difference? It is the sense of roughness and smoothness. Physiologists and anatomists have used the word "tactile" sense, to designate it. I confess that this does not convey much to my mind. "Tactile" is merely "of or belonging to touch," and in saying we perceive roughness and smoothness by a tactile sense, we are where we were. We are not enlightened by being told that there is a tactile sense as a department of our sense of touch. But I say the thing thought of is a sense of force. We cannot away with it; it is a sense of forces, of directions of forces, and of places of application of forces. If the places of application of the forces are the palms of the two hands, we perceive accordingly, and know that we perceive, in the muscles of the arms, effects of large pressures on the palms of the hands. But if the places of application are a hundred little areas on one finger, we still perceive the effect as force. We distinguish between a uniformly distributed force like the force of a piece of smooth glass, and forces distributed over ten or a hundred little areas. And this is the sense of smoothness and roughness. The sense of roughness is therefore a sense of forces, and of places of application of forces, just as the sense of forces in your two hands stretched out is the sense of forces in places at a distance of six feet apart. Whether the places be at a distance of six feet or at a distance of one hundredth of an inch, it is the sense of forces, and of places of application of forces, and of directions of forces, that we deal with in the sense of touch other than heat. Now anatomists and physiologists have a good right to distinguish between the kind of excitement of tissue in the finger, and the minute nerves of the skin and sub-skin of the finger, by which you perceive roughness and smoothness, in the one case; and of the muscles by which you perceive places of application very distant, in the other. But whether the forces be so near that anatomists cannot distinguish muscles, cannot point out muscles, resisting forces and balancing them—because, remember, when you take a piece of glass in your fingers every bit of pressure at every ten-thousandth of an inch pressed by the glass against the finger is a balanced force—or whether they be far asunder and obviously balanced by the muscles of the two arms, the thing perceived is the same in kind. Anatomists do not show us muscles balancing the individual forces experienced by the small areas of the finger itself, when we touch a piece of smooth glass, or the individual forces in the scores or hundreds of little areas experienced when we touch a piece of rough sugar or rough sandstone; and perhaps it is not by muscles smaller than the muscles of the finger as a whole that the multitudinousness is dealt with; or perhaps, on the other hand, these nerves and tissues are continuous in their qualities with muscles. I go beyond the range of my subject whenever I speak of muscles and nerves; but externally the sense of touch other than heat is the same in all cases—it is the sense of forces and of places of application of forces and of directions of forces. I hope now I have justified the sixth sense; and that you will excuse me for having taxed your patience so long in not having done it in fewer words.

ELECTRICAL STANDARDS[1]

THE Committee report that, in accordance with suggestions made at the last meeting of the British Association, arrangements have now been completed for testing resistance coils at the Cavendish Laboratory and issuing certificates of their value. These arrangements have been made by Lord Rayleigh and Mr. Glazebrook, and the report contains an account by the latter of the methods employed and the conditions under which the testing is undertaken, in order that those who use such coils may have a more exact estimate of the value of the test.

When a coil is to be tested, a suitable standard is chosen, and the two are placed in the water baths and left at least three or four hours—more usually over night. The comparison is then made in the ordinary manner by Prof. Carey Foster's method (*Journal of the Society of Telegraph Engineers*, 1874), and the coils again left for some time without being removed from the water. After this second interval another comparison is made. The temperatures of the water baths are taken at each comparison, and as a rule differ very slightly.

[1] Abstract of Report of the Committee, consisting of Prof. G. Carey Foster, Sir William Thomson, Prof. Ayrton, Mr. J. Perry, Prof. W. G. Adams, Lord Rayleigh, Prof. Jenkin, Dr. O. J. Lodge, Dr. John Hopkinson, Dr. A. Muirhead (Secretary), Mr. W. H. Preece, Mr. Herbert Taylor, Prof. Everett, Prof. Schuster, Sir W. Siemens, Dr. J. A. Fleming, Prof. G. F. Fitzgerald, Mr. R. T. Glazebrook, and Prof. Chrystal, appointed for the purpose of constructing and issuing practical Standards for use in Electrical Measurements.

