mountains. These eggs hatch out if exposed to the sun, so they are generally carried by night. The method of production of this wax has been fully described by Mr. Hosie.

After travelling through a very wild region, the party reached an elevation of 5000 feet, where Mr. Pratt gathered a lovely fragrant honeysuckle and a fine mauve-coloured primula, and saw some feathers of the famous Amherst pheasant. On May 24 they struck the main stream of the Tung river, which appears to divide the territory of the independent Lolos from that of the portion of this interesting people subject to the Chinese. Passing by the side of a range of mountains the party followed an affluent of the Tung river, and on May 26, thirty-two days after leaving Chung-king, reached Ta-tsien-chih, a long straggling village of detached clusters of houses. It stands at an elevation of 5980 feet above the sea. The mountain ends in a series of fourteen precipices, each some 200 feet high, the highest being only accessible by ladders. The climate is very much like that of England—cold, rainy, and changeable; the roses very pretty, but single, and strawberries were plentiful; and there is good shooting—wild ox, two species of antelope, two species of bear, and five of pheasant.

The party went on to Ta-chien-lu, the road leading over a pass some 10,000 feet in height. Ta-tsien-lu is a most interesting town. All sorts of Asiatics may be met in its streets, and Europeans, therefore, attract less attention here than in other places where strangers are seldom seen. The natives of the place are the wildest-looking people, invariably armed to the teeth; some of fine physique, tall and handsome, with long matted hair hanging over their faces.

The following year, 1890, Mr. Pratt made a second expedition to Ta-tsien-lu, to increase his collections. This time he carried out the intention he had formed on his previous journey, of ascending Mount Omei. This mountain is 11,100 feet high, and is regarded throughout the neighbouring countries as a spot of peculiar sanctity. There are between sixty and eighty temples on it, and about two thousand priests, and it is continually visited by many thousands of pilgrims. The mountain rises abruptly like a promontory, and can only be ascended from one side. The others are extremely steep, one of them being a precipice nearly a mile and a third high, the highest sheer declivity, perhaps, in the world. As the party approached the mountain, they passed many fine trees, of the species allied to the banyan. One particularly fine specimen, with a magnificent spread of foliage, Mr. Pratt measured, and found it to be 30 feet in circumference. The path led them at first through a wide fertile valley of rice fields, with clumps of trees scattered here and there as in a park. The mountain is covered from head to foot with undergrowth and forest, pines, hollies, and other evergreens predominating. Flowers were very abundant, wild roses, anemones, asters, yellow violets, and two species of hydrangea. Here Mr. Pratt noticed *Paxia begonia*, which he believes has no representative in Europe, but which he believes is represented in America. Near the top he found a primula and a dwarf azalea with fragrant foliage, the latter, so far as he knows, a unique specimen.

During this visit, Mr. Pratt more than once witnessed the curious phenomenon known as the glory of Buddha. Standing on the edge of the precipice, and looking down into the sea of mist which generally fills the valley below, he saw, about 150 feet beneath him, the golden disk surrounded by rainbow-coloured rings of light, which is the chief marvel of Mount Omei, and the clearest evidence of its sanctity. Every year many pilgrims commit suicide by throwing themselves down from this cliff. On May 1, accompanied by Father Soulié, Mr. Pratt made an excursion from Ta-tsien-lu to the snow-capped mountains, and pitched his tent in a forest of rhododendrons just coming into bloom, about two hours below the region of perpetual snow.

By way of summary of the vegetation, Mr. Pratt divides the country here briefly into four regions or zones:—(1) Above 16,000 feet we have perpetual snow. (2) Between 16,000 feet and 10,000 feet, rhododendrons, anemones, primulas, rhubarb, many lilies, a few asters, grass, and wild onions; of birds, *Crossoptilon thibetanum*, *Lophophorus lhuysii*, and Père David's small blue bird. (3) From 10,000 to 5000 feet—rhododendrons, coniferous trees, gooseberries, several species of currant (including one very large black currant with bunches of fruit a foot in length), undergrowth, and several species of birds. (4) Below 5000 feet there is cultivation on a few farms, and pasturage.

