"all they are worth to the community." He even goes so far as to assert that few of these "audible books," as he calls them, benefit the community so much as the average clerk, because "their efforts are not directed and coordinated" as are those of the clerks.

Without disparagement of merchant or clerk, it is to be remembered that it is largely by the guidance of those who perform such service as that of Professor Blank that we progress toward the true state of Nirvana on earth. If the real value of these teachers and researchers were estimated by what America would conceivably be without their intangible, spiritual contributions, not to mention what their discoveries have added to life's comfort, convenience, length and strength, their wages would be incalculably augmented. If for "Professor Blank" were written, for example, "Professor Joseph Henry," is there any salary that would be quite adequate to pay civilization's debt to this Albany schoolmaster and Princeton professor? The tinkle of the tiny bell that he first rang by electricity is soon to be heard by radio around the world. But the influence of many a professor is felt as widely. His merchandise is "better than silver." His "minervals," as his wisdom fees were called in ancient times, should, however, be sufficient to permit him to remain where he can give the highest service to the community.—*The New York Times.*

SCIENTIFIC BOOKS

Labyrinth and Equilibrium. Monographs on Experimental Biology. By S. S. MAXWELL. 163 pp., Philadelphia and London: Lippincott, 1923.

IT should be sufficient, for the purposes of most reviews, to be able to say that the book had been written by one who had actually worked at the problems discussed and who had contributed many illuminating facts in a subject which has been obscure since the first pioneer entered the field. I can say this of the volume now under discussion. The author's own work, so lucidly described in the pages of this book, has given us a clearer idea than we have had of the mechanism of stimulation of the afferent nerve endings in the non-auditory portion of the internal ear.

Goltz stated the general problem of the function of the non-auditory or vestibular portion of the internal ear nearly two generations ago. Three things are necessary: (a) The peripheral receptor and the afferent nerve; (b) the central nervous system, and, (c) the efferent nerves, together with their effectors—the skeletal and various other muscles in the case of the present mechanism. The book deals, for the most part, (a) with the relation of the labyrinth to forced or abnormal positions of the organism, and to the compensatory positions which follow the displacement of the animal from its normal position and, (b) with the general mechanism of stimulation of the vestibular endings. These phases of the subject are handled with all the clearness which our present knowledge of the subject permits.

The final chapter is on nystagmus, the pecular ocular movements resulting from vestibular stimulation; the slow movement in one direction, say to the right, and a quick movement in the opposite direction. Nystagmus is due to some mechanism or mechanisms in the central nervous system—the second part of the problem as Goltz formulated it—and it should not be considered as a reflection upon the book to say that here the author's hand is a little less sure. Nor is it to be taken as a sign that the author is wrong when I say that he does not wholly accept some of the opinions of the reviewer. The problem of the functional organization of the nervous system is one of the most complicated and perplexing which the biologist has to face, and no one has yet given a clear and intelligible statement of the organization of the whole mechanism for the performance of any single function, nystagmus included. This should be a sufficient apology for any lack of certainty of conclusions in the author's final chapter.

Although it is not my purpose to review it here, I wish to mention another recent volume on the vestibule, written by a psychologist.[1] Maxwell's volume deals principally with the purely objective side of vestibular stimulation. Griffith deals with the subjective or psychological side of some common vestibular effects. In addition to giving the most complete bibliography of the subject of which I am aware, he has some remarks upon some common opinions of vestibular phenomena upon which neither fact nor argument has as yet made much impression.

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SPECIAL ARTICLES

A NEW PHOTO-ELECTRIC EFFECT

REFLECTION OF ELECTRONS INDUCED BY LIGHT

A STUDY of some vacuum tubes containing caesium vapor has shown a peculiar photo-electric effect. The action of white light on an adsorbed film of caesium on nickel seems to cause this surface to reflect elastically electrons which are made to impinge on it. The number of electrons that can be thus reflected is proportional to the intensity of the light.

Two nickel cylinders, B and C, open at the ends, were mounted end to end along the same axis, being but slightly separated from one another. Inside of

[1] Griffith, Coleman R.: "An historical survey of vestibular equilibration," pp. 178. University of Illinois Bulletin, XX, No. 5, 1922.

cylinder B was a small tungsten filament A, used as a source of "primary" electrons. The tube containing these electrodes was exhausted to a high vacuum and some caesium was distilled into it before sealing off. Because of the adsorbed film of caesium on the tungsten, electron currents of convenient magnitude (50 micro-amperes) could be obtained at filament temperatures below a red heat (Langmuir and Kingdon, SCIENCE, *57*, 58 (1923)).

