noticed it before. Of course when the apparatus is in full working order there is little opportunity for doing so.

The only explanation I could think of was:—(i) that the light of the lamp had produced some molecular change in the paint coating the notice board; (ii) that this had affected differently the blue and the white paint; (iii) that the same cause had set up some differential electrical condition of the board and the glass; (iv) that a bombardment of particles of the blue paint had taken place on to the glass to which they had adhered; and that (v) the particles so adhering, by dispersing the light, produced the effect of the pale illuminated ground while the spaces occupied by the letters being relatively clean stood out dark.

Royal Gardens, Kew, W. T. THISELTON-DYER.
February 1.

MR. W. B. CROFT's paper on Breath-Figures in your issue of December 22 reminded me of some curious impressions of monumental brasses which are to be seen on the walls of Canterbury Cathedral. When I saw these impressions a few years ago, it occurred to me that they might have been produced by mere contact, the brass plates having possibly been hung for many years against the walls, in secluded corners, at a time when the Reformers would not let them remain in their proper matrices on the church floor. I had forgotten the particulars of these figures, but Dr. Sheppard, of Canterbury, has kindly sent me the following notes by favour of Canon Fremantle:—"A number of impressions of brasses are in the basement (which is open to the air) under Henry IV.'s chantry in the Cathedral. A very good impression is on the western column of the crypt of Trinity Chapel. . . . On the walls appear the shapes of the effigies. Sometimes the stone is unstained all over the area of the figure, and surrounded by a broad dark smudge: and sometimes the case is reversed, and the figure is the exact negative of the former kind; that is to say, the area of the figure is indicated by an uniform dark tint, whilst the surrounding stone is unstained." Dr. Sheppard suggests "that an exact pattern seems to have been made in paper and then fixed to the wall whilst it was brushed over with linseed oil. But this does not account for the white effigies on a dark ground."

I would commend these impressions to the notice of those interested in the subject. It may be that, though some were made intentionally, others are the result of simple contact.

F. J. ALLEN.

Mason College, Birmingham, February 4.

Fossil Plants as Tests of Climate.

IN continuation of my recent letter, permit me to call attention to a communication on the bread fruit trees in North America, by Mr. F. H. Knowlton, of the National Museum, Washington, U.S., which appears in your American contemporary *Science* for January 13. The forty living species of *Artocarpus* are all confined to tropical Asia and the Malay Archipelago. *A. incisa*, the true bread fruit tree, and one or two others, are largely cultivated in the tropics. They are small or medium-sized trees with a milky juice, large leathery leaves, and monœcious flowers. The female flowers are long club-shaped spikes, which uniting form one large mass known as the "bread fruit," the interior containing a pulp when ripe like new bread.

The first fossil bread fruit was discovered in boulder county Colorado in late cretaceous rock, and was named by the late Prof. Leo Lesquereux *Myrica* (?) *Lessigiana*, other fragments he called *Aralia pungens*. The subsequent researches, or more perfect specimens of Dr. A. S. Nathorst, proved these to belong to one species, *Artocarpus Lessigiana*. Dr. Nathorst is the discoverer of another species closely allied to *A. incisa*, which he calls *A. Dicksoni*, which he obtained from the cretaceous flora of Waigatt, West Greenland, which the previous labours of Profs. Heer and Nordenskiöld had shown to be of a tropical or subtropical character, containing as it does numerous species of ferns of the order Gleichenialeæ, and several species of cycas.

CHAS. E. DE RANCE.

H.M. Geological Survey, Alderley Edge, Manchester.

Lunar Rainbow in the Highlands.

THIS interesting phenomenon (a very unusual one in this latitude) was observed near here on the morning of the 3rd inst., about six a.m. The moon was two days past full, and was not shining particularly brightly, being obscured, except at considerable intervals, by driving mist and light clouds. The bow, however, was exceedingly well marked, and formed a singularly beautiful object, stretching as it did completely across the north-western end of Loch Oich, glimmering against the dark background of the mountains, and sinking into the water on the southern shore of the loch. The general colour of the bow was yellow deepening into orange, several of the prismatic colours, however, being intermittently visible, especially a tinge of violet on the upper side.

O. S. B.

The Abbey, Fort-Augustus, N.B.

