method is described in a text-book, its advantages will become more generally known.

Mr. Brough deserves much praise for the care with which he has searched European and American publications so as to bring his work up to date, and there is little call for censure save upon minor points which do not affect the general value of the text-book.

It is time that some one should enter a protest against two of the technical terms defined by the author, and frequently met with in the reports of mining experts, viz. "country rock" and "gangue." To say "country rock" is tautology. The word "country" alone, as used in Cornwall, means "surrounding rock" or "enclosing rock," and, if the provincialism is to be adopted, there is no necessity to add the word "rock." The word "gangue" is objectionable, because it has come to us through Frenchmen, who apparently did not thoroughly understand the meaning of the German word "Gang." "Matrix," "lodestuff," and "veinstuff" are better words than "gangue," which might well be allowed to drop out of mining books, especially as it is rarely heard at mines.

To cite the china clay deposits of Cornwall as examples of *stockworks* is unfortunate, because the occurrence in them of veins bearing workable quantities of tin ore is the exception, not the rule.

In Chapter VIII. Mr. Brough says: "In 1798 Breithaupt, of Cassel, invented a mine-surveying instrument, which he called an *astrolabium*." This remark is not correct, for, as the author well knows, the astrolabe was invented by the ancients. The statement should have been that H. C. W. Breithaupt was one of the first to put an astrolabe upon a stand and use it for surveying underground. According to Mr. Brough the theodolite has been employed more or less for mine surveys since 1836. This date is probably correct as far as Germany is concerned; but as a matter of fact a mining theodolite was supplied to the Imperial Brazilian Mining Association four years earlier.

The description of Prof. Borchers's method of using magnets for ascertaining the precise line in which one should continue to work in order to connect two drivages in opposite directions which are approaching each other, is not so clear as it ought to be. Mr. Brough omits to explain, in reference to Fig. 101, that by construction the points A, B, and C are situated upon the circumference of a circle, the centre of which is E; and the confusion is increased by the statement that the triangle A E C is "equilateral," whereas it is really only isosceles. The consequence is that the reader is very much puzzled.

However, these and a few other errors can easily be corrected in a second edition, which is likely to be required before many years are past; because, as soon as the book becomes known, no English-speaking mine-agent or mining student will consider his technical library complete without it.

C. LE NEVE FOSTER.

OUR BOOK SHELF.

Charles A. Gillig's Tours and Excursions in Great Britain. By Stephen F. Smart. (London: United States Exchange, 1888.)

THIS book is intended in the first instance for Americans, but it may also be of some service to English tourists. Taking London as a central point—"not only because it is

the most notable city of the world, but because it is the Mecca, if not the El Medina, of trans-Atlantic tourists, at least"—the author describes a series of excursions, any one of which will well repay the trouble of those who may elect to follow his guidance. He also describes various tours in Wales and Scotland. Mr. Smart has been at pains to make himself familiar with the ground over which he undertakes to lead others, and the information he presents, so far as we have been able to test it, is thoroughly trustworthy. Of course, no one who wishes to obtain a full account of any particular town or district will think of consulting this little book. But as a general sketch, it has considerable merits; and it will doubtless help many American visitors to make the most of a brief visit to Great Britain.

LETTERS TO THE EDITOR.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. No notice is taken of anonymous communications.]

The Supply of Bait for Sea-Fishermen.

ONE of the first questions of practical importance with which the Marine Biological Association has to deal is that of supplying the long-line fishermen with a continuous supply of bait at a cheap rate. Great distress is often occasioned through fishermen being unable to get the necessary bait for their long lines. Mr. Robert Bayly, of Plymouth, a governor of the Marine Biological Association, has generously given a sum of £500 to be spent on investigations on the bait question, and the Council have instructed me, as Director of the Association, to consider the best means of spending this sum. I shall therefore be glad to receive any suggestions from gentlemen who may interest themselves in this question, or to consider the work of any investigator already in the field, with the view of employing a suitable person to carry out a series of observations and experiments.

Two methods appear to offer a solution to the question. Either the animals used commonly as bait, such as whelks, mussels, and squid, may be reared artificially and kept in confinement till required, or some artificial bait may be invented which will lure the more valuable kinds of fish to the hook.

The former of these methods has been successfully practised in France, but such is the operation of the English laws on shore fisheries that there is very little prospect of its being possible in England, unless those laws are altered.

The second method, though more apparently difficult, is the more likely to attain success. Fish are undoubtedly guided by smell and taste in the selection of their food. Some are known to be very nice about the kind of food offered to them, and will only take certain kinds of bait. The whelk is a very favourite morsel, and has a distinct smell and taste: it may be possible to determine by analysis the essential oil or whatever it may be that gives this odour, and to imitate it sufficiently well to deceive the fish. The trade is able to imitate successfully the bouquet of wines: cannot chemistry produce an imitation of the bouquet of the whelk?

G. C. BOURNE.

The Laboratory, Citadel Hill, Plymouth, July 31.

Geometric Meaning of Differential Equations.

IN the Proceedings of the Royal Asiatic Society of Bengal, 1888, p. 76, Prof. Asutosh Mukhopadhyay has proposed a really excellent mode of geometric interpretation of differential equations in general: viz. writing the equation in form $F = 0$, the geometric meaning of the symbol F considered as a magnitude (angle, line, area, &c.), in any curve whatever (wherein F is of course not zero), is, if possible, to be formed; then the geometric meaning of that equation obviously is that the quantity F vanishes right round every curve of the family represented. This is the most direct geometrical interpretation yet proposed.

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

Circle, $R = 0$; *Parabola*, $S = 0$; *Conic*, $T = 0$,

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) $\tan. \angle$ of aberrancy $= q_1 \cdot R$;
- (2) Index of aberrancy $= q_2 \cdot S$;
- (3) Radius of curvature of aberrancy curve $= q_3 \cdot T$;

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) <i>Circle</i> .—Angle of aberrancy	= 0	} right round
all curves
of each
family.
(2) <i>Parabola</i> .—Index of aberrancy	= 0	
(3) <i>Conic</i> .—Radius of curvature of aberrancy curve	= 0	

The verbal neatness of these interpretations can hardly be excelled.

A writer (*R. B. II.*) 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 $F = 0$ implies *directly*, not only that some one geometric magnitude F vanishes, but also that every geometric magnitude vanishing with F (such as $aF, aF^m, \sin F$, &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 $F = 0$ 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 $F = 0$ be multiplied by any of its integrating factors μ , and write for shortness $\int \mu F dx = \phi$. It follows that $\phi = \text{constant}$. 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 $F = 0$ 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, $F = 0$, $\phi = c$, 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 $F = 0$ is equivalent to $D_x \phi = 0$, 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 $F = 0$ itself. But many will probably prefer the shorter phrase $\phi = \text{constant}$, even though it interprets $F = 0$ 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 $F = 0$; 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 Lumbricidae. Only one species is at present known, viz. *A. tetrastrus*; 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.

WM. B. BENHAM.

University College.

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