Constantine Demetrius Chroustchoff. Professor of mineralogy, crystallography and petrography in the St. Petersburg Academy of Medicine. St. Petersburg.

A. B. Fr. af Schultén. Professor of chemistry in the Alexander University at Helsingfors.

SCIENTIFIC JOURNALS AND ARTICLES

THE December number (volume 17, number 3) of the *Bulletin of the American Mathematical Society* contains the following articles: Report of the September meeting of the San Francisco Section, by C. A. Noble; "A new proof of the theorem of Weierstrass concerning the factorization of a power series," by W. D. MacMillan; Review of Kowalewski's Determinantentheorie, by Maxime Bôcher; Review of Wright's Invariants of Quadratic Differential Forms, by L. P. Eisenhart; Review of Volume 4 of Sturm's Geometrische Verwandtschaften, by Virgil Snyder; "Notes"; "New Publications."

The January number of the *Bulletin* contains: Report of the October meeting of the Society, by F. N. Cole; Report of the Königsberg meeting of the Deutsche Mathematiker-Vereinigung; "On the saddlepoint in the theory of maxima and minima and in the calculus of variations," by R. G. D. Richardson; "Note on identities connecting certain integrals," by Louis Ingold; Review of Poincaré's Göttingen Lectures, by G. D. Birkhoff; Review of Lorentz's Theory of Electrons and of Wien's Elektronen, by E. B. Wilson; "Shorter notices": Lilienthal's Differentialgeometrie, Volume 1, by E. J. Wilczynski; Boehm's Elliptische Funktionen, Part 1, by L. W. Dowling; Dingeldey's Sammlung von Aufgaben zur Anwendung der Differential- und Integralrechnung, by E. W. Ponzer; Murray's Calculus, by W. B. Carver; Crabtree's Theory of Spinning Tops and Gyroscopic Motion, by E. W. Brown; Loney's Dynamics of a Particle and of Rigid Bodies, by W. R. Longley; "Notes"; "New Publications."

The *Journal of Experimental Medicine* begins its thirteenth volume with the announcement that it will hereafter be issued once a month instead of once in two months as heretofore. Two volumes will thus be issued each year. No change is made in the price of subscription. Dr. Benjamin T. Terry takes the place of Dr. Eugene L. Opie as the associate of Dr. Simon Flexner in the editorial control of the journal.

SPECIAL ARTICLES

VISUAL SENSATIONS FROM THE ALTERNATING MAGNETIC FIELD[1]

THE experiments reported by S. P. Thompson in the *Proceedings of the Royal Society*, B, 82 (557), pp. 396 ff., are of great importance, especially in view of the negative results which have been obtained in the several earlier attempts to arouse sensations by subjecting the head to the influence of a magnetic field. Previous experimenters seem, however, to have used direct current, while Thompson used alternating current.

Thompson obtained his magnetic field from a coil of 32 turns of stranded copper conductor of .2 square inch equivalent cross section, the coil having an internal diameter of nine inches and a length of eight inches. This coil was supplied with 50-cycle alternating current, the maximal amperage being 180. The subject's head was inserted in the coil, and under these conditions Thompson and several others were able to obtain flickering light sensations which were especially conspicuous in the peripheral part of the visual field. The flicker was noticed even when the eyes were open. Certain subjects reported sensations of taste also.

It occurred to me on reading Thompson's report that the visual phenomenon might well be due to idio-retinal light, under the suggestion of the hum of the coil due to the alternating current, and as Thompson mentions no specific checks or precautions in his procedure, it seemed worth while to repeat the ex-

[1] I am indebted to the persons mentioned in this paper for their interest and participation in the experiments, and especially to Professor J. B. Whitehead and Mr. Henry C. Louis, without whose cooperation the experiments would have been impossible.

periment. Professor Whitehead readily agreed to cooperate with me, and the first tests were made in his laboratory and under his personal supervision.

The coil used had 27 turns of a cable consisting of 37 copper wires (each .082 inch in diameter) equivalent to 250,000 circular mils. The coil was approximately 8 inches long, and elliptical in cross section, the internal diameters being 10.5 inches and 9 inches. With this coil no part of the subject's head or face touched the internal surface; a condition which we could not always attain with a coil of circular cross section and 9 inches internal diameter, which we first tried. The coil was suspended from the ceiling by ropes, so that the subject could sit in a chair with his head inside the coil. The transformer available forced approximately 200 amperes of 60-cycle A.C. through the coil, the potential drop between coil terminals being slightly over 12 volts. This gave a field of 5,400 ampere turns, against 5,760 maximal in Thompson's experiment.