OPTICAL CONTINUITY.[1]

KEENNESS of sight is measured by the angular distance apart of two dots when they can only just be distinguished as two, and do not become confused together. It is usually reckoned that the normal eye is just able or just unable to distinguish points that lie one minute of a degree asunder. Now, one minute of a degree is the angle subtended by two points, separated by the 300th part of an inch, when they are viewed at the ordinary reading distance of one foot from the eye. If, then, a row of fine dots touching one another, each as small as a bead of one 300th part of an inch in diameter, be arranged on the page of a book, they would appear to the ordinary reader to be an extremely fine and continuous line. If the dots be replaced by short cross strokes, the line would look broader, but its apparent continuity would not be affected. It is impossible to draw any line that shall commend itself to the eye as possessing more regularity than the image of a succession of dots or cross strokes, 300 to the inch, when viewed at the distance of a foot. Every design, however delicate, that can be drawn with a line of uniform thickness by the best machine or the most consummate artist, admits of being mimicked by the coarsest chain, when it is viewed at such a distance that the angular length of each of its links shall not exceed one minute of a degree. One of the apparently smoothest outlines in nature is that of the horizon of the sea during ordinary weather, although it is formed by waves. The slopes of *débris* down the sides of distant mountains appear to sweep in beautifully smooth curves, but on reaching those mountains and climbing up the *débris*, the path may be exceedingly rough.

The members of an audience sit at such various distances from the lecture table and screen, that it is not possible to illustrate as well as is desirable, the stages through which a row of dots appears to run into a continuous line, as the angular distance between the dots is lessened. I have, however, hung up chains and rows of beads of various degrees of coarseness. Some of these will appear as pure lines to all the audience; others, whose coarseness of structure is obvious to those who sit nearest, will seem to be pure lines when viewed from the furthest seats.

Although 300 dots to the inch are required to give the idea of perfect continuity at the distance of one foot, it will shortly be seen that a much smaller number suffices to suggest it.

The cyclostyle, which is an instrument used for multiple writing, makes about 140 dots to the inch. The style has a minute spur wheel or roller, instead of a point; the writing is made on stencil paper, whose surface is covered with a brittle glaze. This is perforated by the teeth of the spur wheel wherever they press against it. The half perforated sheet is then laid on writing paper, and an inked roller is worked over the glaze. The ink passes through the perforations and soaks through them on to the paper below; consequently the impression consists entirely of short and irregular cross bars or dots.

[1] Extract from a lecture on "The Just-Perceptible Difference," delivered before the Royal Institution on Friday, January 27, by Francis Galton, F.R.S.

I exhibit on the screen a circular letter summoning a Committee, that was written by the cyclostyle. The writing seems beautifully regular when the circular is photographically reduced; when it is enlarged, the discontinuity of the strokes becomes conspicuous. Thus, I have enlarged the word *the* six times; the dots can then be easily seen and counted. There are 42 of them in the long stroke of the letter *h*.

The appearance of the work done by the cyclostyle would be greatly improved if a fault in its mechanism could be removed, which causes it to run with very unequal freedom in different directions. It leaves an ugly, jagged mark wherever the direction of a line changes suddenly.

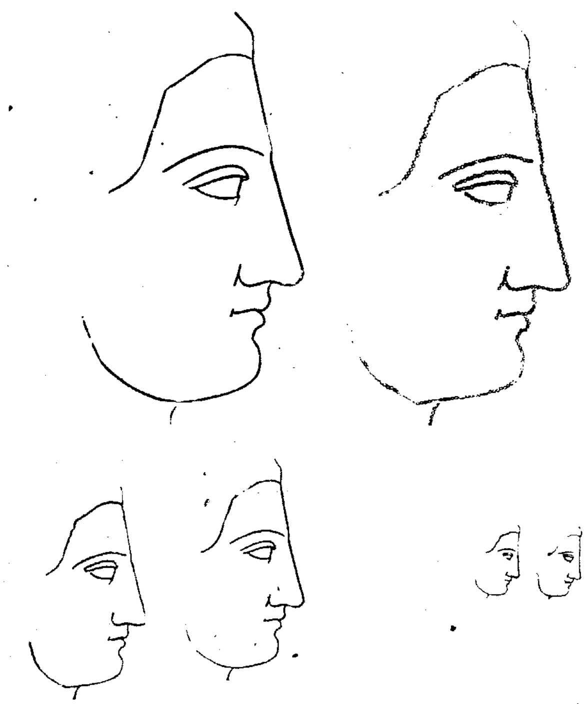
A much coarser representation of continuous lines is given by embroidery and tapestry, and coarser still by those obsolete school samplers which our ancestresses worked in their girlhood, with an average of about sixteen stitched dots to each letter. Perhaps the coarsest lettering that is ever practically employed is used in perforating the books of railway coupons so familiar to travellers. Ten or eleven holes are used for each figure.

