

from the 2,750,000 tons of coal, 6,500,000 tons* of iron ore, 9,000,000 barrels of flour, 36,000,000 bushels† of grain, 250,000 barrels of salt, 60,000 tons of iron, 100,000 tons of copper, 723,000,000 feet B. M. lumber, etc.

[*To be concluded.*]

CHEMICAL SECTION.

Stated Meeting, held April 21, 1896.

DR. HARRY F. KELLER, President, in the Chair.

SEPARATION OF SILVER FROM GOLD BY VOLATILISATION.

BY DR. JOSEPH W. RICHARDS, of the Lehigh University.

In making the quantitative blowpipe assay for gold and silver, it is usual to treat 100 milligrams of ore at a single fusion, yielding buttons which are too small to be weighed accurately, but whose weight must be found by measuring carefully their horizontal diameters.

As determined by Plattner (and often verified in the writer's experience), silver buttons weigh 0.6346 of the weight of spheres of silver of the same diameter as measured, and gold buttons 0.7506 of the weight of gold spheres. The buttons obtained usually weigh 0.5 to 1.5 milligrams, and the separation of the silver from the gold in buttons so small is a matter of considerable difficulty. Plattner remarks that no satisfactory method of separation in the dry way is known, and recommends the parting by nitric acid. Working, however, with buttons smaller than pin-heads, it is extremely difficult to boil two or three times with nitric acid, to wash until the silver salt is all removed, and then to gather and melt down the gold, without losing a considerable proportion of the gold in three or four directions.

* 8,000,000 tons in 1895.

† 46,000,000 bushels in 1895.

Knowing that, on long heating, silver gives a coating of oxide on charcoal, and that gold does not, I made experiments to determine whether silver could be thus separated from gold, and have found the method practicable. On heating to a bright-yellow heat (not to whiteness) upon charcoal an alloy of gold and silver, before a sharp-pointed oxidising flame, the silver volatilises easily and steadily until there is less than 5 per cent. of silver remaining in the gold. I estimate this volatilisation to take place a little above the melting point of copper, say at 1,100–1,200° C. To remove the remainder of the silver, the heat is raised nearly to whiteness, or to about the melting point of steel (1,500° C). When the silver is entirely eliminated, the gold, at this temperature, begins to volatilise also; in fact, a trace of gold will be carried off with the last of the silver, and if the ash of the charcoal be white it will show a faint crimson coating close to the assay. When this coating is heavy enough to be seen without the use of a lens, the silver has been completely volatilised and the remaining button is pure gold. The amount of gold necessary to give this coating is too small to be determined by weighing or measuring.

Having explained the principle made use of, I will give the further details of conducting the operation. The charcoal should be dense, so as not to burn away too quickly. Too light a charcoal will not stand the five or ten minutes' application of the oxidising flame without burning through the piece. It should also leave a white ash under the oxidising flame, so as to furnish a background on which to see the crimson gold coating which determines the end of the operation. I have found the dense, hard charcoal made by Johnson & Co., of New York, to answer these requirements admirably. It is well, also, to work with a porcelain saucer, or large sheet of clean paper, under the flame, to catch the button in case it should be blown from the charcoal.

In order to perform this separation without excessive exertion, I would recommend that a gas flame not over 2 centimeters high be used, that the tip of the blowpipe be advanced at least halfway through the flame, and inclined

somewhat sharply downwards, at an angle of about 45° . By observing these simple directions, a very sharp-pointed, needle-like oxidising flame will be produced, about 1 centimeter in length to the blue tip, which I have found the best for the purpose in view. To produce this the blowing need not be strong, but it should be kept up steadily. The button, in a shallow cavity near the end of the stick of charcoal, is now brought directly in front of the point of the flame, at about 1 to 2 millimeters from the visible blue tip. Its position, of course, is regulated by the temperature observed. The button should not, at this stage, be heated to whiteness, else the silver will boil and cause a loss by sputtering. The charcoal is held inclined towards the flame at an angle of about 30° , so that the flame descends almost vertically upon the button, and thus decreases the liability of its displacement by the force of the blast.