M. GRZIMAILO'S EXPEDITION.

ON March 25, the Russian Geographical Society held an extraordinary meeting to listen to a communication by G. E. Grum-Grzimailo about his expedition to Central Asia. The expedition consisted of M. Grum-Grzimailo, his brother, a collector, an interpreter, six Cossacks, and two men. The luggage was transported on some fifty horses and donkeys. After having crossed the Russian frontier on June 8, 1889, they soon reached Kulja, and thence went north-east, towards the spurs of the Boro-Khoro Mountains. By the way they visited Central Djungaria, in order to obtain specimens of the wild horse discovered by Przevalsky, and described as *Equus przevalski* by the late Polyakoff from one single specimen brought in by the great traveller. Four specimens more were obtained. Returning from Djungaria, the expedition proceeded, in September, to the Eastern Tian-Shan, and completed the exploration of its remotest eastern parts. The well-known oasis of Turfan proved to be a desert which has been recovered for industry only by the hardest imaginable labour. It has no water, notwithstanding the proximity of the snow-mountains of Bogdo; and its inhabitants have dug out a whole system of underground canals and wells (some of which are 300 feet deep) to irrigate the desert. The canals collect the water underground, and then bring it to the surface in the lower grounds. The whole work is so colossal that the members of the expedition compare it with the colossal works of Egypt. As to the absolute height of the oasis, M. Grum-Grzimailo pointed out that parts of it appear to be *below the level of the sea*. Of course, this conclusion of the Russian traveller, being based upon barometrical measurements only, cannot yet be taken as quite certain; but it shows that the oasis of Turfan is extremely low, and that it in no case rises more than from 200 to 300 feet. It thus must represent the bottom of a great lake, which occupied on the border of the Central Asian plateau the same position as Lake Baikal occupies now; and this quite unexpected fact is one of great importance for the physical geography and geology of the whole region.

In February 1890 the expedition reached Hami, and thence proceeded to Mor-gol. Heavy snowfalls, however, prevented their further advance eastwards; so they turned towards the south, and went to the Nian-Shan ridge, which had already been crossed in three different places by Przevalsky and Potanin. MM. Grum-Grzimailo studied that interesting ridge over a length of 300 miles, and crossed it in a picturesque gorge which brought them to the Babo-ho river, and thence to the Chinese town Yunan-tcheu. After having explored the Alps of Si-nin, they reached the Hoang-ho, and thence began their return journey. The snowstorms rendered travelling difficult, so they rested for a while at Su-tcheu, and thence, crossing the Be-tchan Mountains, went to Gu-tchen, thence to Urumtchi, and finally reached the Russian frontier on November 25, 1890. Survey has been made over a length of 4840 miles, of which 4000 miles were previously untrodden ground; latitudes and longitudes were often determined during the journey; so also were altitudes. Nearly 200 photographs were taken, and the natural history collections are sure to be very interesting.

SCIENTIFIC SERIALS.

American Journal of Mathematics, vol. xiii., Nos. 2 and 3.—In No. 2 is concluded Part I. of a lengthy article by O. Bolga on the theory of substitution-groups and its application to algebraical equations; the final section discusses groups of operations, especially those obtained from the "groups" of rotations of a regular polyhedron which leave it congruent with its first position. Part II. deals with Galois' theory of algebraic equations."—The following papers also appear:—"Quelques propriétés des nombres K_m^p," by M. M. d'Ocagne. These numbers have been discussed in a previous article (1887, p. 353), where they were defined by means of a triangle analogous to Pascal's.—"Sur les lois de forces centrales faisant décrire à leur point d'application une conique quelles que soient les conditions initiales," by P. Appell.—On certain identities in the theory of matrices, by H. Taber.—Systems of rays normal to a surface, by W. C. L. Gorton.—On the epicycloid, by F. Morley. Some interesting results of

Wolstenholme's and others are here obtained by the use of circular co-ordinates.—The reduction of

$$dx/\sqrt{A(1+mx^2)(1+nx^2)} \text{ to } Mdy/\sqrt{(1-y^2)(1-k^2y^2)}$$

by the substitution $x^2 = a + by^2/a' + b'y^2$, by H. P. Manning. A table of available forms is added, and attention drawn to those forms in it given by Cayley ("Elliptic Functions," p. 316).—A simple statement of proof of reciprocal theorem, by J. C. Field.—Related expressions for Bernouilli's and Euler's numbers, by J. C. Field.——In No. 2 appears a third memoir, on a new theory of symmetric functions, by Major P. A. MacMahon, R.A. Attention is drawn to a fundamental theorem in operations, given without proof. It is a generalization of a theorem by Sylvester which is itself a generalization of Taylor's theorem; "it enables us from any linear function P of the operators to determine another linear function Q, such that $\exp. P = \overline{\exp}. Q$," the bar in $\overline{\exp}. u$ being used by the author to indicate that the multiplication of operators that occur in u is symbolic.—M. Joseph Perrott also contributes a paper entitled "Remarque au sujet du théorème d'Euclide sur l'infinité du nombre des nombres premiers."

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, April 9.—"The Measurement of the Power supplied by any Electric Current to any Circuit." By Prof. W. E. Ayrton, F.R.S., and W. E. Sumpner, D.Sc.

I.—During the meeting of the Electrical Congress in Paris in 1881, one of us[1] devised a method of using an electrometer for measuring the power given to any circuit by any current. This method is the only electrical one hitherto published, the accuracy of which does not depend on assumptions either as regards the character of the current variations or as regards the nature of the circuit the power given to some part of which we desire to measure.

