be expressed in the most general form possible, and to include all conceivable varieties of crystalline symmetry.

It has, however, recently been pointed out by Wulff[1] that the partial symmetry of certain crystals belonging to the rhombohedral system—that, namely, of the minerals phenacite and dioptase—is not represented among the sixty-five arrangements of Sohncke.

Other systems of points in space have also been studied by Haag[2] and Wulff, which do not exactly possess the properties of a Sohncke system, and yet might reasonably be adopted as the basis of crystalline structure, since they lead to known crystalline forms.[3] These, however, and all other systems of points which have been proposed to account for the geometrical and physical properties of crystals, may be included in the theory of Sohncke after this has received the simple extension which is now added by its author.

In Bravais's network all the particles or structural elements were supposed to be identical, and in Sohncke's theory also there is nothing in their geometrical character to distinguish one particle from another.

In Fig. 2, the hexagonal series of dots may, as was said above, be regarded as composed of a pair of triangular webs, A and B; now these, although identical in other respects, are not parallel, for the distribution of the system round any point of A is not the same as that round any point of B until it has been rotated through an angle of 60°.

It is possible, however, to conceive similar interpenetrating networks which differ not only in their orientation but even in the character of their particles. The centre of each hexagon, for example, may be occupied by a particle of different nature from A and B to form a new web, O. The three webs are precisely similar in one respect, since their meshes are equal equilateral triangles; moreover, if the *position* of the points alone be taken into account, the whole system would form a Bravais web, *i.e.* if the particles of O were identical with those of A and B. If, however, as is here supposed, the set O consists of particles different in character from A and B, the distribution round any point of O is totally distinct from that round any point of A or B. The points O are geometrically different from the points A B. The web A is interchangeable with B, but O is interchangeable with neither.

Now, it is precisely an extension of this kind which must be given to Sohncke's earlier theory if it is to embrace all the crystalline arrangements which have been alluded to above. The interpenetrating networks are no longer to be regarded as consisting necessarily of identical particles; the structural units of a crystal may be of more than one kind.

The above figure represents a Sohncke system, A B, of particles of one sort interpenetrated by a Bravais web, O, of another sort; but there is no reason why two or more different Sohncke systems, no one of which is identical with a Bravais network, may not interpenetrate to form a crystal structure.

In its most general form, then, the theory may now be expressed—

A crystal consists of a finite number of interpenetrating Sohncke systems which are derived from the same Bravais network. The constituent Sohncke systems are in general not interchangeable, and the structural elements of one are not necessarily the same as those of another.

Or, since each Sohncke system consists itself of a set of interpenetrating networks, the theory may be thus expressed—

A crystal consists of a finite number of parallel interpenetrating congruent networks: the particles of any one network are parallel and interchangeable; these networks group themselves into a number of Sohncke systems in each of which the particles are interchangeable but not necessarily parallel.

The number of kinds of particles which constitute the crystal may therefore be equal to the number of Sohncke systems involved in its construction.

The structural units are no longer, as they were in the theory of Bravais, necessarily identical, but may represent atomic groups of different nature.

The system in Fig. 2 consists of two sets of particles, A B and O; and, if a large enough number of these be taken, any portion of the system (*i.e.* any crystal constructed in this manner) consists of the particles united in the proportion of two of the first group to one of the second. Such an arrangement, then, may represent the structure of a compound, $O\ A_2$.

"When, for example, a salt in crystallizing takes up so-called water of crystallization which is only retained so long as the crystalline state endures, the chemical molecule salt + water cannot be said to exist except in the imagination, for the presence of such a molecule cannot be proved. To obtain an easily intelligible example, without, however, pronouncing any opinion as to whether it may be realized, imagine the centred hexagons in the figure to be constructed in such a way that each corner consists of the triple molecule $3H_2O$, and each centre consists of the molecule R. The chemical formula would then be $R + 6H_2O$, and yet a molecule of this constitution would not really exist; on the contrary, the structural elements in the crystallized salt would be of two sorts—namely, R and $3H_2O$."[1]

Hence it is geometrically possible that the structural elements of a crystal may be different atomic groups which are held in a position of stable equilibrium by virtue of being interpenetrating networks.

