots.	10—15°
June 29. Coil 10 cm.	Do.	Do.	3—7°
2nd Frog.	Do.	Do.	3—9°
June 30. Coil 10 and 15 cm.	Do.	Do.	10—17°
2nd Frog.	Do.	Do.	3—4°
July 1. Coil 10 cm.	Do.	Do.	2—3°
2nd Frog.	Do.	Do.	5—10°
July 2. Coil 10 cm.	Do.	Do.	2—3°
July 5. Coil 10 cm.	Do.	Do.	5—9°

No exact quantitative estimation of electrical effects was aimed at in these experiments, but as a rough term of comparison, the negative variation of a directly stimulated sciatic was occasionally noted, this deflection was seldom less than 250° of the scale. The average effects obtained in the six series of experiments are given below.

	Part stimulated.	Part led off.	Deflection of galvanometer.
	Ordinary negative variation from sciatic		250°
I. (1)	Central end of sciatic (9 expts.).	Central end of off sciatic.	14°
II. { (2)	Central end of left sciatic (2 expts.).	Central end of same anterior roots.	16·2°
(3)	Bulb (2 expts.).	Central end of anterior roots.	33·5°
{ (4)	Central end of left sciatic (6 expts.).	Central end of same posterior roots.	6·5°
III. { (5)	Central end of right sciatic.	Central end of opposite posterior roots.	7·5°
(6)	Bulb (9 expts.).	Central end of posterior roots.	6·6°

Throughout the experiments fallacies arising through induction were carefully guarded against, the negative variation was tested by reversing the direction of the stimulating current; and as a final test for current escape the led-off nerve was cut through with wet scissors in such a way that the severed ends remained in contact, though physiological continuity was destroyed; the stimulation was then repeated, but in no case was there any deflection after such section.

In the main my results exhibit—

- I. Electrical effects of an indubitably reflex character in the mixed nerve and in the anterior roots alone.
- II. Slight effects of doubtful character in the posterior roots.

My warmest thanks are due to Professor Hering for the courteous hospitality of his laboratory, and to Professor von Frey I would offer my grateful acknowledgment of his ready help.

February 23, 1899.

The LORD LISTER, F.R.C.S., D.C.L., in the Chair.

A List of the Presents received was laid on the table, and thanks ordered for them.

The following Papers were read :—

- I. "On the Order of Appearance of Chemical Substances at different Stellar Temperatures." By Sir NORMAN LOCKYER, K.C.B., F.R.S.
- II. "The Efficiency of Man, or Economic Coefficient of the Human Machine." By Dr. W. MARCET, F.R.S., and R. B. FLORIS.
- III. "Some Experiments bearing on the Theory of Voltaic Action." By J. BROWN. Communicated by Professor EVERETT, F.R.S.
- IV. "Deposition of Barium Sulphate as a Cementing Material of Sandstone." By Dr. F. CLOWES. Communicated by Professor ARMSTRONG, F.R.S.