We thus have two values of the resistance of the coil to be tested at two slightly different temperatures.

The mean of these will be the resistance of the coil in question at the mean of the two temperatures.

We are thus able to issue a certificate in the following form:—"This is to certify that the coil No. X has been compared with the British Association Standards, and that its value at a temperature of $A°$ C. is P B.A. Units or P' R. ohms; 1 B.A. Unit being ·9867 R. ohms." We further propose to stamp all coils in the future with this monogram and a reference number.

It will be noticed that nothing is said about the temperature coefficient of the coil or the temperature at which the coil is accurately 1 B.A. Unit. To determine this exactly is a somewhat long and troublesome operation, but at the same time it is one which every electrician, if he knows the value of the coil at one given temperature, can perform for himself with ordinary testing apparatus. It does not require the use of the standards. For many purposes the approximate value of the temperature coefficient obtained from a knowledge of the material of the coil will suffice; we may feel certain that any one requiring greater accuracy would be quite able, and would prefer, to make the measurement himself. We can state with the very highest exactness that the resistance of the coil X at a temperature $A°$ C. is R. To obtain the temperature coefficient accurately requires an amount of labour which may be quite unnecessary for the purpose for which the coil is to be used.

In accordance with the resolution of the Committee, a fee of 1*l.* 1*s.* has been charged for testing single units, and of 1*l.* 11*s.* 6*d.* for others.

The only coils the testing of which is regularly undertaken are single units and multiples of single units by some powers of 10.

But though this is so, two standard ohms have been ordered, using for the value of the B.A. unit ·9867 ohms, and when they arrive and have been tested, it will be easy to determine the value of coils which do not differ much from a real ohm. At present, without these standards—the coils actually used in the recent experiments at the Cavendish Laboratory have a resistance of about ·1, 24, and 168 ohms—the operation is troublesome. The simplest accurate method seems to be to combine in multiple arc the real ohm, and one of the 100 B.A. unit standards, and to compare the combination with a single unit.

ON THE MEASUREMENT OF ELECTRIC CURRENTS[1]

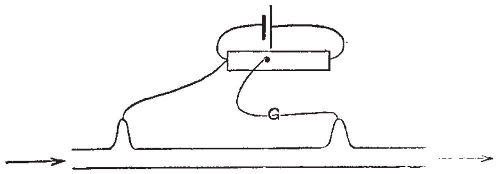
PERHAPS the simplest way of measuring a current of moderate intensity when once the electro-chemical equivalent of silver is known, is to determine the quantity of metal thrown down by the current in a given time in a silver voltameter. According to Kohlrausch the electro-chemical equivalent of silver is in C.G.S. measure $1{\cdot}136 \times 10^{-2}$, and according to Mascart, $1{\cdot}124 \times 10^{-2}$. Experiments conducted in the Cavendish Laboratory during the past year by a method of current weighing described in the British Association Report for 1882 have led to a lower number, viz. $1{\cdot}119 \times 10^{-2}$. At this rate the silver deposited per ampere per *hour* is 4·028 grams, and the method of measurement founded upon this number may be used with good effect when the strength of the current ranges from 1/20 ampere to perhaps 4 amperes. It requires, however, a pretty good balance, and some experience in chemical manipulation.

Another method, which gives good results and requires only apparatus familiar to the electrician, depends upon the use of a standard galvanic cell. The current from this cell is passed through a high resistance, such as 10,000 ohms, and a known fraction of the electromotive force is taken by touching this circuit at definite points. The current to be measured is caused to flow along a strip of sheet German silver, from which two tongues project. The difference of potential at these tongues is the product of the resistance included between them and of the current to be measured, and it is balanced by a fraction of the known electromotive force of the standard cell (see figure). With a sensitive galvanometer the balance may be adjusted to about 1/4000. The German silver strip must be large enough to avoid heating. The resistance between the tongues may be 1/200 ohm, and may be determined by a method similar to that of Matthiessen and Hockin (Maxwell's "Electricity," § 352). The propor-

[1] Abstract of a paper read at the Cambridge Philosophical Society.

tions above mentioned are suitable for the measurement of such currents as 10 amperes.