Whether such systems are chemically and physically possible must be left for future criticism to decide.

Finally, we may call attention to a remarkable declaration of faith which has recently been made in Germany by one who is a recognized leader in crystallographic and mineralogical science.

Prof. Groth[2] has suggested that there may be something more than a chance similarity between the theory of Sohncke and the views of the eminent French crystallographer Mallard, whose classical research upon the optical anomalies of crystals has been the means of dividing the students of this subject into two adverse camps. The explanation of Mallard has up to the present time found little favour among those German mineralogists who have made similar investigations. Prof. Groth has now, however, declared himself in favour of Mallard, being apparently induced to do so by the support which is given to his views by the theory of Sohncke.

Mallard has ascribed the optical anomalies of various substances to a complete or partial intergrowth of two or more crystals which combine in such a manner as to simulate a symmetry of higher order than that which naturally belongs to them. Now, since Mallard regards each crystal as composed of a Bravais network, it is evident that his views are not far removed from those of Sohncke, whose system is based upon the possible intergrowth of two or more networks.

H. A. MIERS.

THE EARTHQUAKE AT BAN-DAI-SAN, JAPAN.

AS it may interest our readers to know the present state of matters at the scene of the great earthquake which occurred lately at Ban-dai-san, Japan, we think it well to publish the following narrative just received by Dr. George Harley, F.R.S., in a private letter from his son, who has recently visited the locality of the sad disaster.

[1] *Zeitschr. f. Kryst.* xiii. (1887) p. 503.
[2] "Die regulären Krystallkörper." (Rottweil, 1887.)
[3] Cf. W. Barlow, NATURE, xxix. (1884) pp. 186, 205.

[1] Sohncke, *Zeitsch. f. Kryst.* xiv. p. 443.
[2] "Ueber die Molekularbeschaffenheit der Krystalle." (Festrede, München, 1888.)

The letter is dated December 2, 1888, from on board the Peninsular and Oriental s.s. *Verona*, while in the Inland Sea on its voyage back from Japan to China.

Mr. Vaughan Harley says that on October 20 last, having procured the services of an interpreter, he started by train from Yokohama to Tokio, where he obtained a permit from the Japanese Foreign Office to visit the Ban-dai-san valley. From Tokio he went by train to Kuragano, where he engaged, for himself and interpreter, a couple of *jinrickshas*, with two coolies for each. On the following morning he started at 4.45 a.m.,—that is to say, before daylight. It being then early winter in Japan, the day did not break till 6.45. The weather at the time was both cold and rainy; but so long as the roads were good, the coolies, running tandem-fashion, managed to get along at an average rate of from 6 to 7 miles an hour, and accomplished 50 miles a day. On arriving at Inawashiro Lake, after having engaged a guide, he proceeded direct to Ban-dai-san, where the scene that met his eyes, though magnificent, was truly awe-inspiring. It was a veritable valley of devastation. For the whole side of a mountain—3 miles in circumference—had been completely blown away, and hurled as if it had been the mere outside wall of a house, into the valley below, completely burying beneath it four villages and their surrounding farms, along with all their inhabitants. Such was the stupendous force of the explosion, that the mere wind-shock produced by its concussion knocked down, as if they had been nothing more than ninepins, the whole of the trees growing on the opposite mountain-side. The river in the valley, too, was so dammed across by the huge mass of detached mountain as to have formed itself into a small lake, the waters of which now occupy the place where formerly well cultivated crops grew.