In view then of the present wide use of alternating currents for industrial purposes, it might have been expected that this electrometer method of measuring the power given by any intermittent or alternating current to an inductive circuit would have been extensively employed. Unfortunately, however, as pointed out by one of us in conjunction with Prof. Perry (Journal of Soc. of Tel. Engs. and Elects., vol. xvii., 1888), the use of this method is restricted by the fact that Sir W. Thomson's quadrant electrometers do not generally obey the mathematical law given for these instruments in text-books,[1] as it was supposed they did when this electrometer method of measuring power was first suggested. And hence the main result that has, up to the present time, followed from the publication of this method has been the stimulation of inventive minds to devise forms of electrometers in which the text-book law is strictly fulfilled.

In 1888, Mr. Blakesley published a very ingenious method for measuring the power supplied by alternating currents to the primary coil of a transformer, by the use of three dynamometers. The proof originally given was geometrical, and was based on several assumptions, amongst others that the currents and magnetic fluxes varied with the time according to a simple sine law. An analytical proof has recently been given (meeting of Physical Society, February 27, 1891) by one of us, in conjunction with Mr. Taylor, showing that the method gives equally good results however the currents and magnetic fluxes vary, but there still remains a serious objection to the method, as it is assumed that there is no magnetic leakage in the transformer, or, in other words, every line of force is supposed to thread each convolution of both primary and secondary coils. Further, the method cannot be used with a single circuit as the coils of one of the dynamometers must be placed in different circuits.

The employment of an electro-magnetic wattmeter for the measurement of power is well known, but errors are introduced when alternating currents are used, owing to the self-induction of the fine wire coil. Several investigators have considered the magnitude of this error, and have suggested various devices for reducing it to a minimum.

II.—Several months ago, however, while working at alternate-current interference, we noticed that it was possible to employ an extremely simple method for measuring the power supplied by *any* current to *any* circuit. This method, which has since been in regular use in the laboratories of the Central Institution, is quite independent of any assumptions as to the nature of the current, or of the circuit, the power given to which it is desired to measure, and it has the further great advantage that the only measuring instrument required is the ordinary alternate-current voltmeter of commerce.

In series with the circuit *ab* (Fig. 1), the power given to which we desire to measure, connect a non-inductive resistance *bc* of *r* ohms.

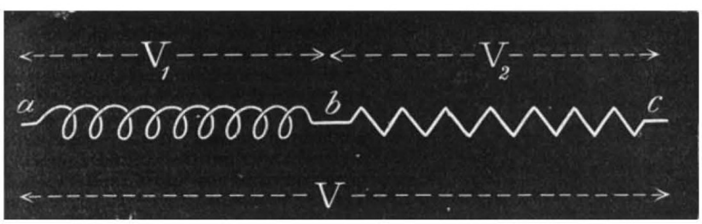

FIG. 1.

Let V_1, V_2, and V be the readings of the voltmeter when applied between *a* and *b*, *b* and *c*, and *a* and *c* respectively; then, if W be the mean watts supplied to the circuit *ab*, we have in all cases, whatever the nature of the current, or of the circuit *ab*—

$$W = \frac{1}{2r}(V^2 - V_1^2 - V_2^2) \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

For, let v_1, v_2, and v be the instantaneous values of the P.D. between *a* and *b*, *b* and *c*, and *a* and *c* at some moment *t*, then

$$v = v_1 + v_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

If a be the current in amperes flowing through the circuit at time *t*, then av_1 equals the watts w given to *ab* at that time. But

$$a = \frac{v_2}{r},$$

since the resistance *bc* is non-inductive;

$$\therefore w = \frac{v_1 v_2}{r}.$$

Then, squaring (2), we have—

$$v^2 = v_1 + 2v_1v_2 + v_2^2;$$

$$\therefore w = \frac{1}{2r}(v^2 - v_1^2 - v_2^2).$$

As this equation is true at every moment, it must also be true for the mean values of w, v^2, v_1^2, and v_2^2.

So that

$$\int_0^T w dt = \frac{1}{2r}\left(\int_0^T v^2 dt - \int_0^T v_1^2 dt - \int_0^T v_2^2 dt\right),$$

and

$$W = \frac{1}{2r}(V^2 - V_1^2 - V_2^2),$$

which is the equation given above.

If the resistance of *bc* be not known, or if there be any fear that it may be changed by the passage of the current, then an

[1] This method was simultaneously arrived at independently by Prof. Fitzgerald.

[1] We may mention that an investigation on quadrant electrometers has been going on from time to time at the Central Institution for the last five years, and we had hoped to have communicated the complete report long before this to the Royal Society.