A good test of the degree of approximation with which a cyclostyle making 140 perforations to the inch is able to simulate continuous lines, is to use it for drawing outline portraits. I asked the clerk who wrote the circular just exhibited to draw me a few profiles of different sizes, ranging from the smallest scale on which the cyclostyle could produce recognisable features, up to the scale at which it acted fairly well. Here are some specimens of the result. The largest is a portrait of $1\frac{1}{2}$ inches in height, by which facial characteristics are fairly well conveyed; somewhat better than by the rude prints that appear occasionally in the daily papers. It is formed by 366 dots. A medium size is $\frac{3}{4}$ inch high and contains 177 dots, and would be tolerable if it were not for the jagged strokes already spoken of. The smallest sizes are $\frac{1}{2}$ inch high and contain about ninety dots; they are barely passable, on account of the jagged flaws, even for the rudest portraiture.

I made experiments under fairer conditions than those of the cyclostyle, to learn how many dots, discs, or rings per inch were really needed to produce a satisfactory drawing, and also to discover how far the centres of the dots or discs might deviate from a strictly smooth curve without ceasing to produce the effect of a flowing line. It must be recollected that the eye can perceive nothing finer than a minute blurr of one three-hundredth part of an inch in angular diameter. If we represent a succession of such blurs by a chain of discs, it will be easily recognised that a small want of exactitude in the alignments of the successive discs must be unimportant. If one of them is pushed upwards a trifle and another downwards, so large a part of their respective areas still remain in line, that when the several discs become of only just perceptible magnitude, the projecting portion will be wholly invisible. When the discs are so large as to be plainly perceptible, the alignment has to be proportionately more exact. After a few trials it seemed that if the *bearing* of the centre of each disc from that of its predecessor which touched it, was correctly given to the nearest of the 16 principal points of the compass, N., NNE., NE., &c., it was fairly sufficient. Consequently a simple record of the successive bearings of each of a series of small equidistant steps is enough to define a curve.

The briefest way of writing down these bearings, is to assign a separate letter of the alphabet to each of them, *a* for north (the top of the paper counting as north), *b* for north-north-east, *c* for north-east, and so on in order up to *p*. This makes *e* represent east, *i* south, and *m* west.

To test the efficiency of the plan, I enlarged one of the cyclostyle profiles, and making a small protractor with a piece of tracing paper, rapidly laid down a series of equidistant points on the above principle, noting at the same time the bearing of each from its predecessor. I thereby obtained a formula for the profile, consisting of 271 letters. Then I put aside the drawing, and set to work to reproduce it solely from the formula. I exhibit the result; it is fairly successful. Emboldened by this first trial, I made a more ambitious attempt, by dealing with the profile of a Greek girl copied from a gem. I was very desirous of learning how far the pure outline of the original admitted of being mimicked in this rough way. The result is here; a ring has been painted round each



dot in order to make its position clearly seen, without obliterating it. The reproduction has been photographically reduced to various different sizes. That which contains only fifty dots to the inch, which is consequently six times as coarse as the theoretical 300 to an inch, is a very creditable production. Many persons to whom this portrait has been shown failed to notice the difference between it and an ordinary woodcut. The medium size, and much more the smallest size, would deceive anybody who viewed them at the distance of one foot. The protractor used in making them was a square card with a piece cut out of its middle, over which transparent tracing paper was pasted. A small hole of about $\frac{1}{8}$ of an inch in diameter was punched out of the centre of the tracing paper; sixteen minute holes just large enough to allow the entry of the sharp point of a hard lead-pencil were perforated through the tracing paper in a circle round the centre of the hole at a radius of $\frac{1}{4}$ inch. They corresponded to the 16 principal points of the compass, and had their appropriate letters written by their sides. The outline to be formulated was fixed to a drawing-board, with a T rule laid across it as a guide to the eye in keeping the protractor always parallel to itself. The centre of the small hole was then brought over the beginning of the outline, and a dot was made with the pencil through the perforation nearest to the further course of the outline, and this became the next point of departure. While moving the protractor from the old point to the new one it was stopped on the way, in order that the letter for the bearing might be written through the central hole.