The catastrophe which brought about these physical changes appears to have been due to the sudden explosion of superheated pent-up steam, either alone or in conjunction with volatile gases, set free by the decomposing chemical action of heat and water on the constituents of the subjacent mineral strata. The whole surrounding ground is at present full of hot springs, giving forth volumes of steam, while from every crack and crevice in the earth issues, either continuously or spasmodically, clouds of hot watery vapour, so that one has to be very careful where he places his feet. Not only the fact of the presence of these hot springs, but likewise of the still frequent occurrence of earthquakes, shows that the same agent or agents that rent the mountain in twain are still actively at work. Even in the morning of the day following his visit (at 5 a.m.) there was a shock of earthquake, which, although it was strong enough to admit of his feeling the earth quiver beneath him, the people spoke of as being such a mild one as to merit no attention. He says, moreover, that the appearance presented by the standing half of the cleft mountain, with its surrounding clouds of steam, was, to his way of thinking, far grander, and vastly more awe-inspiring, than are either the geysers of Iceland or the yet greater and more numerous ones he had seen in the volcanic district of the Yellowstone Park in North America. For here the scene he witnessed not only plainly pointed to the cause, but gave him ocular demonstration of its stupendous power, and made him feel that, if superheated steam could thus easily, apparently, rend asunder a solid mountain of rock, there could be no difficulty in understanding why the live volcanoes scattered over the globe were looked upon as safety-valves for the effects of the various chemical decompositions brought about by heat and water in the molten minerals within the bowels of the earth. For were there no outlets even to the superheated steam—heated by the vast internal fires up to a point when it possibly resolves itself into its elements—he could readily enough imagine, from what he saw, that its sudden explosion might suffice to shatter the earth's crust into fragments—just, perhaps, as takes place in some of the heavenly bodies, fragments from which ever and anon fall, in the shape of meteorites, upon the surface of our globe. Having got back to the tea-house at 7.15 p.m., leg-tired and foot-sore, but thoroughly satisfied with all he had seen and learned, immediately after a hot bath—a natural one, for there is no need of artificially heating bath-water here, Nature does that amply for them—and supper, he went to bed, the bedstead being the floor, as is usual in Japan. Next morning, he started on his return journey to Yokohama, and arrived in good time for the sailing of the *Verona* on the 25th for Hong Kong, where he immediately posted his letter, in order to catch the homeward mail.

NOTES.

THE Vice-Chancellor of Cambridge University has appointed Prof. Stokes, P.R.S., Rede Lecturer for the present year.

MR. ISAAC ROBERTS, the eminent photographic astronomer, has presented to Dunsink Observatory a photographic reflecting telescope with a mirror by With of 15 inches aperture. The generous donor is erecting the instrument at his own expense, and it will be employed in furthering the study of star parallax—a study with which Dunsink has been so long associated.

ON Thursday evening last, the first meeting of the Institution of Electrical Engineers was held in the rooms of the Institution of Civil Engineers, at George Street, Westminster. Mr. Edward Graves, retiring President, occupied the chair. He opened the proceedings by announcing that the last legal steps had been taken to change the name of their body from "Society of Telegraph Engineers and Electricians," by which name it had hitherto been known, to "Institution of Electrical Engineers." Sir William Thomson, President for the year, then delivered his inaugural address on "Ether, Electricity, and Ponderable Matter."

THE forty-second annual general meeting of the Institution of Mechanical Engineers will be held on Wednesday, January 30, Thursday, January 31, and Friday, February 1, at 25 Great George Street, Westminster, by permission of the Council of the Institution of Civil Engineers. The chair will be taken by the President at 7.30 p.m. on each evening. The President, Mr. Edward H. Carbutt, having been in office for two years, will retire, and will induct into the chair the President-elect, Mr. Charles Cochrane.

THE annual general meeting of the Anthropological Institute of Great Britain and Ireland will be held on Tuesday, the 22nd inst., at half-past eight o'clock p.m. Mr. Francis Galton, F.R.S., will take the chair, and deliver the Presidential address.

AT a meeting of the Council of the Sanitary Institute on January 9, Mr. G. J. Symons, F.R.S., in the chair, it was decided that two courses of twelve lectures for sanitary officers should be held, the first course to begin in March, the second in October.

AT the Central Institution, Exhibition Road, during the spring term, Prof. Armstrong will give about ten lectures on some of the more important current problems in chemistry, on Mondays, at 4.30 p.m., commencing Monday, January 21. The following subjects will be dealt with as far as time permits: the nature of chemical change; the interdependence of chemical change and electrolysis; the molecular composition of gases, liquids, and solids; the nature of solutions; physical constants; laws of substitution and isomeric change as bearing on the problem of the nature of chemical change; valency; geometrical isomerism and allo-isomerism.

ZOOLOGISTS will regret to hear of the death of Dr. Heinrich Alexander Pagenstecher. His "Allgemeine Zoologie," in four volumes, the first of which appeared in 1875, the last in 1881,