First, "*The electromotive force* of a voltaic circuit varies with the number of the elements, and the nature of the metals and liquids which constitute each element, but is in no degree dependent on the dimensions of any of their parts." Second, "*The resistance* of each element is directly proportional to the distances of the plates from each other in the liquid, and to the specific resistance of the liquid; and is also inversely proportional to the surface of the plates in contact with the liquids." Third, "*The resistance of the connecting wire of the circuit* is directly proportional to its length and to its specific resistance, and inversely proportional to its section." Some of the more important forms of battery in use will now be described.

Daniell's Battery, Fig. 42, consists of an earthenware or glass vessel, within which a smaller jar of some porous material is placed; the space between the inner and outer jars is filled with a dilute solution of sulphuric acid and water, and within the porous jar a saturated solution of sulphate of copper; a cylinder of zinc is immersed in the acid solution, and a cylinder of copper in the sulphate solution, crystals of sulphate of copper being introduced to maintain the strength of the copper medium. The current from this battery is remarkably constant, a matter of the greatest importance in the working of a telegraphic circuit, as with a variation in the working strength of the current, continued adjustment of the transmitting and recording apparatus is rendered necessary. Bunsen's battery (Fig. 43) in many respects resembles the Daniell arrangement; carbon is used within the porous cell in place of the copper cylinder, and nitric acid replaces the saturated solution of sulphate of copper. The current produced is stronger, but less constant than that from the Daniell's cell.

Many other arrangements for the generation of a voltaic current for telegraphic purposes are in use, such as the "Marié Davy" (Fig. 44), the "Leclanché," and "Callaud" batteries; more or less, each has its special merits and demerits: practically, the "Daniell" remains unsurpassed. The essential condition of every practical form of battery is that it shall produce a constant current be free from local action, and possess mechanical facility of renovation, with simplicity and economy of construction.

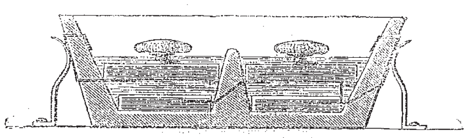

FIG. 44.—The Marié Davy sulphate of mercury Battery.

The measurement of the value of every telegraphic line as regards electrical resistance, as compared with some ascertained standard of resistance, is a matter of vast importance. By this means the electrical insulation of a submarine cable or a land wire is definitely ascertained, and the existence of a fault, together with its locality, defined. Without some established *unit* of resistance by which to compare the working circuit with its electrical equivalent, no test of insulation can be maintained or restoration of a circuit carried out. By general acceptance a standard of measurement has been adopted, a unit of resistance known as the B.A. (British Association) unit. It is unnecessary to enter into detail as to the mechanical problems which determine this unit of resistance; it is sufficient to state that the electrical resistance or value of every circuit, land wire and submarine cable, is now by universal acceptance recorded in B.A. units. For instance, a guttapercha submarine cable core may be stated to be so many hundred millions B.A. units of insulation test; while, again, an indiarubber core may be stated to be so many thousand millions of B.A. units of resistance; a correct comparison is thus at once determined.

(*To be continued.*)

OUR ASTRONOMICAL COLUMN

THE TRANSIT OF VENUS, 1882 DECEMBER 6.—The Greenwich time of first *internal* contact in this transit at any point in these islands, according to Leverrier's Tables of Sun and Planet, may be accurately found by the following equation, in which l is the geocentric latitude of the place, ρ the corresponding radius of the earth, and L the longitude, reckoned positive, if east of Greenwich, and negative, if west:—

$$\text{G.M.T. first Int. Cont.} = \text{Dec. 6d. 2h. 16m. 16s.}$$
$$+ [2{\cdot}5855]\ \rho \sin l - [2{\cdot}4774]\ \rho \cos l \cos (\text{L} - 85^\circ\ 58'{\cdot}6)$$

The quantities within square brackets are logarithms; the correction of course results in seconds. Direct computations for Greenwich, Edinburgh, and Dublin, furnish the following particulars of the first internal contact at these places:—

	Local Time. d. h. m. s.	Angle from N. point. ° ′	Angle from Vertex. ° ′	Sun's Altitude. °
Greenwich ...	Dec. 6 2 21 2 ...	150 40 ...	128 2 ...	9·2
Edinburgh ...	„ 2 8 46 ...	150 42 ...	132 8 ...	6·5
Dublin ...	„ 1 56 8 ...	150 41 ...	132 24 ...	9·6

At Greenwich the sun sets just one hour and a half after Venus has wholly entered upon the sun's disc.

