II. *On the relative powers of various metallic substances as conductors of electricity.* *By Mr.* William Snow Harris, *of Plymouth, Surgeon.* *Communicated by* J. Knowles, *Esq. F.R.S.* *November* 14, 1826.

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The relation between metallic bodies, as conductors of electricity, has engaged the attention of those whose talents have, at various periods, enriched that branch of science; I enter therefore upon a further investigation of this interesting subject with much diffidence; but having, by an easy method, obtained a series of results, apparently calculated to advance our knowledge of it, I am led to hope that a short account of my inquiries may be honoured by the notice of the Royal Society.

It has been long since observed by one of the most active contributors * to the success of modern science, that the heat evolved by a metallic body, whilst transmitting an electrical charge, is in some inverse ratio to its conducting power—a principle generally admitted, not only as a reasonable deduction, but also as being established by a great variety of facts; I have therefore sought to measure the relative degree of heat, so evolved, by various metallic substances in a gazeous medium such as air, and thus to discover their precise relations as conductors of electricity.

I employed for this purpose a very simple instrument, (represented by fig. 1. in the annexed plate,) which may be

* Mr. Children's Experiments with a large Galvanic Battery.

considered as little more than an air thermometer, the metal to be examined being drawn into a wire and passed air tight through the bulb. There is a glass tube, whose interior diameter is regular, and somewhat less than $\frac{1}{10}$th of an inch; one of its extremities is bent upwards and outwards for about two inches, and is united by welding to a short glass cup; this last contains a small quantity of coloured spirit. The opposite leg of the tube is sustained by a graduated scale, fixed upon a convenient base. The point at which the coloured spirit rests in this leg is marked zero. Upon the cup is screwed a glass ball of 3 inches diameter, having the metallic wire to be examined passed air tight across its centre. To effect this, there are two flanches of brass carefully cemented about the holes in its sides, each flanch has a small projecting shoulder, which receives the wire, and upon which is finally screwed a small brass ball; this ball has a flattened part to bear against a similar part of the flanch, and thus by a thin collar of leather, the whole is rendered air tight. The wire is secured firmly in its situation by means of a small peg of wood, and the holes in the balls are sufficiently deep to allow both the extremity of the wire and the peg to project a little, for the convenience of removal; thus the substitution of one wire for another is very simple and expeditious. Besides these flanches and balls, the bulb is also furnished with a sort of valve, attached in a similar way to its upper part, which being rendered air tight by a screw, can be occasionally opened so as to form a communication with the external air, and thus the coloured spirit may at all times be adjusted to zero. Fig. 2. Under these circumstances when an electrical explosion of sufficient force is passed through the wire in the bulb, the relative degree of heat it evolves is made evident by the ascent of the fluid along the graduated scale.

I submitted to experiment, by means of this instrument, the following metallic substances; silver, copper, gold, zinc, platinum, iron, tin, lead, alloys of gold and copper, of silver and copper, of silver and gold, brass, alloys of tin and lead, of tin and zinc, and an alloy of tin and copper. The above-named metals were carefully drawn through successive holes in a plate of steel until their diameters were the same, and in order to insure the transmission of an equal and similar explosion through each metal, I adopted the following method; two brass balls of the same dimensions were fixed at a given distance from each other, as in LANE's well known discharging electrometer; one of these balls, being insulated, was placed in immediate connection with the positive side of the battery, whilst the other was connected with the negative side, the metal to be examined forming part of the circuit. This last connection was effected by means of two fixed copper wires, inserted into the balls on each side of the glass bulb, and made perfect at the points of junction. When therefore the charge, accumulating in the battery, acquired a sufficient intensity to pass the given interval, the discharge took place through the wire in the bulb, which thus became immediately the subject of experiment.

The battery consisted of five jars, each containing five square feet of coated surface. They were placed on a metallic base communicating with the negative conductor, and were charged by means of long copper rods projecting immediately from the bottom of each jar.

The electrical machine employed to charge this battery consisted of a circular plate of glass, three feet in diameter, mounted between two horizontal supports of mahogany, the rubbers being insulated on glass pillars at each side of the plate, and joined together behind it by means of a curvilinear tube of brass, which formed the *negative* conductor; whilst the *prime* conductor projected vertically from the front of the frame.

