Three examples have been given by him, all very neat. Writing for shortness the differential equations thus—

Circle, R = o; *Parabola*, S = o; *Conic*, T = o,

he has proved (in Journ. As. Soc. Bengal, vol. lvi. p. 144, and NATURE, vol. xxxviii. p. 173) that in general *in any curve* whatever,

(1) Tan. ∠ of aberrancy = q_1 . R;
(2) Index of aberrancy = q_2 . S;
(3) Radius of curvature of aberrancy curve = q_3 . T;

where q_1, q_2, q_3 are certain functions in general finite. Hence the geometric meaning of the differential equations of the three curves is at once

(1) *Circle.*—Angle of aberrancy = o
(2) *Parabola.*—Index of aberrancy = o
(3) *Conic.*—Radius of curvature of aberrancy curve = o
} right round all curves of each family.

The verbal neatness of these interpretations can hardly be excelled.

A writer (R. B. H.) in NATURE, vol. xxxviii. p. 197, objects to the last that it really only means that *a conic is a conic* (because its aberrancy curve shrinks into the centre)! Now, this is precisely what was to be expected: the differential equation of a curve expresses *exactly* that the curve of some family which osculates it in the highest degree is *the curve itself*. But the new interpretation puts this in a neat form, viz. in assigning a *meaning* to the magnitude F, which differs from zero in general, and whose vanishing at all points of every curve of a certain family (say conic) indicates a property of high generality of those curves.

But the Professor makes, what I conceive to be, the mistaken claim (Proc. As. Soc. Bengal, 1888, p. 75, *et seq.*), that this mode of interpretation is the *only true one;* and further that, accepting this mode of interpretation, *only one meaning* can be attached to it (p. 76, l. 29, *op. cit.*).

Now it must be observed that the equation F = o implies *directly*, not only that some one geometric magnitude F vanishes, but also that every geometric magnitude vanishing with F (such as aF, $a\mathrm{F}^m$, *sin*F, &c.) vanishes right round every curve of the family. All of these are equally good geometric interpretations *of the same kind* as proposed.

But the equation F = o also implies, more or less directly, countless theorems of position, osculation, &c. All of these may be fairly considered geometric meanings of that equation. Thus, attending to the meaning of "aberrancy," the results quoted involve directly—

(1) *Circle.*—Normal coincides with diameters.

(2) *Parabola.*—Diameters are axes of aberrancy, and meet at infinity.

(3) *Conic.*—Diameters are axes of aberrancy, and are concurrent (in the centre).

Surely these are also *true* geometric interpretations.

Lastly, let the equation F = o be multiplied by any of its integrating factors μ, and write for shortness $\int \mu \mathrm{F} dx = \phi$. It follows that ϕ = constant. Hence, since the number of integrating factors is infinite, another (indirect) geometric interpretation arises, viz. that all the geometric magnitudes ϕ are constant right round every curve of the family.

These latter *general* modes of interpretation, viz. theorems of position, osculation, and of first integrals ($\phi = c$), I had given eleven years ago (in *Quart. Journ. Math.*, vol. xiv. p. 226).

To the last of these the Professor has objected (p. 76 of his paper quoted), that it is not an interpretation of the equation F = o at all, but only of its first integrals $\phi = c$. This is, of course, admitted. But it is worth noting that the connection between the two, F = o, $\phi = c$, is so very close, that many will accept an interpretation of the latter as a fair (indirect) interpretation of the former also.

In fact, since F = o is equivalent to $\mathrm{D}_x\phi$ = o, the former is now seen to mean *directly* that there is no variation of any of the magnitudes ϕ right round every curve of the family; and this is a strict *direct* interpretation of the equation F = o itself. But many will probably prefer the shorter phrase ϕ = constant, even though it interprets F = o only indirectly.

There is, moreover, a *slight* disadvantage in the former mode of interpretation, viz. that the meaning of the magnitude F must necessarily be sought in curves other than, and *usually more complex* than, the curves denoted by F = o; whereas the interpretation of $\phi = c$ only requires the finding a meaning for ϕ, which is explained in my paper quoted to be any fundamental geometric magnitude *of the curve itself*.

ALLAN CUNNINGHAM, *Lt.-Col., R.E.*

British Earthworms.

THE occurrence of any new animal in England is a point of some interest, however humble that animal may be; and, in order to work out the species of British earthworms, I sent a letter to the *Field* some time back, requesting readers of that journal to forward me specimens. In reply I received a large number of worms from various people, amongst them being Mr. F. O. Pickard Cambridge, of Hyde, who has very kindly sent me several parcels of worms. One of these parcels contained some very fine gravel taken from the bed of a stream, together with a number of small worms about $1\frac{1}{2}$ to 2 inches in length. These turned out to be a species of *Allurus*, a genus formed by Eisen for a worm in which the male pores are on the thirteenth segment instead of on the fifteenth, as in the other genera of the family Lumbricidæ. Only one species is at present known, viz. *A. tetraëdrus;* it is of a beautiful sienna colour, with a dull orange clitellum.

I wish to record, for the first time, its occurrence in England, and also to draw attention to the fact that it lives below water, at any rate for some part of the year. Mr. Cambridge has been most obliging in giving me the facts as to the place in which he found the worms: they occur in the gravelly bed of a stream which at certain times of the year runs down so low as to leave small gravelly islands 2 or 3 inches high. In these islands he found *Allurus;* but he finds none in the banks of the stream. We already know of *Criodrilus* as being a thoroughly aquatic earthworm, living in the muddy beds of rivers and lakes; and although this worm has not yet been recorded in Great Britain, I see no reason to doubt that it exists here.

I should add that Mr. Beddard has informed me that he received a specimen of *Allurus* from Lea, Kent, some time after I received these from Hyde. It has been recorded also from Sweden, Italy, and Tenerife.

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THE SUN MOTOR.

INDIA, South America, and other countries interested in the employment of sun power for mechanical purposes, have watched with great attention the result of recent experiments in France, conducted by M. Tellier, whose plan of actuating motive engines by the *direct* application of solar heat has been supposed to be more advantageous than the plan adopted by the writer of increasing the intensity of the solar rays by a series of reflecting mirrors. The published statements that "the heat-absorbing surface" of the French apparatus presents an area of 215 square feet to the action of the sun's rays, and that "the work done has been only 43,360 foot-pounds per hour," furnish data proving that Tellier's invention possesses no practical value.

The results of protracted experiments with my sun motors, provided with reflecting mirrors as stated, have established the fact that a surface of 100 square feet presented at right angles to the sun, at noon, in the latitude of New York, during summer, develops a mechanical energy reaching 1,850,000 foot-pounds per hour. The advocates of the French system of dispensing with the "cumbrous mirrors" will do well to compare the said amount with the insignificant mechanical energy represented by 43,360 foot-pounds per hour developed by 215 square feet of surface exposed to the sun by Tellier, during his experiments in Paris referred to.

The following brief description will give a clear idea of the nature and arrangement of the reflecting mirrors adopted by the writer for increasing the intensity of the solar heat which imparts expansive force to the medium propelling the working piston of the motive engine. Fig. 1 represents a perspective view of a cylindrical heater, and a frame supporting a series of reflecting mirrors composed of narrow strips of window-glass coated with