THE SUN'S PARALLAX.—M. Liais, Director of the Imperial Observatory of Rio de Janeiro, has intimated his intention to make a serious attempt to determine this important element from the very favourable opposition of the planet Mars, which will occur early in September 1877, being encouraged thereto by the success which attended his observations about the opposition of 1860, when his instrumental appliances were very inferior to what they are likely to be in 1877. The planet arrives at perihelion on the 21st of August in that year, and in opposition at midnight on the 5th of September; it is in perigee on September 2nd at a distance of only 0·3767, which is not far from the minimum, though slightly greater than in the last three repetitions of the 79-year period, as will appear from the following comparison:—

Opposition.	Mars—Mean Anomaly.
1640·64	− 0° 12′
1719·65	+ 2 31
1798·66	+ 5 15
1877·68	+ 7 58

The horizontal parallax of Mars will attain a value which, as M. Liais remarks, will be sensibly equal to that of Venus, diminished by that of the sun. With firm instruments and experienced observers, it is very probable that the amount of solar parallax may be determined by differential observations of Mars at the opposition of 1877, with a precision which may be comparable with that resulting from observations of a single transit of Venus.

A THIRD COMET IN 1813 (?).—Bode, after mentioning in his Miscellaneous Notices (*Berl. Jahrb.* 1818) that Canon Stark of Augsburg had observed the first comet of 1813 on the 19th of February, states that Stark had also discovered on the same evening with a 3½ feet Dollond telescope, a very small and exceedingly faint comet without tail above the variable star Mira in Cetus, the position of which, by comparison with the variable, he found to be at 7h. 28m. 37s., in R.A. 31° 17′ 23″, and Decl. 1° 52′ 9″ S. He saw the comet a second time on the 20th, and again comparing it with Mira, and another adjacent star, its place at 7h. 32m. 13s. was in R.A. 33° 47′ 3″, and Decl. 5° 49′ 7″ S. Cloudy skies are said to have prevented further observation. Bode remarks, with respect to this comet, that it is strange that no other astronomer had perceived it, "doch versichert Herr Stark," he adds, "noch in seinem letzten Schreiben an mich, aufs Heiligste, die Richtigkeit dieser Wahrnehmung." However suspicious this circumstance may have appeared, we know that several of the comets of short period have been revolving in such orbits for one or two centuries, visiting these parts of space without doubt under favourable circumstances for observation on more than one occasion, yet entirely escaping detection, so that the mere fact of a single observer only having seen a comet, is hardly a sufficient argument against its existence. The late Prof. d'Arrest even thought it worth while to submit the reputed observations of the D'Angos-Comet of 1784 to further calculation, notwithstanding Encke's well-known investigation in the "Correspondance Astronomique" of the Baron de Zach, and we may have something to say on this subject in a future column. Not having seen any reference to "Stark's comet" in English astronomical works, we have given the particulars recorded of it here.

THE GREAT COMET OF 1843.—There was some doubt at the time, from the difficulty attending the determination of the orbit of this extraordinary body upon the European observations, whether it had transited the sun's disc on the day of perihelion or not. The definitive orbit calculated by a most complete investigation by the late Prof. Hubbard, of Washington, shows that a transit did actually take place on the evening of February 27, Greenwich time, and might have been observed in Australia. In next week's "Astronomical Column" we shall give the particulars of this interesting phenomenon, and reproduce Hubbard's elements with some inferences drawn from them.

D'ARREST'S COMET IN 1877.—The mean motion of this comet at the last appearance in 1870, determined by M. Leveau from an elaborate calculation of the perturbations in the two preceding revolutions, would bring this comet into perihelion again on April 17, 1877. The effect of planetary attraction in the present revolution being comparatively small, if we take this date for perihelion passage, the computed path is not likely to differ materially from the true one. It is as follows :—

Obs. Greenwich.	R.A. h. m.	N.P.D. °	Distance. from Earth.
1877 March 8	20 51	100·6	2·03
„ 28	22 6	97·2	1·94
April 17	23 16	93·2	1·89
May 7	0 25	89·2	1·89
„ 27	1 30	85·7	1·90

It would appear from this track that the only chances of observation will be with the aid of powerful telescopes in the southern hemisphere. At the last return the comet was excessively faint, and was only detected at a few of the European observatories.

