AN AMPERE BALANCE.[1]

THE Report of the Committee on Electrical Standards for 1897 ended with the following paragraph :—"It thus appears to be a matter of urgent importance that a redetermination of the electro-chemical equivalent of silver should be made, and that the general question of the absolute measurement of electric currents should be investigated. . . ." This work we were asked by the Committee to carry out, and a grant of 75*l.* was voted in its aid. We were thus led to examine into the methods which had been employed by Lord Rayleigh, Prof. Mascart and others, for determining the absolute value of a current, as well as to consider some other methods which have not, as far as we know, been hitherto used.

After much consideration we decided to adopt a form of apparatus which, while generally resembling the type employed by some previous experimenters, possessed certain important differences; and, before expending any part of the grant of 75*l.*, to construct, without expense to the British Association, the following preliminary ampere balance.

On a vertical cylinder about 17 inches high and 6·8 inches in diameter we wound two coils, about 5 inches in height, separated by an axial distance of 5 inches. The coils consisted each of a *single* layer of about 170 convolutions of wire, and were wound in opposite directions. From the beam of a balance there was suspended, inside this cylinder, a light bobbin about 4 inches in diameter, on which was wound a coil about 10 inches long consisting of a *single* layer of 360 convolutions, and the whole apparatus was so adjusted that when the beam of the balance was horizontal the inner and outer coils were coaxial, and the top and bottom of the inner suspended coil were respectively in the mean planes of the outer stationary coils

This arrangement was adopted because with coils consisting of only one layer the geometrical dimensions could be accurately determined, and because the shapes of the coils lent themselves to the use of the convenient formula, readily expressible in elliptic integrals, for the force, F, between a uniform cylindrical current sheet and a coaxial helix, viz. :—

$$F = \gamma\gamma_h(M_1 - M_2)$$

where γ is the current per unit length of the current sheet, γ_h the current in the helix, and M_1 and M_2 the coefficients of mutual induction of the helix and the circular ends of the current sheet.[2]

The value of a particular current of about 0·63 ampere having been determined *absolutely* by means of this apparatus, the rate at which it would deposit silver under specified conditions was ascertained indirectly, by observing its silver value on a Kelvin balance which had been kept screwed down in a fixed position for several years past, and which had been calibrated many times during that period by reference to the silver voltameter.

The result of this preliminary investigation showed that the silver value of the *true* ampere was so nearly equal to the reputed value, viz. 1·118 milligramme per second, as to require the use of an apparatus still more perfectly constructed, and therefore of a much more expensive character, to enable the error, if any, in this value to be ascertained with accuracy.

We, therefore, started on the design of the instrument, of which we now submit the working drawings, and for the future construction of which we would ask for a grant of 300*l.*, including the unexpended grant of 75*l.* voted last year.[3] And we anticipate that this new piece of apparatus may prove worthy of constituting a national ampere balance, the counterpoise weight for which will be determined purely by calculation based on the dimensions of the instrument, the number of convolutions of wire in the three coils, and the value of the acceleration of gravity at the place where the instrument may be permanently set up. In this particular it will differ entirely from the "Board of Trade Ampere Standard Verified, 1894," which has had its counterpoise weight adjusted so that the beam is horizontal when a current passes through the instrument, which will deposit *exactly* 1·118 milligramme of silver per second under specified conditions. In fact, the proposed ampere balance and the existing ampere standard will differ exactly in the same way as do a Lorenz apparatus and the "Board of Trade Ohm Standard Verified, 1894."

We have to express our thanks to Mr. Mather for taking charge of the construction and use of the preliminary apparatus, for checking all the calculations in connection with the determination of the electro-chemical equivalent of silver that was made with it, as well as for superintending the making of the working drawings of the new ampere balance. We have also to thank Messrs. W. H. Derriman and W. N. Wilson, two of the students of the City and Guilds Central Technical College, for their cordial assistance in carrying out the work.

[1] By Prof. W. E. Ayrton, F.R.S., and Prof. J. Viriamu Jones, F.R.S. (Read before Section A of the British Association, Bristol.)

[2] *Proceedings* of the Royal Society, vol. lxiii., "On the Calculation of the Coefficient of Mutual Induction of a Circle and a Coaxial Helix, and of the Electro-magnetic Force between a Helical Current and a Uniform Coaxial Circular Cylindrical Current Sheet." By Prof. J. V. Jones.

[3] This grant of 300*l.* has since been made.

GEOLOGY OF BIRMINGHAM.

ONE of the most important geological memoirs issued of late years is the "Sketch of the Geology of the Birmingham District," by Prof. Lapworth, F.R.S., with contributions by Prof. W. W. Watts and Mr. W. Jerome Harrison : a companion work to that on the "Geology of South Shropshire," by Profs. Lapworth and Watts, issued four years ago. The present work, like the one just mentioned, was prepared with special reference to the areas to be visited by the Geologists' Association during their long summer excursion. It is not merely a lucid summary of the facts already made known ; it contains the latest results of the work done by the author and his associates. The "Birmingham district" is admittedly a large one, being the region within a radius of about thirty-five miles from the city. Thus we find references to the Archæan or Pre-Cambrian rocks of Malvern and the Abberley Hills, of the Wrekin and Lickey Hills, of the Caldecote district and Charnwood Forest. It is stated that the Charnwood or "Charnian Rocks" are theoretically paralleled with the Lower Longmyndian and its volcanic equivalents, and the Caldecote rocks, together with the Barnt Green rocks of the Lickey, are grouped with the Upper Longmyndian and Uriconian.

In the Cambrian areas order is established by comparisons of the quartzites of the Wrekin, Hartshill, and the Lickey. The Hartzhill quartzite is shown to be composed of three main divisions, the upper one containing a band of *Hyolithus*-limestone, the fauna of which answers in part to the *Olenellus*-zone of other regions. Hence this upper or "Camp Hill quartzite" of Hartshill is compared with the Comley or Hollybush Sandstone of the Shropshire and Malvern successions. The Stockingford shales, which overlie the Hartshill beds, are divided into three groups which represent the *Paradoxides* or Menevian zone and portions of the Lingula flags. Comparisons are then made between the Warwickshire strata and those in the north-west of Scotland, the place of the argillaceous Stockingford shales being there taken by the Durness Limestone group.

The Silurian strata (Llandovery to Ludlow), and the Carboniferous system are fairly well known, and the leading facts are pointed out. With reference to the Permian rocks it is observed that, as a general rule, they follow conformably upon the Upper Coal Measures of the district. The origin of the Permian breccias is discussed, and the opinion of Mr. W. Wickham King is quoted to the effect that they are largely torrential deposits formed more or less of scree and talus, swept down in flood times from the sides of steep hill-slopes near at hand. The similar views of Mr. Horace T. Brown respecting these strata in the country near Burton-on-Trent might have been mentioned.

A useful account is given of the Triassic strata which occupy so large a portion of the Birmingham district, and this is followed by a brief notice of the Rhætic beds and Lias. The petrology of the Birmingham district is dealt with by Prof. Watts, and the glacial drifts are described by Mr. Harrison. In conclusion there is a summary of the history of geological research among the rocks of the district.

The entire work is full of valuable information and suggestions, the stratigraphical facts being clearly stated and supported by palæontological evidence where that is forthcoming. Hence for a long time to come, this memoir, which is well illustrated with sections and pictorial views, will be the standard work of reference on the area of which it treats; and the Geologists' Association may be heartily congratulated on having received so important an addition to its *Proceedings*. Of this publication it constitutes the whole of part 9 of volume xv., and it is issued to the public at the price of 1*s.* 6*d.*