On first trial I distinctly perceived the flicker. Dr. Anderson, Dr. Cowles, Dr. Essick and a student also perceived it on first trial. Dr. Watson was uncertain on first trial, but on second trial perceived the flicker, although not very distinctly until after several trials. Dr. Jennings, Dr. Whitehead and several others perceived absolutely nothing, even after careful trials. It still seemed to me possible that idio-retinal light and suggestion were at the bottom of the phenomenon and therefore Dr. Watson and I carried out some careful tests in which suggestion was excluded to the fullest possible extent, which tests showed conclusively that my suspicion was unfounded. In these tests the transformer rested on a table close beside the coil, so that the loud noise of the former completely drowned the hum of the latter. The current could be switched off the coil, and on resistance carrying practically the same amperage as the coil, so that in either case the transformer noise was the same. A telephone receiver connected with the transformer was hung on the coil, emitting a loud noise whether the current was on the coil or on the resistance. For further precaution the subject's ears were plugged up as well as was possible. Under these conditions, where there was absolutely no way of telling by the sound whether the current was on or off the coil, each of us was able to identify the flicker with absolute precision.

Several subjects noticed a twitching of the eyelids, when the head was in the coil. This was noticed especially by two of the subjects who were unable to perceive the flicker, and who thought it probable that the muscular sensations were at the base of the phenomenon. They were asked to report on the twitching, while the current was being turned now on the coil, now on the resistance, and it was found that the twitching occurred just as strongly when there was no current on the coil as when there was current.

Those who perceived the flicker found it becoming less distinct after a minute or even less of stimulation, and found it restored by a few minutes' rest.

The flicker was best perceived with the eyes closed or with the room darkened, but was noticeable with the eyes open if the room was not too brightly lighted. The interior of the coil furnished a fairly dark background.

I made tests with both positive and negative after-images but could not find that the flicker affected them in any way. The flicker was strongest in the peripheral visual field, and possibly did not affect to any considerable degree the central portion of the field, in which were the after-images.

It was clear, as a result of these tests, that the phenomenon was really a matter of visual sensation, and that we were dealing with threshold values; it needed only higher intensity to make the flicker visible to all subjects. Further it seemed to me strongly indicated that current of less frequency would give more intense flicker. Mr. A. E. Loizeau, of the Consolidated Gas, Electric Light and Power Company, kindly offered us the facilities of his testing plant, and the coil was accordingly removed thither, and further tests

carried out under the supervision of Mr. Henry C. Louis of the company's electrical engineering department.

We forced 440 amperes of 60 cycle alternating current through the coil, with terminal potential drop of 32 volts. The flicker now became much more distinct than it had been at the lower amperage. Dr. Whitehead, Dr. Jennings and one of the students who before had not noticed any flicker, were present at these tests and now got the flicker very clearly at first trial. Mr. Louis and a number of the electricians also testified to the unmistakable nature of the phenomenon.

With 480 amperes of 25-cycle current (20 volts) a much more striking result was obtained. With my head below the level of the coil, and with my eyes open, the flicker was strongly noticeable, although the room was brightly lighted by afternoon daylight. The whole visual field quivered as if illuminated by a rapidly intermittent light. Several other subjects made a similar observation, although in some cases the flicker was noticed only in the less illuminated parts of the visual field, as where shadows fell in the room. With the head inside the coil the flicker was so pronounced as to be intensely disagreeable. The flicker seemed to me slower than with the 60-cycle current, and Mr. Louis and one of his assistants found the same apparent difference. Others were uncertain as to this point. The flicker with 60-cycle current had seemed to me to differ in character from ordinary visual flicker; it was odd, or novel in an indefinite way; but the flicker with 25-cycle current seemed quite like ordinary rapid flicker. This difference I am inclined to explain by the fact that normally a flicker of 60 per second is imperceptible, hence such a flicker seems unusual when produced under these abnormal conditions.

With the 200-ampere current, I had found that with the head either above or below the coil, with the face turned either upward or downward, practically no effect was obtained, although in two of these positions the eyes were close to the plane of the end of the coil, and hence in a strong magnetic field. Rotation of the head from one of these positions through 90° (presenting the side of the head to the coil) brought in the flicker distinctly. My observation on this point was confirmed by Dr. Anderson and Dr. Watson. With the stronger currents the effect was much more pronounced. Although some flicker was observed when the occipito-frontal axis was vertical, rotation of the head through 90° caused a great increase. This would suggest that the effect is due to induction currents in the optic pathway, since in the position with occipito-frontal axis vertical, the general direction of the optic pathway is parallel to the lines of force, whereas rotation of the head through ninety degrees brings the pathway across the lines. When the head is inside the coil, the pathway crosses the lines in the most intense part of the magnetic field.