The following table exhibits the results deduced from an extensive series of experiments on the different metallic substances above-named, in which the effect of the explosion is placed opposite the corresponding metal.

	Metals.	Effects.		Metals.	Effects.
	Copper	6	Alloys.	Copper 1 part, silver 1 part	6
	Silver	6	Alloys.	Copper 1 part, silver 3 parts	6
	Gold	9	Alloys.	Copper 3 parts, silver 1 part	6
	Zinc	18	Alloys.	Gold 1 part, silver 1 part ..	20
	Platinum	30	Alloys.	Gold 1 part, silver 3 parts .	15
	Iron	30	Alloys.	Gold 3 parts, silver 1 part .	25
	Tin	36	Alloys.	Tin 1 part, lead 1 part	54
	Lead	72	Alloys.	Tin 3 parts, lead 1 part....	45
	Brass	18	Alloys.	Tin 1 part, lead 3 parts ...	63
Alloys.	Gold 1 part, copper 1 part	20	Alls.	Tin 1 part, zinc 1 part	27
Alloys.	Gold 3 parts, copper 1 part	25	Alls.	Tin 3 parts, zinc 1 part ...	32
Alloys.	Gold 1 part, copper 3 parts	15		Copper 8 parts, tin 1 part	18

There are some interesting circumstances observable by reference to this table. If we consider the heat to be in the inverse ratio to the conducting power, it appears; 1st. That the heats evolved from silver and copper are alike, as also those of iron and platinum, and likewise zinc and brass; whilst the heats evolved from lead and tin, compared with each other are as 2 : 1; the same may be said of zinc and gold, or brass and gold.

2ndly. Considering silver and copper as the *best* conductors, (being the least heated by the explosion) then the conducting power of

Gold to copper or silver is as	-	2 : 3
Zinc or brass to copper or silver	-	1 : 3
Platinum or iron to copper or silver	-	1 : 5
Tin to copper or silver	- -	1 : 6
Lead to copper or silver	- -	1 : 12

3rdly. It may be observed that the conducting power of metals, when alloyed, is variously affected: thus the conducting power of gold and copper, or gold and silver, when alloyed together, is *less* than either of these metals in a separate state; and the difference in the conducting power increases with the quantity of the inferior conductor alloyed. Thus, gold one part, with copper three parts, had its temperature raised to 15° of the scale; gold and copper in equal parts to 20°; gold three parts, with copper one part, to 25°: the same may be said of gold and silver; whilst an alloy of copper and silver, in similar proportions, does not vary from either of the metals separately.

Tin and lead, alloyed, appears to give a conducting power formed by that of each metal taken singly, and varying, as above, with the quantity of the inferior conductor; thus, an alloy of lead and tin in equal parts, gives an effect equal to one-half the effect on tin, added to one-half the effect on lead, and so on; the same may be said of zinc and tin.

4thly. It is observable that a very small quantity of alloy may influence materially the conducting power; thus copper alloyed with only one-eighth part of its weight of tin, becomes heated by an electrical explosion as much as iron. In accordance with this fact, it was found that wires drawn from some foreign gold coins, said to be very pure, were much worse conductors of electricity, than when drawn from the same previously refined.

I did not find the conducting power to be influenced by any new disposition or arrangement of the quantity of metal; thus, whether the metallic wire was perfectly cylindrical, flattened into a ribbon, or separated into four smaller wires, the effect produced was in each case alike.

The influence of a small portion of alloy on the conducting power renders it necessary to have the metals pure, and I have reason to believe that the specimens, which were in these instances made the subjects of experiment, were as nearly so as possible.

The alloys were prepared by fusing the metals together with a common blow-pipe on a charcoal support, having previously weighed the relative proportions; after which the small button of metal was again weighed and drawn into wire. I am not aware that this method of forming alloys with small quantities of metal is liable to any material error.

The wires operated on in the course of this investigation varied from the $\frac{1}{40}$th to the $\frac{1}{80}$th of an inch in diameter, below which it was not found desirable to reduce them.