THE INTERNATIONAL GEOGRAPHICAL EXHIBITION

THE idea of holding an International Geographical Exhibition at Paris, the opening of which we announced last week, in connection with the Geographical Congress which opens in a day or two, was a happy one, and has so far been fruitful in results. The catalogue of articles exhibited covers about 450 octavo pages, and the daily number of visitors reaches thousands ; last Sunday it was 12,000, including the Sultan of Zanzibar, and other visitors of all ranks and classes of society. No better method could have been adopted of showing the advances made in geography in recent years ; how from being a mere record of "hairbreadth 'scapes by flood and field," it has become a complicated science, or rather meeting-ground of all the sciences ; for, as the equipment of and instructions to the English Arctic Expedition show, it requires the aid of all the sciences to do its work well, and in return carries contributions back to them all. We have no doubt that the great majority of the visitors to the Exhibition will be astonished that geography has so many and so varied apparatus and results to show, and we hope that the Exhibition and Congress will be the means of awakening in France, as well as in other countries, an increased interest in geography, lead to its being raised to a higher platform in education, and to its being taught in a more comprehensive and more scientific way than hitherto. No doubt this will be but the first of a series of such exhibitions and congresses, though probably not annual, and we hope that the next one will be held in London. We think they are well calculated to give a strong stimulus to the scientific study of geography.

The arrangements of the Paris Exhibition make it accessible to all classes, the price of admission in some cases being as low as a penny. The articles are arranged mainly according to countries, Britain occupying but a comparatively narrow space in the catalogue. While Russia has 42 pages, Sweden, Norway, and Denmark about 40, Holland 30, Austria and Hungary 44, Great Britain and her Colonies cover only 9 pages. Even Germany has only 12 pages allotted to her. These apparent anomalies no doubt arise from some imperfections in the preliminary arrangements, and are probably to be looked for in first attempts of this kind ; no doubt the organisers of the next Geographical Exhibition will profit by the defects of the present, and have one complete all round.

As our readers are aware, the objects exhibited are classified into seven groups ; an indication of what is included in each group will convey some idea of the nature of the objects exhibited, as well as of the comprehensive nature of modern geography.

Group I., Mathematical Geography, Geodesy, and Topography, includes of course instruments of practical geometry, surveying, topography, geodesy and astronomy ; tables of projection and calculation, maps according to the various systems of projection, sidereal maps, maps of triangulation, maps showing the curves of magnetic declination, &c. In the second group, that of Hydrography and Maritime Geography, is included a great variety of instruments besides those used on board all sea-going ships ; there are dredging and sounding apparatus with specimens of what is brought up from the sea-bottom, sounding thermometers and charts, and publications of various kinds. The third group is an interesting one ; it includes Physical Geography, General Meteorology, General Geology, Botanical and Geological Geography, and General Anthropology. These are illustrated by instruments used in the observation of the principal meteorological phenomena, by maps, atlases and globes representing the essential facts belonging to the domain of Physical Geography, Meteorology, and the other sciences referred to, as well as publications bearing upon them. In group IV., that of Historical Geography, History of Geography, Ethnography, and Philology, are included, works and MSS., ancient and modern, bearing on these subjects, ancient globes and maps, antiquated instruments, ethnographic collections, and dictionaries of geography.

As might be expected, the fifth group, Economic, Commercial, and Statistical Geography is a large and varied one ; it includes works and maps bearing on population, agriculture, industry, commerce, ways of communication, ports, colonisation, emigration, &c., plans and models of bridges, tunnels, railways, routes, telegraph lines ; new apparatus for piercing rocks, manufactures or mineral objects peculiar to any country, collections of all kinds of commercial products, machinery used in manufactures of such products, produce and apparatus of deep-sea fishing, &c. Group VI., Education and the Diffusion of Geography, includes of course works, maps, charts, globes, models and instruments of various kinds, and deserves the attention of all engaged in education. Group VII. comprehends Explorations, Scientific, Commercial, and Picturesque Voyages, and, as might be expected, includes a great variety of objects. There are astronomical, topographical, meteorological, and photographic instruments of various kinds ; collections of every kind bearing on voyages of exploration, including cooking apparatus and drugs ; native implements and