and the conducting power of the metals perform a part in the thermo-electric phenomena ; but this is not established by observations yet made.

The following table, by Professor Cumming, shews the relations of the thermo-electric and voltaic series, and of the series of conductors of heat and electricity. To these we have added two columns on the optical properties of the metals.

series of conductors.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Thermo-Electric series.** | **voltaic series by acids.** | **Of Electricity.** | **Of Heat.** | **Order of Metals in their degrees of Elliptical Polarization.@@1** | **order of Metals in their Re­fractive Power.** |
| Galæna.  Bismuth.  Mercury.  Nickel.  Platinum.  Palladium.  Cobalt.  Manganese.  Tin.  Lead.  Brass.  Rhodium.  Gold.  Copper.  Silver.  Zinc.  Cadmium.  Charcoal.  Plumbago.  Iron.  Arsenic.  Antimony. | Potassium.  Borium.  Zinc.  Cadmium.  Tin.  Iron.  Bismuth.  Antimony.  Lead.  Copper.  Silver.  Palladium. Tellurium.  Gold.  Charcoal.  Platinum.  Iridium.  Rhodium. | Silver.  Copper.  Lead.  Gold.  Brass.  Zinc.  Tin.  Platinum. Palladium.  Iron. | Silver.  Gold. Tin.  Copper. Platinum. Iron.  Lead. | Pure silver.  Common silver.  Fine gold.  Jeweller’s gold.  Grain tin.  Brass.  Tin plate.  Copper.  Mercury.  Platina.  Bismuth.  Speculum metal.  Zinc.  Steel.  Iron pyrites.  Antimony.  Arsenical cobalt.  Cobalt.  Lead.  Galæna.  Specular iron. | Grain tin.@@’  Mercury.  Galæna.  Iron pyrites.  Grey cobalt.  Speculum metal. Antimony, melted. Steel.  Bismuth.  Pure silver.  Zinc.  Iron plate, hammered. Jeweller’s gold. |

The structure or the crystalline arrangement of the par­ticles of bodies seems to exercise some influence over their thermo-electric powers. In a thermo-electric combination of *zinc* and *silver,* for example, the electricity increases with the temperature up to about 250° of Fahrenheit, when it ceases altogether, and by increase of temperature the elec­tric current is re-established in an opposite direction.

In order to measure the thermo-electric power of differ­ent binary combinations of metals, from the same differ­ences of temperature, a compound circuit must be formed of all those which we desire to compare. The junctions of the metals must be kept at the temperature of melting ice, excepting the junction which is to be made active, and which is to be plunged into hot oil. In this way the mere conducting power of the circuit is the same in every experiment, and the results obtained become strictly com­parable.

The following table, given by Becquerel,@@3 exhibits the quantities of the currents for a difference of tempera­ture of 36°, of pairs of *eight* metals differently arranged. The lengths of the metals were 7·88 inches, and their dia­meter about the 200th of an inch. The sign + indicates the metal from which the electric current proceeds.

|  |  |  |  |
| --- | --- | --- | --- |
| ***Thermo-Electric Power of Different Metallic Couples.*** | | | |
|  | **Tempera­ture of junction.** | **Deviation of needle.** | **Intensity of currents.** |
| + Iron and — tin | 68° | 36·°50 | 31·°24 |
| + Copper and — platinum | 68 | 16∙ 00 | 8∙ 55 |
| + Iron and — copper | 68 | 34∙50 | 27∙96 |
| + Silver and — copper | 68 | 4∙ 00 | 2∙00 |
| + lron and — silver | 68 | 33∙00 | 26∙20 |
| + Iron and — platinum | 68 | 39∙00 | 36∙07 |
| + Copper and — tin | 68 | 7∙00 | 3∙ 50 |
| + Zinc and — copper | 68 | 2∙00 | 1∙ 00 |
| + Silver and — gold ..... | 68 | 1∙ 00 | 0∙50 |

If we compare the numbers in the last column, we shall find, as Μ. Becquerel states, that, for a temperature of 36°, each metal acquires such a degree of thermo-electric

*power* that the intensity of the current, produced by the contact of the two metals, is equal to the difference of the quantities which represent each of these actions in each metal. Thus, if we call the *power* of each metal *p,* we shall have, in the case of the iron and copper junction, *p.* iron —*p.* platina = 36∙07∙ Substracting the first from the second, we have *p.* copper—*p.* platina = 8∙11, instead of 8∙55, given by experiment. The iron and tin junction gives 31∙24, and that of copper and tin 3∙50. The differ­ence in that of iron and copper is thus 27·74, in place of 27·96 by experiment. The intensity of the thermo-elec­tric current being, therefore, equal to the difference of the thermo-electric action produced in each metal by the same temperature, we shall obtain the powers of each of these metals as follows : Calling the *power,* or thermo-electric action of iron at 36° Fahrenheit, *x,* we shall have,

|  |  |
| --- | --- |
| ***p.*** Iron ***x***  ***p.*** Silver ***x — 26·20***  ***p.*** Gold ***x — 26***∙***10***  ***p.*** Zinc ***x —*** 26∙96 | ***p.*** Copper *x* — 27∙96  ***p.*** Tin *x* — 31∙24  ***p.*** Platina ***x —*** 36∙ |

Hence, if *x* were known, we should obtain *p* upon the supposition that the thermo-electric powers are propor­tional to the radiating powers of the metals. M. Becquerel has obtained the following numbers :—

|  |  |  |  |
| --- | --- | --- | --- |
| **Metals.** | **Thermo-Electric Powers.** | **Metals.** | **Thermo-Electric Powers.** |
| Iron 5∙  Silver 4∙07  Gold 4∙052  Zinc 4∙035 | | Copper 4∙  Tin 3∙89  Platina 3∙68 | |

These values will suit any thermo-electric circuit, and all cases where the thermo-electric power increases with the temperature, that is for all temperatures below 122° Fah­renheit.

Μ. Nobili@@4 formed similar circuits, with substances whose conducting power was inferior to that of the metals. Hav­ing made cylinders of porcelain clay, about two and a half inches long, and three and a half lines in diameter, he coil­ed round the ends of each of them cotton steeped in a con­ducting liquid, by which they were made to communicate directly with the galvanometer. One end of the cylinder

@@@1 See Phil. Trans. 1830, p. 294.

@@@s Id. p. 324.

@@@, Traité Exp. de L'Electricite, tom. ii. p. 53.

@@@‘ Biblioth. Univers, tom. xxxvii. p. 54.