Another method, available with the strong currents which are now common, depends upon Faraday's discovery of the rotation of the plane of polarisation by magnetic force. Gordon found 15°[1] as the rotation due to the reversal of a current of 4 amperes circulating about 1000 times round a column of bisulphide of carbon. With heavy glass, which is more convenient in ordinary use, the rotation is somewhat greater. With a coil of 100 windings we should obtain 15° with a current of 40 amperes; and this rotation may easily be tripled by causing the light to



traverse the column three times, or, what is desirable with so strong a current, the thickness of the wire may be increased and the number of windings reduced. With the best optical arrangements the rotation can be determined to one or two minutes, but in an instrument intended for practical use such a degree of delicacy is not available. One difficulty arises from the depolarising properties of most specimens of heavy glass. Arrangements are in progress for a redetermination of the rotation in bisulphide of carbon.

RAYLEIGH

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

OXFORD.—In spite of the large majority in favour of the preamble of the statute allowing women to enter for certain University Examinations, the statute was again opposed on March 11, on being brought up by Council after amendment. After a lengthy debate, the statute was carried by 107 against 72. The chief arguments used against the measure were based on the alleged unfairness to men in allowing women to compete under no restrictions of time and residence, and for portions only of any examination; and on the evil to the health of women which might arise from their competing with men. Mr. Pelham, of Exeter, pointed out that the statute was not one to confer degrees upon women, but to make Oxford an examining body for the various centres of female education in England, and enable it to confer certificates which would have a recognised value. Mr. Sedgwick read letters from the heads of Newnham and Girton, at Cambridge, showing that the health of the students was excellent.

SCIENTIFIC SERIALS

THE *American Journal of Science*, February.—Examination of Alfred R. Wallace's modification of the physical theory of secular changes of climate, by James Croll. While agreeing with much that has been advanced by Wallace in his "Island Life," in explanation of geological climate, the author fails to perceive that any of the arguments or considerations there adduced materially affect his own theory as advocated in "Climate and Time." He still holds that with the present distribution of land and water, without calling in the aid of any other geographical conditions than now obtain, the physical agencies detailed in "Climate and Time" are sufficient to account for all the phenomena of the Glacial epoch, including those intercalated warm periods, during which Greenland would probably be free from ice, and the Arctic regions enjoying a mild climate.—Communications from the United States Geological Survey, Rocky Mountain division, No. v.; on sanidine and topaz, &c., in the nevadite of Chalk Mountain, Colorado, by Whitman Cross. The sanidine crystals contain gas inclusions, but no fluids, and the topaz, elsewhere found only in granite, gneiss, or other metamorphic or crystalline schists, here occurs in an eruptive rock probably of early Tertiary age.—On the occurrence of the Lower Burlington limestone in New Mexico, by Frank Springer. The observations made by the author in 1882 in the Lake Valley Mining District, Southern New Mexico, have brought to light numerous facts confirming the views of the Burlington geologists regarding the distinct character of the upper and lower subcarboniferous groups in that district, but demonstrating that the Lower Burlington limestone has a much wider geographical range than had hitherto been suspected.—The Minnesota Valley in the Ice Age (concluded, with two maps), by Warren Upham.—Glacial drift in Montana and Dakota, by Charles A. White. The author, who had already determined the presence of true northern Glacial drift in the region about the Lower Yellowstone River, now traces the same drift much further west. His observations were mainly confined to the Missouri Valley, but also reached to the vicinity of the Great Paw Mountains, extending for over a thousand miles at intervals from the Great Falls of the Missouri to Bismarck in Dakota.—Phenomena of the Glacial and Champlain periods about the mouth of the Connecticut Valley, that is, in the New Haven region (with two plates), by James D. Dana. The author concludes that during the Ice period the Mill River channel was excavated or deepened by glacier action. This channel, as it widened southwards below the mouth of the Pine Marsh Creek, became partly obstructed by sand-bars, which increased as the flood made progress, and ultimately merged in the wide terrace formation of the New Haven plain.—Supplement to paper on the paramorphic origin of the hornblende of the crystalline rocks of the North-Western States, by R. D. Irving.—On herderite, a glucinum calcium phosphate and fluoride from Oxford County, Maine, by William Earl Hidden and James B. Mackintosh.—Note on the decay of rocks in Brazil, by Orville A. Derby.