A clear distinction must be made between the proposed plan and that of recording the angle made by each step from the *preceding one*. In the latter case, any error of bearing would falsify the direction of all that followed, like a bend in a wire.

The difficulties of dealing with detached portions of the drawing, such as the eye, were easily surmounted by employing two of the spare letters, R and S, to indicate brackets, and other spare letters to indicate points of reference. The bearings included between an R and an S were taken to signify directive dots, not to be inked in. The points of reference indicated by other letters are those to which the previous bearing leads, and from which the next bearing departs. Here is the formula whence the *eye* was drawn. It includes a very small part of the profile of the brow, and the directive dots leading thence to the eye.

The letters should be read from the left to the right, across the vertical lines. They are broken into groups of five, merely for avoiding confusion and the convenience of after reference.

The part of the Profile that includes U

&c. iiiilU jiihi &c. &c.

The Eye.

URkkk	kklll	mSVap	ponmn	mmlmm
mlmlm	llmZZ	VnTnn	mnmmm	mmmlm
mmnZZ	Tjjjj	jjkkc	cbmmn	mnnnn
onooZ				

Letters used as Symbols.

R....S=(....). Z=end.
U, V, T are points of reference.

By succeeding in so severe a test case as this Greek outline, it may be justly inferred that rougher designs can be easily dealt with in the same way.

At first sight it may seem to be a silly waste of time and trouble to translate a drawing into a formula, and then, working backwards, to retranslate the formula into a reproduction of the original drawing, but further reflection shows that the process may be of much practical utility. Let us bear two facts in mind, the one is that a very large quantity of telegraphic information is daily published in the papers, anticipating the post by many days or weeks. The other is that pictorial illustrations of current events, of a rude kind, but acceptable to the reader, appear from time to time in the daily papers. We may be sure that the quantity of telegraphic intelligence will steadily increase, and that the art of newspaper illustration will improve, and be more resorted to. Important local events frequently occur in far-off regions, of which no description can give an exact idea without the help of pictorial illustration; some catastrophe, or site of a battle, or an exploration, or it may be some design or even some portrait. There is therefore reason to expect a demand for such drawings as these by telegraph, if their expense does not render it impracticable to have them. Let us then go into details of expense, on the basis of the present tariff from America to this country, of one shilling per word, 5 figures counting as one word, cypher letters not being sent at a corresponding rate. It requires two figures to perform each of the operations described above, which were performed by a single letter. So a formula for 5 dots would require 10 figures, which is the telegraphically equivalent of 2 words; therefore the cost for every 5 dots telegraphed from the United States would be 2 shillings, or £2 for every 100 dots or other indications.

In the Greek outline there is a total of 400 indications, including those for directive dots, and for points of reference. The transmission of these to us from the United States would cost £8. I exhibit a map of England made with 248 dots, as a specimen of the amount of work in plans, which could be effected at the cost of £5. It is easy to arrange counters into various patterns or parts of patterns, learning thereby the real power of the process. The expense of pictorial telegraphs to foreign countries would be large in itself, but not large relatively to the present great expenditure by newspapers on telegraphic information, so the process might be expected to be employed whenever it was of obvious utility.

The risk is small of errors of importance arising from mistakes in telegraphy. I inquired into the experience of the Meteorological Office, whose numerous weather telegrams are wholly conveyed by numerical signals. Of the 20,625 figures that were telegraphed this year to the office from continental stations, only 49 seem to have been erroneous, that is two and a third per thousand. At this rate the 800 figures needed to telegraph the Greek profile would have been liable to two mistakes. A mistake in a figure would have exactly the same effect on the outline as a rent in the paper on which a similar outline had been drawn, which had not been pasted together again with perfect precision. The dislocation thereby occasioned would never exceed the thickness of the outline.

