using this apparatus, the vessel AA is filled two-thirds with water, the bulb of the thermometer being in the middle of the vessel, and the soldered extremity *s* of the wires in con­tact with it. The wires *f, f* are then placed in the cups, and the trough *e* filled with water and pounded ice, and carefully surrounded with flannel. The water in AA is then brought to the boiling point with a spirit-lamp, and kept at that temperature till the astatic needles and thermometer are steady. For temperatures above 212°, Dr Draper substi­tutes for the glass vessel a tubulated retort containing quicksilver. Dr Draper’s experiments were all made with the metals in the form of wires, and he obtained the fol­lowing general results:—

1. Equal increments of heat do not set in motion equal quantities of electricity.

2. The tension undergoes a slight increase with increase of temperature.

3. The quantity of electricity evolved at any given tem­perature is independent of the amount of heated surface, a point being as efficacious as an indefinitely extended sur­face.

4. The quantities of electricity evolved in a pile of pairs is directly proportional to the number of the ele­ments.

Dr Draper has been led to the following forms of con­struction, which give peculiar advantages to thermo-elec­tric combinations.

In fig. 84, A, let *a* be a bar of an­timony, and *b* one of bismuth, sol­dered at *c d,* and let the temperature be raised at *d,* a current is excited, which does not pass round the bars *a* ft, but in a shorter and readier path, through the metals between *c d,* circulating as shewn by the arrows. Nor will the whole current pass round the bars till the temperature of the sol­dered surface has become uniform. The combination A will therefore be improved, by giving it the form in fig. B, a part being cut out at the dotted lines. In this form the whole current will be immedi­ately forced to pass along the bars, and in such a pair the temperature will change very quickly. Dr Dra­per considers the form in fig. C, as the best for a thermo-electric couple. In this form *a* is a semi-cylindrical bar of antimony, ft one of bismuth, united to­gether by the opposite corners of a lo­zenge-shaped piece of copper *c.* From its extent of surface, the copper becomes readily hot and cold, and may be made very thin. With a pair of bars, three-fourths of an inch thick, and a circular copper plate *c*, with both surfaces blackened, Dr Draper repeated the greater part of those experiments, which M. Melloni made with his multiplier. Dr Draper found that thermo-electric currents, evolved by pairs of dif­ferent metals, do not differ specifically, like the rays of light and heat.@@1

We regret that our limits do not permit us to give an account of some interesting experiments of Mr Noad, on the effects of strong and weak electrical currents,@@2 on long flat coils of considerable breadth of surface, and of vari­ous inventions made in the United States by Dr Henry, Dr Page, and other eminent philosophers, an account of which will be found in the recent numbers of Professor Silliman’s *American Journal of Science.*

CHAP. IV ON THERMO-ELECTRICITY.

While investigating the influence of heat in voltaic com­binations, Dr Seebeck of Berlin was led to the importantdiscovery that magnetism was developed in two metals forming a circuit, when the equilibrium of temperature in that circuit was disturbed.

If A B C D, for example, fig. 85, be a metallic circuit, consisting of an arch of *bismuth,* A B C, and an arch of *copper,* A D C, then if one of the junctions, A, is heated, an electrical current is established, passing into the heated junction from the bismuth to the copper. From many ex­periments, Dr Seebeck found that, in vari­ous circuits formed with bismuth and other metals, the current always passes from the bismuth to the other metals, the bismuth losing *positive* electricity, or becoming *negative* with all the other metals.

The order of the metals, beginning with galæna, in which they are negative in reference to those which pre­cede them, is given in the following table, which, excep­ting some additions and alterations, was drawn up by Pro­fessor Oersted.

|  |  |
| --- | --- |
| Galæna placed above bismuth by Professor Cumming. | Copper placed here by Professor Cumming. |
| Bismuth.  Mercury placed here by Profes­sor Cumming, but beside lead by Oersted.  Nickel.  Platinum, very variable in its results.  Palladium.  Cobalt.  Uranium.  Manganese.  Titanium.  Tin, English and Bohemian.  Lead,@@1 pure lead and that occur­ring in trade.  Brass, different specimens give different results.  Gold purified by antimony, Oer­sted, and also that reduced from the oxide. | Silver purified by cupellation, and also that produced from the chloride.  Uranium.  Molybdenium.  Rhodium.  Iridium.  Zinc, pure and that occurring in trade.  Wolfram.  Cadmium.  Charcoal.  Plumbago.  Steel.  Iron, pure iron and that occur­ring in trade.  Arsenic.  Antimony.  Tellurium. |

Although Dr Seebeck found that most of the metals which stand near each other in the above series produce feeble thermo-electricity, and those more distant a more powerful effect, yet this law did not always hold. *Tel­lurium,* for example, is less thermo-electric with bismuth, and most of the other metals, than antimony is ; and with *silver* it is more effective than most of the metals above it. *Antimony,* too, is more effective with *cadmium* than with mercury ; while *iron* is very feebly thermo-electric with most of the other metals, especially *nickel* and *cobalt.*

The effects of the sulphurets Dr Seebeck found to be remarkable. Sulphuret of lead becomes negative even in contact with the bismuth. The sulphurets of iron, arsenic, cobalt and arsenic, and copper, all of which have a *maxi­mum* of sulphur, stand near to bismuth ; while all the sul­phurets, with a *minimum* of sulphur, have nearly the same power as antimony. The sulphuret of copper, with a mini­mum of sulphur, occupies a place even below antimony. Concentrated *nitric* and *sulphuric* acids stand above bis­muth ; while concentrated solutions of *potass* and of *soda* are below antimony and tellurium.

It has been considered probable that the specific heat

@@@, See Lend, and Edin. Phil. Mag., June 1840, vol. xvi. p. 431.

@@@’ Lectures, p. 356.

@@@• Professor Daniel places ***lead*** before ***tin.***