Bulletin de l'Académie Royale de Belgique, December 1, 1883.—Note on the presence of erratic boulders on the Belgian lowlands, by M. E. Delvaux. From the blocks of Scandinavian granites found at Limburg, in East Flanders, at Wachtebeke, and other places, the author concludes that during the Ice Age glaciation extended over the whole of the Netherlands, Belgium, and the shallow or exposed lands now flooded by the North Sea, terminating on the plains of Norfolk and Suffolk.—On amygdaline and germination, by M. A. Jorissen.—On the scintillation of the stars, in connection with the constitution of their light as revealed by spectrum analysis, by M. Ch. Montigny. The author's spectroscopic studies lead to the conclusion that those stars sparkle most whose spectra present the fewest bands, scintillation being weakest in those whose spectra are marked by broad dark bands.—On the fossil remains of *Sphargis rupeliensis* discovered in the brick clay of the Waas district, by P. J. van Beneden.—Note on a new differential dilatometer and its application to the study of the expansion of alums under the action of heat (one illustration), by W. Spring.—Some experiments on thin liquid layers of glycerine prepared from the oleate of sodium, by J. Plateau.—On the false appearances of aurora borealis observed in Belgium during the month of November 1883, by F. Terby.—Note on the anatomy and histology of a *Turbellaria rhabdocelis* (three illustrations), by P. Francotte.—On the laws regulating the proprietary rights of authors of musical and dramatical works in Belgium, by M. Cattreux.—An historical study of the reformer Froment and his first wife, Marie d'Ennetières, by M. Jules Vuij.—On a Society of Lawyers that flourished in Brussels during a great part of the eighteenth century, by Louis Hymans.—Remarks on the present state of music in the chief cities of Central Europe, by X. van Elewyck.—Generalisation of a property of surfaces of the second order, by M. Jamet.—Appearance of the satellites of Jupiter during the night of October 14, 1883, by F. Terby.—Note on the parallax of the sun deduced from the micrometric observations made at the Belgian stations during the transit of Venus on December 6, 1882, by means of specially constructed heliometers, by J. C. Houzeau.—Contributions to the history of the ovum; indirect relation of the germinative vesicle to the periphery of the vitellus (twelve illustrations), by Ch. van Bambeke.—Remarks on the study of biology and natural history in Belgium, by M. Ed. van Beneden.—On the salient features of the beds of the great marine basins, by M. A. Renard.

Atti della R. Accademia dei Lincei, December 16, 1883.—Notice of G. Orano's treatise on "Habitual Criminals," by S. Ferri.—On the causes of the retirement of the Alpine glaciers, by Roberto Paolo. The author concludes that the glaciers were developed under a mean summer temperature lower than at

[1] January, 1884. In a note recently communicated to the Royal Society (*Proceedings*, November 15, 1883) Mr. Gordon points out that, owing to an error in reduction, the number given by him for the value of Verdet's constant is twice as great as it should be. The rotations above mentioned must therefore be halved, a correction which diminishes materially the prospect of constructing a useful instrument upon this principle.