By placing a 200-watt Mazda lamp near the tube, so that some light entered the open end of cylinder C, photo-electric effects of two kinds were observed. The *first* was the *normal* photo-electric effect due to an adsorbed film of caesium on the cylinders. If either cylinder was made 40 volts or more negative with respect to the other, a current of electrons of a fraction of a micro-ampere passed from the negative to the positive cylinder under the influence of the light. By varying the voltage on the lamp it was found that this photo-electric current was proportional to the intensity of the yellow component of the white light (6000 A°). The photo-electric current was only cut down to about 1/10th by interposing a piece of deep red glass.

The *second* effect produced by light was observed only when B and C were both at positive potentials with respect to A and the filament A was heated sufficiently to emit electrons. The effect was manifested by an electron current flowing to C (through the space) which could not be accounted for by the normal photo-electric effect and which continued to flow to C even when the potential of B was much higher than that of C.

TYPICAL PHOTO-REFLECTION DATA

Tube at Room Temperature

$E_C=100$ volts $E_B=60$ volts $I_A=21.8$ microamperes

Volts on Lamp	Light Intensity	Current to C micro-amperes	Normal Photo Effect micro-amperes	Photo Reflection micro-amperes
V_L	L	I_C	I_N	Δ
0	0	0.14	0.000	0.00
40	5	0.18	0.000	0.04
50	18	0.28	0.001	0.14
60	50	0.52	0.002	0.38
70	98	0.87	0.005	0.72
80	172	1.21	0.010	1.06
90	266	1.26	0.016	1.104
100	385	1.28	0.024	1.116
110	540	1.30	0.037	1.123
120	730	1.32	0.055	1.125
130	960	1.36	0.103	1.12
140	1200	1.39	0.130	1.12

Typical data illustrating this effect are given in the table. The cylinders B and C were maintained at potentials of 60 and 100 volts respectively, these being measured from the filament A. This filament was heated to such a temperature that the emission from it was 21.8 micro-amperes.

Since this total emission was always uninfluenced by the amount of light entering the tube, the observed effect is not due to any variation in the electron emission from the filament. The light, however, did cause a change in the distribution of the current between the two cylinders, as indicated by the data in the third column, which gives the current to the cylinder C. In the absence of light a current of only 0.14 micro-amperes of electrons flowed to C, while the remainder flowed to B. This small current to C was, however, due to electrons reflected from the surface of B rather than electrons coming directly from the filament.

The first column gives the voltage applied to the Mazda lamp whose rated voltage was 120. The second column gives in arbitrary units the relative light intensity of wave length 5300 A°, calculated from the filament temperature by Wien's law for radiation.

It is seen that the current to C increased with the intensity of illumination at first rapidly, but then approached a nearly constant limit. A part of this current, however, is due to normal photo-electric current. Column 4 gives the current I_N to the electrode C, due to this normal effect. This was observed by lowering the filament temperature to any point lower than that at which it ceased emitting electrons.

Column 5 contains the quantity $\Delta = I_C - 0.14 - I_N$, which is that part of the *increase in current to C which is caused by light and which can not be accounted for as a normal photo-electric effect.*

This increase in current Δ varies at first in proportion to the light intensity L, but then becomes constant while the light intensity increases from 385 to 1200.

A large number of such runs were made with this tube, varying such factors as the voltages on B and C, the temperature of A, and the bulb temperature, and, therefore, the vapor pressure of caesium. The effect of transverse and longitudinal magnetic fields was also studied.

The results indicated that *below a certain light intensity,* which, however, varied with the conditions, *the quantity Δ is proportional to L, and in this range the ratio of Δ to L is entirely independent of the voltages on B and C, the electron emission from the filament, the bulb temperature or the presence of a magnetic field.*

On the other hand, with light intensities *above a certain limit* (not much greater than the limit previously referred to), *the quantity Δ is independent of L, but depends on each of the factors already enumerated.*

Thus by plotting Δ against L a family of curves is obtained which has as an envelope a straight line passing through the origin. If the light intensity is kept constant and the electron emission from A is increased from 0 to a large value, Δ increases at first with the emission (with the 1.6*th* power of it in one set of experiments) and then becomes constant when Δ/L has reached its limiting value.

