## Letters to the Editor.

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### Amplifying the Optophone.

IT may be of interest to record some experiments that I have recently been making on the application of a thermionic amplifier to increase the volume of the sounds produced by Dr. Fournier d'Albe's very wonderful optophone so as to render these sounds audible to everyone in a room without the necessity of each listener being furnished with a separate telephone receiver.

The experiments were carried out at the instance of Mr. J. M. McCarthey, who is teaching blind soldiers to read with this instrument, and who asked me whether it would not be possible to magnify the sounds sufficiently to enable a class of a dozen or more to hear them simultaneously.

The Fournier d'Albe optophone instrument employed was one of the improved type designed and manufactured by Messrs. Barr and Stroud, and the amplifier I found to work best out of several I tried was an audio-frequency one with three "R" valves, transformer-coupled, of the French military type. This was used with a Brown loud-speaking telephone with considerable success.

In Mr. McCarthey's opinion, and so far as a person such as myself, who has no experience with the optophone, could judge, the best results were obtained when the optophone was arranged for what is technically known as "black sounding," when the white paper is represented by silence and notes are sounded as the beam of light passes over the black letters.

I have very little doubt that still better results could be obtained with an amplifier specially designed for the purpose. Further experiment is desirable in order to obtain the best results, but, so far, what has been accomplished is quite encouraging.

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### Molecular and Cosmical Magnetism.

DR. CHAPMAN'S important letter (NATURE, November 25, 1920) bases a theory of cosmical magnetism on the presence of gyroscopic magnetic elements proved to exist in ferro-magnetic substances by my investigations on magnetisation by rotation. But he considers my fundamental theory to require serious modification. As I understand his letter, however, his theory is identical with mine (see *Science*, vol. xlviii., p. 304, 1918, and references) except as to paramagnetic and diamagnetic bodies. He has, I think, confused my treatments of magnetic intensity and intensity of magnetisation.

While in my papers electron rings or orbits have been assumed, the fundamental theory is essentially the same if ring electrons or magnetons of other types, preferable for Dr. Chapman's purpose, are assumed instead; and I have referred to this equivalence before the Physical Society and elsewhere.

The gist of the theory is this: A magneton or electron orbit, being a gyroscope, tends to take an orientation with the direction of its revolution coincident with that of any rotation impressed upon it. Being a magnet, it also tends to set with its axis parallel to an impressed magnetic intensity. Ultimate coincidence in either case may be prevented by extraneous forcives. But, in given circumstances, whatever the forcive towards alignment, and whatever alignment of the magneton is produced by a magnetic intensity, H will be produced by rotation about the direction of the intensity with velocity $\Omega = H/R$, where R is the ratio of the angular momentum of the magneton to its magnetic moment. The general idea has been applied to cosmical magnetism by Schuster (1912), by Einstein and by de Haas (1915), and by myself (1909 and 1915), though not with Dr. Chapman's detail.

*If all the magnetons within a body are alike,* rotating it at velocity $\Omega$ will produce the same magnetisation as would be produced by applying a uniform magnetic field of strength $H = R\Omega$.

For weak fields the ferro-magnetic bodies rotated all receive intensities of magnetisation proportional to the intensities of the fields applied, and are thus *magnetised* by rotation proportionally to velocity. This proportionality exists only for elastic displacements to which Dr. Chapman refers (and to which I have referred, comparing the molecular forces to those due to springs).

*If the magnetons in a body are of two kinds,* positive and negative, with constants $R_1$ and $R_2$, rotating the body will have the same effect as if a magnetic intensity $H_1 = R_1\Omega$ were applied to the positive magnetons and an intensity $H_2 = R_2\Omega$ were applied to the negative magnetons. If the effect on the negative magnetons is preponderant, the rotation will thus produce an intensity of magnetisation in the direction of $H_2$, but of magnitude less than that which would be produced by the intensity $R_2\Omega$ if all the magnetons were negative.

When the displacements are not elastic my theory gives results analogous to those of Voigt for a swarm of magnetons in an ordinary magnetic field. If there are N similar magnetons per unit volume, if the rotations are damped only about the axes perpendicular to the magnetic axis, and if the effects of collisions and the molecular field are negligible, all the magnetons, even in the weakest magnetic field of strength H, will ultimately become oriented with their axes in the direction of the field. In this case, if C and U denote the moment of inertia and initial (permanent and undamped) angular velocity about the magnetic axis of a magneton, the intensity of magnetisation will be

$$I = NC/R.(U - H/R).$$

The first and principal term is entirely independent of H. The orientation is produced by the field, but only the time taken to arrive at the steady state is affected by its magnitude. If collisions are not absent, or the molecular field becomes appreciable, the intensity of magnetisation will not reach saturation, but will increase with the field strength, being greater for a given applied field strength the greater the time between collisions and the weaker the molecular and demagnetising fields.

For the same swarm of magnetons subjected to an angular velocity $\Omega$ instead of a magnetic field with intensity H, we have, when the effects of collisions and the molecular and demagnetising fields are negligible,

$$I = NC/R.(U + \Omega).$$

The first and only important term is independent of $\Omega$. Here the orientation is produced by the velocity