It will be found practicable to continue a blowing for about three minutes without discomfort, at the end of which time the operator may stop to observe the color of the button. Supposing the alloy, on starting, to have been white, it will usually become pale yellow in from three to six minutes. When the alloy exhibits a brass-yellow color, the heat should be raised, and the next blowing continued for not over two minutes. At the end of this time the alloy will usually exhibit nearly the pure gold color, but no gold coating, or, at most, only a trace of it will be seen on the charcoal. After this, the heat should be raised to nearly whiteness, and then continued for not over one minute at a time. If a faint gold coating appears, further heating for one minute will usually develop a distinct crimson coating, visible without the lens, and the alloy will show the pure gold color. It is then taken out, cupelled and measured.

If the amount of gold present be very small, it is difficult to continue volatilising silver after the button gets smaller than $\frac{1}{4}$ millimeter in diameter. The difficulty is caused by the ash of the charcoal, which, fusing to a slag, envelopes the button. To continue the removal of the silver, should the button arrive at this size without showing the gold color,

the operator cupels and measures a pure gold button of about the same size and adds it to the button being treated. The enlarged button is now worked down to pure gold, as before, removed, cupelled and measured. The weight of gold obtained is diminished by the amount added, the difference giving that in the ore.

If the heating to incipient whiteness be continued two or three minutes after the visible gold coating is obtained, a very pretty gold coating of bright, peach-blossom color is obtained, and a sensible amount of gold is lost by volatilisation. A pure gold button, 1 millimeter in diameter, weighing 7.58 milligrams, lost 0.03 milligrams (0.4 per cent.) each minute that it was heated to whiteness, and in five minutes gave a beautiful crimson coating. A silver button of similar size lost 18 per cent. of its weight, each minute, at only a bright-yellow heat. I estimate the point at which gold begins to volatilise as about the melting-point of soft steel (1,500° C.). It is certainly considerably below the melting-point of platinum (1,775° C.).

In conclusion, I wish to say that I have tested this method of separation in many different ways, with large and small buttons, and upon alloys rich and poor in gold, and have found the separation to be absolute when the conditions above described are properly observed. I have repeatedly alloyed a gold button with different amounts of silver, and then driven off the silver, the button, after two or three of such separations, remaining of exactly the same size and weight as at the start. In proposing this method of separation, I do not wish to disguise the fact that, to ensure success, it demands a steady hand and an experienced operator, and some practice; but I believe that any one who has mastered the art of blowpiping sufficiently to make gold and silver assays, can, in a short time, master this method of separating the gold and silver.

[In the discussion of the above paper, it was suggested that the method might be practicable in the ordinary assay of gold and silver, as, at assay offices, if an electrically heated furnace could be devised, in which the buttons could be placed on suitable supports, and kept at the proper temper-

ature to volatilise silver, with a current of air passing over them. The movement to the hottest part of the furnace would suffice to remove the last traces of silver, just as the last traces of lead are removed in cupellation in an ordinary muffle. The process of removing the silver would then resemble cupellation in its general outlines, except that the temperature would be about 300° to 500° higher.]

ELECTRICAL SECTION.

Stated Meeting, December 19, 1895.

MR. CARL HERING, President, in the Chair.

MECHANICAL CONCEPTIONS OF ELECTRICAL PHENOMENA.

BY PROF. A. E. DOLBEAR,
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And now we might add something concerning a most subtle spirit which pervades and lies hid in all gross bodies, by the force and action of which spirit the particles of bodies attract each other at near distances, and cohere if contiguous, and electric bodies operate at greater distances as well repelling as attracting neighboring corpuscles, and light is emitted, reflected, inflected and heats bodies, and all sensation is excited and members of animal bodies move at the command of the will.—*Newton, in Principia.*

In Newton's day the whole field of nature was practically lying fallow. No fundamental principles were known until the law of gravitation was discovered. This law was behind all the work of Copernicus, Kepler and Galileo, and what they had done needed interpretation. It was quite natural that the most obvious and mechanical phenomena should first be reduced, and so the *Principia* was concerned with mechanical principles applied to astronomical problems. To us, who have grown up familiar with the principles and conceptions underlying them, all varieties of mechanical phenomena seem so obvious, that it is difficult for us to understand how any one could be obtuse to them; but the records of Newton's time, and immediately after this, show that they were not so easy of apprehension. It