These relationships are in many ways analogous to those in electron tubes where the current is in general limited either by emission from the cathode or by space charge, depending upon which limit has the lower value. Similarly, we may assume that the photo-electric reflection may be limited either by the number of electrons that strike the electrode, or by the amount of light reaching the electrode.

Although all the characteristics of this effect are not yet understood, it seems safe to assume that the effect is caused by an activation of an adsorbed caesium film by light, the atoms in this film being brought to such a state that they cause the impinging electrons to make elastic collisions.

The effect disappears if the voltage of either B or C is brought to zero. When the voltage E_C is less than E_B the normal photo-electric effect reverses in direction, but Δ does not do so. The limiting value of Δ for sufficiently high values of L, which we may call Δ_L, is greatest when E_C is considerably larger than E_B. Thus with $E_C = 100$, $E_B = 60$, and $I_A = 26$, Δ_L had a value 2.9, while for $E_C = 20$, $E_A = 100$, and $I_A = 47$, Δ_L was 0.07. The fact that the effect still existed under the latter conditions proves that several per cent. of the electrons which are reflected from B lose not more than 20 per cent. of their energy.

With E_B kept at 20 volts, Δ_L was 1.4 for $E_C = 20$, and it steadily increased as E_C was lowered below this point, until, at $E = 5$ volts, there was a sharp maximum ($\Delta_L = 3.3$). Another even greater maximum of $\Delta_L = 4.2$ occurred at $E_C = 1.1$ volt. At $E_C = 0.5$ volt the effect fell abruptly to zero.

A sharp distinction between the new photo effect, measured by Δ, and the normal effect I_N, is that the new effect disappears entirely if a piece of red glass is interposed in front of the light source, Δ falling at least to 1/1000th of its original value, whereas the normal effect decreases only to about one tenth.. It is probable that the effect is mainly due to light having a wave length of about 5300 A° (blue-green).

A similar activation of a nickel surface causing electron reflection has also been found in connection with some measurements of the distribution of velocities of electrons in the positive column of the mercury arc, by a method like that described recently for measuring positive ion currents. (Langmuir, Science, *58,* 290 (1923)). By introducing high speed electrons (40 volts) into the mercury arc by means of a heated negatively charged tungsten filament, it was found that the ability of a small collecting electrode (1 sq. cm area) to take up low speed electrons was greatly impaired.

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THE ABNORMAL REFLECTION OF X-RAYS BY CRYSTALS

In recent papers[1] we have described experiments which show that under certain conditions a crystal of potassium iodide deflects x-rays in a way that does not obey the ordinary laws of x-ray reflection. The discovery and extensive study of these abnormal reflections, called x-peaks, were made by means of ionization spectrometers. A number of experiments demonstrated that the x-peak reflections vanished when the voltage fell below the critical voltage required to produce the K series lines of iodine. From this we conclude that the abnormally reflected rays consisted of the characteristic line spectrum excited by the primary x-radiation in the iodine atoms of the reflecting crystal itself. The angle of reflection from the crystal depended in a complicated way upon the angle of incidence of the primary rays, and the phenomenon can not be regarded as ordinary reflection from any single set of crystal planes. We took special care to prevent rays regularly reflected by the various sets of planes from entering the ionization chamber.

We published in the *Journal* of the Optical Society (*l.c.*) the reproduction of a photograph taken in such a way as to show the x-rays defracted by the crystal of potassium iodide. The primary x-rays in this case passed through the crystal parallel to an axis. Four spots, in addition to that due to the direct beam of x-rays, appeared on the photograph in positions corresponding with the data obtained for the x-peaks by the ionization spectrometer. Thus the existence of the x-peak reflection was confirmed by the photographic method.

A letter from the Geophysical Laboratory has appeared in Science recently (July 20, p. 52) written by Mr. R. W. G. Wyckoff, in which he briefly describes experiments with a potassium iodide crystal and a photographic plate. The very excellent copies of these photographs, which he has been kind enough to send us, show no spots that can be attributed to the abnormal x-peak reflection. We thought it best to delay comment on this letter until we could make

1 *Proc.* Nat. Acad. Sci., 8, 90 (1922); 9, 131 (1923); *Jour.* Optical Soc., 7, 455 (1923).