cavity is complicated so that parts of it act with some degree of independence, the vibrations will be of the form (2) with values for $a$, $\epsilon$, and $T$ different from those for the larynx. The result of the action of one puff from the larynx will be a double sum of the form expressed in equation (2), where $a$, $\epsilon$, and $T$ have independent values in the two sums.

The actual molecular movement for a vowel likewise consists of the sum of frictional sinusoids from the larynx plus the sum from the vocal cavities.

Such a function has three sets of independent variables and cannot be analysed by any method now known. Even the most accurate curves of a vowel cannot be directly analysed for just this reason. The physical movement itself cannot be analysed by any apparatus, even by a resonance organ in the ear if we had one.

The piano experiment quoted by Mr. Wilkinson in NATURE of May 31, p. 781, demonstrates that piano strings respond only when *not* damped (the fibres of the basilar membrane are heavily damped); that even undamped strings respond only to a few vowels when they are prolonged on a constant tone; that they respond with confused noises to vowels sung portamento; and that they fail to respond to short spoken vowels. As Mr. Wilkinson recognises, the statement "that sounds containing [damped] inharmonic partials are incapable of being completely resonated" would, if true, "completely dispose of the resonance theory of hearing." This is the crux of the whole matter. If my brief statement is not clear, I hope the mathematicians will do better. For the microscopic anatomy of the ear, reference can be made to Prof. Kolmer's section in Alexander and Marburg's "Neurologie des Ohres."

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## Darwin and Evolution.

MAY I briefly comment on a paragraph in "Current Topics and Events" on p. 866 of NATURE of June 14? The writer of the note, who is evidently an authoritative biologist, expresses himself with more vigour and certainty than I should have ventured on in an alien though admired subject. My claim is that some mental or psychic activity or influence can be inferred from the facts of evolution; but to step from that to the influence and purpose of a Mind with a very big M—though a step natural to faith—is a greater stride than I suppose science alone can ever take: for the intermediate grades of intelligence are perhaps infinite.

In my *Spectator* letter of May 31, on which the note comments, I trust I was not improperly critical of the work of the greatest naturalist. To compare any one with Copernicus, and even guardedly with Newton, is surely eulogistic so far as can be reasonable and right.

OLIVER LODGE.

June 14.

## A Method of increasing the Effective Sensitiveness of Galvanometers, etc.

REQUIRING recently to increase the sensitiveness of a mirror galvanometer, I found the following optical method very satisfactory. I have not seen it described previously, but in any case it seems worth while to make it more widely known.

Let the light from a vertical lamp-filament be reflected by the concave galvanometer mirror to a focus in front of a short-focus concave mirror at the principal focus of the latter. The beam is thus reflected again as a parallel pencil, and can be observed by the telescope of a spectrometer. The short focus mirror is mounted on the table of the spectrometer. Instead of a concave mirror a convex lens can be used and the transmitted parallel beam observed, or a convex mirror or a concave lens may be placed similarly between the galvanometer mirror and the focus of the original reflected beam.

If the distance of the galvanometer from the mirror (or lens) is $a$, large compared with the focal length of the latter, $f$, if $d\phi$ is the deflexion of the galvanometer mirror and $d\theta$ the angle through which the spectrometer telescope has to be turned to keep the final reflected beam in view, then $d\theta = \frac{2a\,d\phi}{f}$, if the galvanometer mirror lies on the principal axis of the mirror or lens. In practice this is impossible in the case of the mirror, and if $\phi$ is the angle of incidence the formula becomes $d\theta = \frac{2a\,d\phi}{f\cos\phi}$.

Such a magnification is sufficient for many purposes, but the process may be repeated if necessary. Instead of a parallel final beam one uses a slightly convergent one, and allows it to fall on a second short-focus mirror or lens, under conditions similar to those in the first stage of magnification.

Since the beam reflected by the galvanometer mirror is afterwards dealt with as a whole, there is no loss of light save through the imperfections of polish and form of the accessory lenses or mirrors, and it is easy to work in a well-lighted room. The resolving power of the system, with two stages of magnification, is obviously low, but the final image of the filament is still sharp enough for settings to be made to the nearest minute on the spectrometer scale without special precautions.

A few illustrations may be of interest. A galvanometer which gave a deflexion of 1 mm. per $7\cdot2 \times 10^{-9}$ amp. on a scale at a distance of about 90 cm., when used in the ordinary way, showed a telescope deflexion of 1′ per $4 \times 10^{-11}$ amp. when a 1 inch objective taken from a travelling microscope was set up as described on the spectrometer table at the same distance as the scale. Under ordinary conditions, the ballistic throw was 1 mm. for $1\cdot9 \times 10^{-8}$ coulomb: with the lens, 1′ corresponds to $1 \times 10^{-10}$ coulomb. This means that a throw is observable when a coil of a single turn, 7 cm. in diameter, is connected to the galvanometer and turned over in the earth's field. Capacities of the order of 0·001 mfd. can be compared with an accuracy of about 5 per cent. using an ordinary accumulator as the source of potential difference.

The method is obviously available for any type of instrument in which small angular displacements are to be observed or measured.

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June 6.

## Comparison of Wave-lengths with a Fabry and Perot Étalon.

IN investigations on the accurate measurement of wave-lengths by means of a Fabry and Perot étalon, it is possible to obtain the desired values without the necessity of measuring the focal length of the optical system. In such work as carried on by Rayleigh (*Phil. Mag.* 11, 685, 1906), Fabry and Perot (*Astrophys. Jour.* 15, 73, 1902), Eversheim (*Astrophys. Jour.* 26, 172, 1907), Pfund (*Astrophys. Jour.* 28, 197, 1908), Brown (*Astrophys. Jour.* 56, 53, 1922), and others, use is made of the relation

$$\frac{\lambda}{\lambda'} = \frac{p'}{p}\left(1 + \frac{x'^2}{8} - \frac{x^2}{8}\right), \quad . \quad . \quad . \quad (1)$$

where $\lambda$, $\lambda'$ are the two wave-lengths to be compared;