The command of 100 figures from 0 to 99, instead of only 26 letters, puts 74 fresh signals at our disposal, which would enable us to use all the 32 points of the compass, instead of 16, and to deal with long lines and curves. I cannot enter into this now, nor into the control of the general accuracy of the picture by means of the distances between the points of triangles each formed by any three points of reference. Neither need I speak of better forms of protractor. There is one on the table by which the ghost of a compass card is thrown on the drawing. It is made of a doubly refracting image of Iceland spar, which throws the so-called "extraordinary" image of the compass card on to the ordinary image of the drawing and is easy to manipulate. All that I wish now to explain is that this particular application of the law of the just perceptible difference to optical continuity gives us a new power that has practical bearings.

POSTSCRIPT.—A promising method for practical purposes that I have tried, is to use "sectional" paper; that is, paper ruled into very small squares, or else coarse cloth, and either to make the drawing upon it, or else to lay transparent sectional paper, or muslin, over the drawing. Dots are to be made at distances not exceeding 3 spaces apart, along the course of the outline, at those intersections of the ruled lines (or threads) that best accord with the outline. Each dot in succession is to be considered as the *central point*, numbered **44** in the following schedule, and the couplet of figures corresponding

11	21	31	41	51	61	71
12	22	32	42	52	62	72
13	23	33	43	53	63	73
14	24	34	**44**	54	64	74
15	25	35	45	55	65	75
16	26	36	46	56	66	76
17	27	37	47	57	67	77

to the portion of the next dot, is to be written with a fine pointed pencil in the interval between the two dots. These are subsequently copied, and make the formula. By employing 4 for zero, the signs of + and − are avoided; 3, standing for −1, 2, for −2; and 1, for −3. The first figure in each couplet defines its horizontal coordinate from zero; the second figure, its vertical one. Thus any one of 49 different points are indicated, corresponding to steps from zero of 0, ±1, ±2, and ±3 intervals, in either direction, horizontal or vertical. Half-an-hour's practice suffices to learn the numbers. The figures 0, 8, and 9 do not enter into any of the couplets in the schedule, the remaining 51 couplets in the complete series of 100 (ranging from 00 to 99), contain 21 cases in which 0, 8, or 9 forms the first figure only; 21 cases in which one of them forms the second figure only, and 9 cases in which both of the figures are formed by one or other of them. These latter are especially distinctive. This method has five merits—medium, short, or very short steps can be taken according to the character of the lineation at any point; there is no trouble about orientation; the bearings are defined without a protractor, the work can be easily revised, and the correctness of the records may be checked by comparing the sums of the small coordinates leading to a point of reference, with their total values as read off directly.

A method of signalling is also in use for military purposes, in which positions are fixed by coordinates, afterwards to be connected by lines.

F. G.

BRITISH NEW GUINEA.[1]

MR. THOMSON'S work on British New Guinea has been looked for with some impatience. Now that it has come it falls short of our expectations. We had hoped for a comprehensive work marshalling into order and summarising the observations and investigations made in the British part of New Guinea, by so many missionaries, explorers, naval and government officers and scientific men, for many years. Instead of this we find that the book is made up almost entirely of the explorations during the past four or five years of the administrator, boiled down out of the official reports by Mr. J. Thomson, the secretary of the Queensland branch of the Geographical Society of Australasia. Throughout the volume there is everywhere evidence that its author is new to literary composition. In consequence, the terse and vigorous English of the original reports suffers severely in the process, so much so that we regret that their important parts have not been presented to us as extracts in the explorer's own words. Mr. Thomson has himself never visited New Guinea, if we may judge by internal evidence, although his phraseology in many places is not unlikely to lead the reader to suppose that he has had a share in the results presented in its pages. Had the author had some personal acquaintance with the country of which he writes he would have formed opinions, we believe, different from many of those he has expressed on his own account throughout the book.

The work opens with a sketch "of the historical aspects of the whole of the great Papuan land," but we miss in it the names of many who deserve honourable mention for their contributions to the "making" of New Guinea. We find no mention of the investigations of Dr. Otto Finsch carried on in all three possessions, of those of Mr. O. Stone, of the missionaries in Geelvink Bay, of Mr. Romilly, of the Special Commissioners Sir Peter Scratchley and the Hon. John Douglas, of Mr. Milman, and of Commanders Pullen and Field, who have all contributed to our knowledge of different regions.