EXPLANATION OF PLATE II.

abcd The glass bulb.

ab The wire.

d The brass caps and screws which unite the ball to the glass cup.

e The glass cup.

c A small valve.

ab The flanches and balls.

gfe The glass tube.

gf The scale.

s The stand.

P*a*. *b*N The connecting wires.

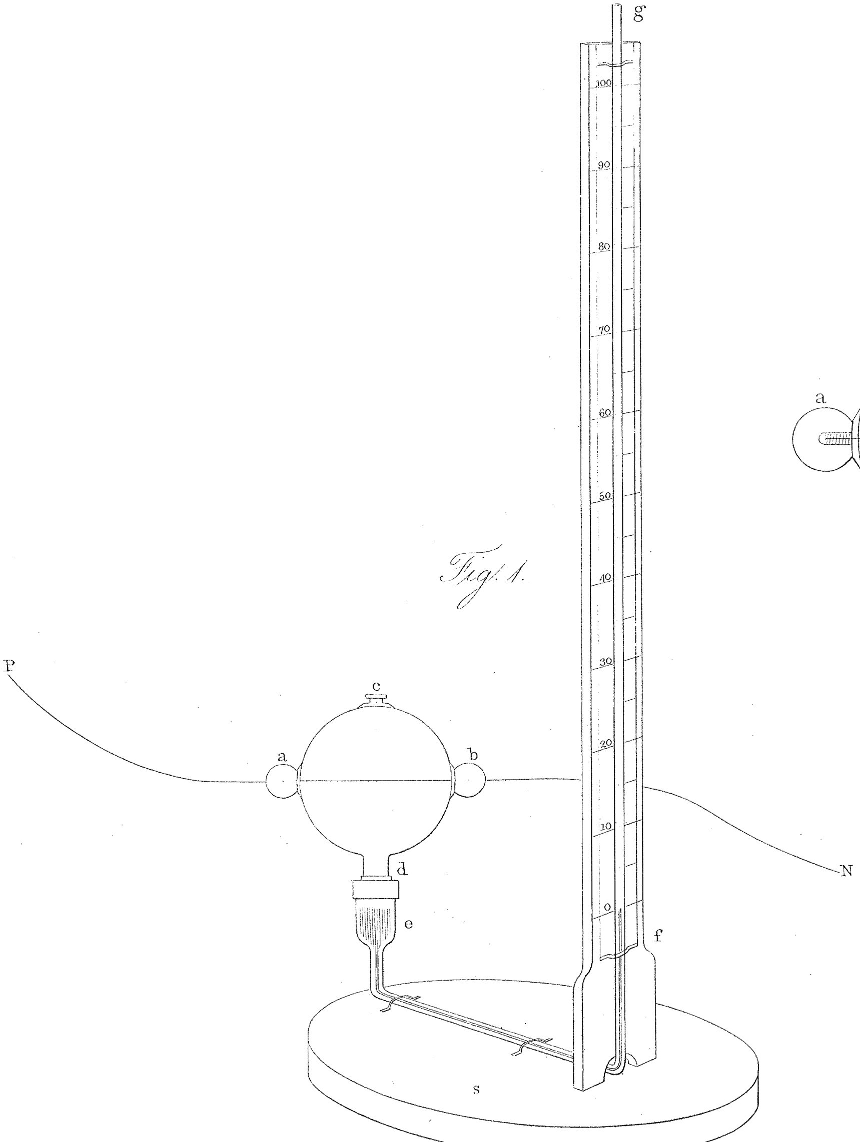

Fig. 1.

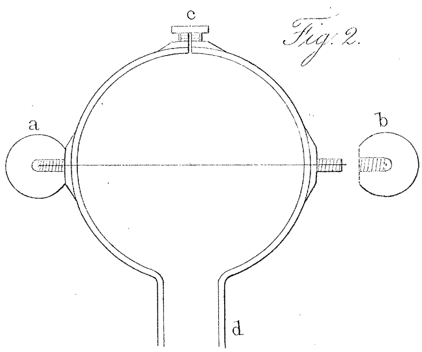

Fig. 2.