Whether currents induced in the optic pathway excite the occipital cortex directly, or excite the retina primarily, is yet a matter for conjecture. That flicker is produced by alternations faster than the fastest flicker from normal light stimulation is of course no evidence for the non-retinal character of the flicker in question.

I can not say as yet that there is a definite *arousal* of visual sensation by the alternating field; the effect appears more like an alternate intensification and inhibition of whatever sensory process is already in progress. That is to say: if a certain intensity of normal light-sensation or idio-retinal light is present before the current is turned on, the apparent effect of setting up the alternating field is alternately to increase and decrease the intensity of the sensation so that the average intensity is not changed. It is quite possible that further observation will change my opinion on this point.

No sensations other than the visual, which could be connected with the alternating field were noticed by any of us. That there is no after-effect from the stronger fields, I should not like to say at present. I should advise any experimenter to proceed cautiously.

It is very desirable that experiments with a

large range of amperages and frequencies be made, but I am not certain that I shall be able to carry these out in the near future. The difficulties in the way of securing adequate control of current when high amperages are used are greater than may appear to the casual reader.

KNIGHT DUNLAP
JOHNS HOPKINS UNIVERSITY,
December 20, 1910

THE GERM CELL DETERMINANTS IN THE EGGS OF CHRYSOMELID BEETLES

PARTS of my papers on "The Origin and Early History of the Germ Cells in Some Chrysomelid Beetles,"[1] and "The Effects of Removing the Germ Cell Determinants from the Eggs of Some Chrysomelid Beetles"[2] have recently been subjected to criticism,[3] which, it seems to me, needs some analysis. I have shown in these papers that a disc-shaped mass of darkly staining granules appears at the posterior end of the eggs of certain chrysomelid beetles just before deposition. Because of the shape of this mass and its position in the egg, I have called it the "pole disc." During the formation of the blastoderm, those cleavage products which, in their progress toward the periphery, encounter the pole disc granules, gather these about themselves and continue their migration, finally becoming entirely separated from the egg. They then lie in a compact group at the posterior end. These are the primordial germ cells; they can be traced back into the embryo, where they separate into two groups which become the germ glands. The conclusion was reached that the cleavage products "are potentially alike until in their migration toward the periphery they reach the 'keimhautblastem.' Then those which chance to encounter the granules of the pole disc are differentiated by their environment, *i. e.*, the granules, into germ cells; all the other cleavage products become somatic cells" (1908, p. 21).

[1] *Journ. Morph.*, Vol. 20, 1909, pp. 231–296.
[2] *Biol. Bull.*, Vol. 16, 1908, pp. 19–26.
[3] Wieman, H. L., "The Pole Disc of Chrysomelid Eggs," *Biol. Bull.*, Vol. 18, 1910, pp. 180–187.

It was found to be possible to remove the pole disc from freshly laid eggs by pricking the posterior end with a needle and allowing them to flow out. Eggs operated upon in this way produced embryos and larvæ either without germ cells or with only a few. This experimental evidence, added to that derived from the morphological study, seemed to prove that the pole disc granules were necessary for the production of the primordial germ cells and, in fact, determined them as such. This led to the conclusion that the "granules of the pole disc are therefore either the germ cell determinants or the visible sign of the germ cell determinants" (1908, p. 21). Recent experiments give additional evidence. When the posterior ends of freshly laid eggs are killed with a hot needle, thus preventing the pole disc from taking part in development, no germ cells are produced in the embryos and larvæ which develop from them.

Wieman objects to the term "germ cell determinant" since "the term implies the attribute of certain potentialities that these granules have not been shown to possess" (1910, p. 180). He also objects to my hypothesis that the pole disc granules consist of chromatic material extruded by the nucleus of the oogonium, and claims that "the granules of the pole disc consist of particles derived from the food stream of the ovum that form an accumulation of the protoplasm in its posterior part" (1910, p. 187). This is no doubt correct. I did not attempt to discover the origin of these granules, but concluded that they were of nuclear material because of the derivation of similar substances in the early development of *Ascaris, Cyclops* and a number of insects. According to Wieman, "the granules are not all taken up by the cells in their migration and the greater part of them remains behind after the cells have passed through" (p. 186). This is certainly not the case in the four species of beetles that I have used in my work.

Wieman suggests several possibilities as to the ultimate origin and significance of the pole disc granules. These possibilities were