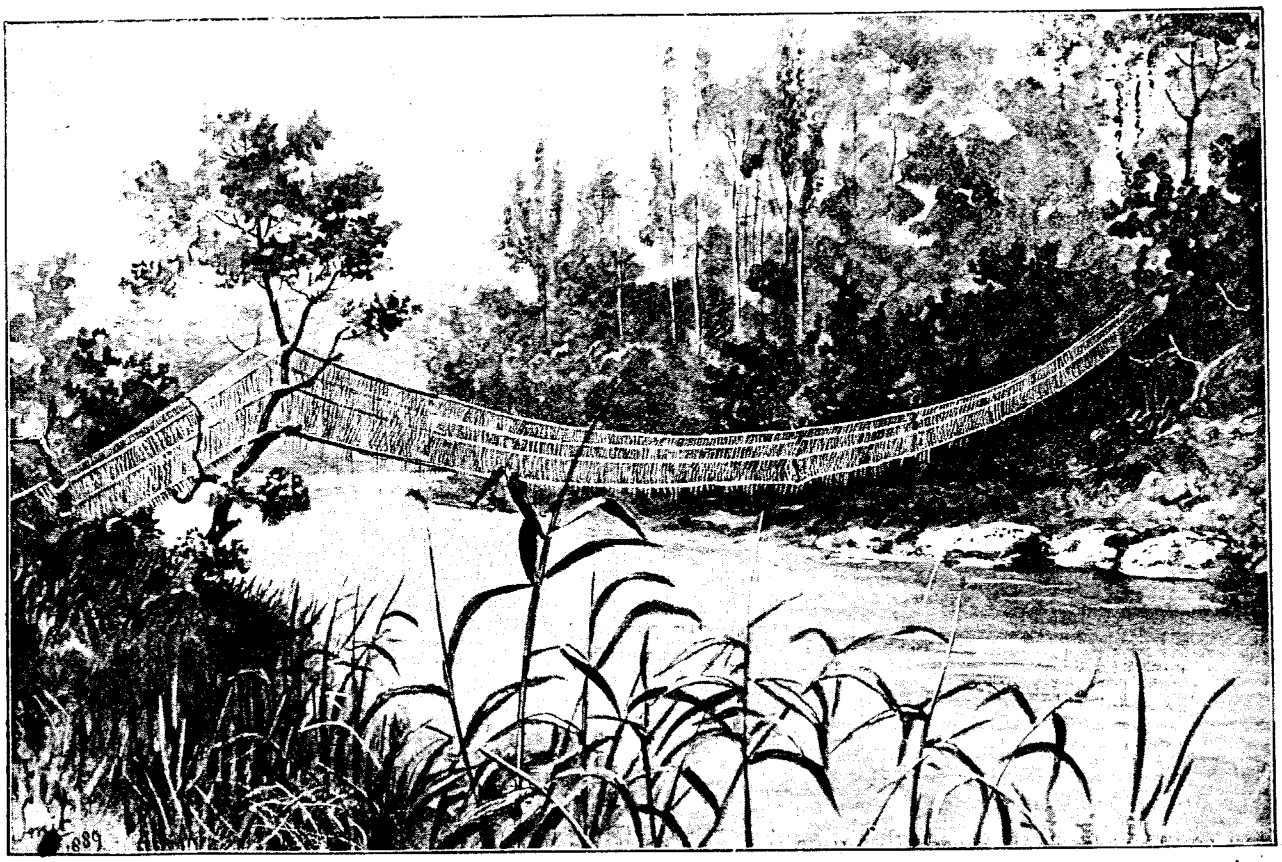


FIG. 1.—Native suspension bridge across the Vanapa river.

This chapter is prefaced by a quotation from the writings of Plinius Minor:—"It appears to me a noble employment to rescue from oblivion those who deserve to be eternally remembered, and by extending the reputation of others, to advance at the same time our own." These words are the true key-note of the book from which our Brisbane Pliny—Plinius Major—has never once deviated throughout his task. It is doubtless no small compliment to any man to have his deeds held up in the light of "eternal remembrance" by one of his fellows, but the task requires the delicate hand of a judicious fellow; and we fear that our Pliny has marred the compliment in the paying. So inspired with veneration for his patron is he that every act of his appears almost extraordinary, and his name too august ever to be mentioned without the humblest obeisance expressed in the constant recapitulation of his titles, dignities, and office, which must be as nauseous to

[1] "British New Guinea." By J. P. Thomson, F.R.S.G.S., &c. (London: George Philip and Co., 1892.)