The application of Fermat's Principle to paths through non-aplanatic systems generally involves a lengthy mathematical procedure. A relatively simple case is that in which the end-points are on the axis of a refracting sphere. When the end-points are equidistant from the sphere, the actual non-axial paths are merely stationary while the corresponding axial paths are minima.

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¹ NATURE, **133**, 830; 1934. ³ Dublin Univ. Review, p. 795, Oct. 1833. Mathematical Papers, 1, 311; 1931. ⁴ Drude, "Theory of Optics", 9-11; 1902.

In the wave theory of light, the 'geometrical' laws of optics-rectilinear propagation, reflection and refraction-and other results besides, rest on a single principle. The fundamental postulate is that any train of waves may be replaced by a sheet of sources of suitable intensities and phases, that is, paths such as APCB of Fig. 1 of Mr. Darbyshire's letter are to be taken into consideration equally with paths like AQDB. Of all possible paths, the 'rays' of geo-metrical optics are found to be stationary paths and so suitable for phase calculations; this is the essence of Fermat's Principle.

Of the specific objections Mr. Darbyshire raises, the first rests on an unnecessary restriction of 'image'. By this term we ought to understand any point where the wave system exhibits a singularity; this normally corresponds to the re-intersection of any two neighbouring rays arising from the same object point. As regards the second, I have assumed the stationary property throughout, and the reasoning used is, I think, generally applicable with a symmetrical system. As to the third objection, which has been mentioned by other physicists also, it may be observed that, according to geometrical optics, APR and AQR are the only possible paths between A and R for a single reflection, and the labelling of two isolated paths as a minimum and a maximum seems to me inappropriate in any case. Taking the more general view of the wave-theory, the mistake to which I directed attention is due to the neglect of the Jacobi test¹ for the existence of maxima and minima. The need for this test can be formally shown by considering the lengths AP and PR of Fig. 2, which, as Mr. Darbyshire mentions, are the minimum paths from P to A and R. The statement that the path APR is a maximum then takes the form

minimum + minimum = maximum,

which is obviously false.

T. SMITH.

¹ Forsyth, "Calculus of Variation", pp. 26, 134, etc.

Points from Foregoing Letters

RADIOPOTASSIUM (atomic mass 42) has been made from potassium atoms of mass 41 and from scandium atoms of mass 45 by bombarding them with neutrons. It has now been obtained by Prof. G. Hevesy and Miss Hilde Levi, in the same manner, from calcium atoms of mass 42. These investigators have also prepared radioactive isotopes of calcium, zirconium and hafnium from the corresponding elements.

Prof. H. Alfvén and Mr. V. H. Sanner have obtained ultra-violet light of very short wave-lengths (down to 21A., on the borderland of X-rays) from a spark discharge between graphite electrodes.

The relation between the intensity of the field applied and the magnetic induction produced in lead-thallium and lead-bismuth alloys at very low temperatures (when their electrical resistance approaches zero) is described by Messrs. J. N. Rjabinin and L. W. Shubnikow. They show that above a certain field strength the alloys lose their 'supraconductivity'.

Contrary to theoretical expectations, the duration of luminescence of fluoresceine in water and in alcohol was found to be greater than in glycerine. Dr. A. Jabloński and Mr. W. Szymanowski consider that this unexpected behaviour can be explained by the rotation of the molecules.

Mr. J. E. Carruthers and Dr. R. G. W. Norrish report that the presence of a small amount of formic or acetic acid quickens the condensation of gaseous formaldehyde to its solid polymer (known com-mercially as 'meta'). They act in a similar way upon acetaldehyde vapour.

Mr. S. M. Neale finds that the addition of salt to oxicellulose liberates its acidic hydrogen ion. The action can be made use of in the quantitative estimation of the acidity of oxycellulose.

The anomodont or dicynodont reptiles differ from all the other mammal-like reptiles, in having no teeth in the premaxillary bones. The discovery of a fossil type which has teeth in the premaxillaries is reported by Prof. R. Broom. It helps to bridge the gap between the several known families of reptiles.

Mr. S. D. Rossouw finds a close proportionality between the percentage of cystine and of protein in grass in South Africa throughout the year. The sulphur compound, cystine, is a constituent of sheep's wool

Messrs. F. T. Farmer and J. A. Ratcliffe have determined the average frequency of collisions between electrons and molecules in the F_2 region of the ionosphere (about 300 km. high). Their experiments were carried out at times of the day when the absorption of the reflected waves by the E region (about 100 km. high) does not change with time, a precaution which, they state, Mr. Eckersley did not take when he measured the collisional frequency of electrons in the F_1 region (about 200 km. high).

Working with dialysed muscle extracts, Dr. D. M. Needham and Mr. W. E. van Heyningen confirm the findings of Prof. Parnas and his co-workers that adenylic acid and creatine are essential intermediaries in the reaction by which the muscle obtains its energy from the transformation of glycogen into lactic acid.

Mr. O. Darbyshire criticises the illustrations given by Mr. T. Smith, who has claimed that Fermat's principle requires an optical path to be stationary only, and not necessarily a maximum or a minimum. Mr. T. Smith, in replying, justifies his consideration of non-linear optical paths in his variational treatment, by reference to the extended Huygens' principle.