TOUGHENING (PURIFICATION) OF GOLD (SILVER, &c.), IN THE CRUCIBLE.

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In all operations in the Arts, economy, especially the avoidance of needless wastage, is of importance, in direct proportion to the value of the material operated on.

While a loss of 10 per cent. may be and is tolerated in working iron in the fire, the United States Government holds the officers of Mint responsible, in working gold, for any wastage beyond .001 ($\frac{1}{10}$ of one per cent.), and in silver, beyond .0015. In practice, the actual loss is usually far within that range. In general, the tolerance of loss, in working the metals, is inversely as their commercial value.

The recent progress of knowledge and skill, in the Arts, is well shown in the improved commercial character of some of the commoner metals. When I first examined the copper of commerce, in 1850, with reference to its use for minor coinage, or for alloying gold, and silver, coin, I found that a large amount of the best commercial article contained about 98 per cent. copper, and that it often made hard or brittle alloys. We now employ copper averaging 99 per cent. pure, with small quantities of nickel, silver, oxygen, silica, and the usual intruder into everything on earth, iron. In a few instances, 50,000 lbs. of extra refined copper (from Pope, Cole & Co., Baltimore, Md.), yielded, to a specially fine analysis (by Booth, Garrett and Blair), about 99$\frac{3}{4}$ per cent. copper. In like manner, a remarkable change has occurred in the silver market. About 1850, the best commercial silver usually assayed 99 per cent., and in 1853, I took credit in exhibiting a pile of about ten tons of silver, that averaged nearly 99$\frac{5}{10}$ per cent. At the present time, a large amount of the good silver of commerce, from the mining regions, averages 99$\frac{9}{10}$, and sometimes attains 99$\frac{95}{100}$; failing only by $\frac{5}{1000}$ of absolute purity.

The gold of commerce generally requires toughening, or purifying, to fit it for coinage, or jeweler's use, as it consists of bars, with silver, somewhat improved by melting,—of lumps and grains of ore, —and of old jewelry, containing tin, lead, zinc, and all the cheap elements that ingenuity, greed, and deception can use to dilute and cheapen the precious metal, without wholly obliterating its coveted

yellow color, and its toughness. Some really tasteful jewelry, of fair quality to the eye, which chooses to judge for itself, contains only one-fourth of gold, and some still less.

The lumps and grains are melted to drive off mercury, &c., and are then refined, together with good silvery bars, by acid processes, termed quartation, or parting. Where tin is present, as in jewelry, the nitric acid process is preferable, and after thoroughly washing out nitrates, muriatic acid, drenching the residue, dissolves out the tin, and the residue is pure gold. Iron is a frequent enemy to the ductility of gold, an extremely small percentage rendering it hard or brittle, as in the case quoted in "Jour. Amer. Chem. Soc., vi. 182." The principle, there developed, is to remove all the embrittling elements, with the least practicable quantity of the valuable metal, on one side (to be subsequently purified); and on the other, to have all the rest of the gold, practically pure. The loss of gold, in the fire, is in proportion to the length of exposure, and to the quantity exposed; and the process described eminently guards these points. A single practical illustration will make the principle clear. Suppose a melt of 5,000 ozs. of gold, containing .001 (5 oz.) embrittling impurity, is separated, by a short working in the fire, into 100 oz. skimmed off impurity (consisting of 95 oz. gold, and 5 oz. of embrittling matter, together with flux), and 4,900 oz. practically pure gold; then only 95 ozs. are exposed to further possible wastage, in the fire.

TOUGHENING, OR PURIFYING, SILVER FROM LEAD, &C.

The principles, and to some extent, the practice, above applied to gold, may be applied to silver, adulterated with lead, tin, zinc, &c.

In spite of the great improvements in preparing silver bars for the market, as noted above, we often received them alloyed with lead, &c., and quite unfit for coinage, some 10 or 15 years ago. Recently they have generally been unexceptionable. There was no reason for having inferior silver in the market, because the Western smelters then had cupels, and knew how to use them, but the lower price of the inferior silver was an irresistible temptation to a purchaser. I bore the brunt of the mistaken purchase, for the question given to me for solution was, to refine a few tons of plumbic silver, without a cupelling hearth; for even if I had desired

one, there was no room for its erection in the Mint. Since I solved the question successfully, and by a rather novel method, it seems to be worth describing. At one time I smelted a lot of some 50,000 ozs. of commercial silver bars, in melts of about 3,500 ozs. each, and treated each melt in the same way, as follows: It was melted, with the addition of about an ounce or more of anhydrous borax, which greatly facilitates fusion, and, to a limited extent, prevents volatilization, although forming only a paper-thick covering to the melted metal. A covering of bone-ash ($\frac{1}{8}$ to $\frac{1}{4}$in. thick), having been sprinkled over the surface, crystals of soda-nitre are here and there dropped through the covering, and after effervescence has somewhat progressed, a black lead dipper, held in the tongs, is moved around the top, in interlacing circles, to spread the oxidation, and the metal is then more thoroughly mixed by plunging the dipper to the bottom of the metal, moving it up and down, once or twice, and, after lifting it out full, by pouring it back into the metal. This operation, of oxidizing throughout, is advantageously repeated, and more than once, if the silver is known to be foul with lead. All these operations being rapidly performed, the surface is hastily skimmed by a triangular crucible (so as to have always a flat side for skimming), experience guiding the melter to take off all the fluxed matter, with as little silver as is conveniently practicable. The whole time of oxidation, and skimming, is of but a few minutes duration, so that no chance is given to the oxidized metals to revert to the metallic condition, in the presence of their tempters, carbon and melted metal. The processes of oxidizing, and skimming, are repeated until the *look* of the remaining silver, or the test of a cast strip, proves sufficient purity of metal. In the case here specially noted, the working of 12 melts occupied between one and one and a-half days to resolve them into over 49,000 oz. of silver sufficiently pure and tough for coinage, and less than 1,000 ozs. of silver with litharge, and other oxides, in the skimmings. These last consist of bone-ash, cemented by litharge, borax and alkali, into mixed soft and hard sponge, or brick, with some grains of silver entangled in the mass.

The treatment of the skimmings constitutes the chief, and, I believe, novel peculiarity of the process. The whole residues having been charged into pots, with the addition of some charcoal, to aid in reducing the litharge, and of pearlash, to make the slags thinner,

was melted in a covered crucible, at a full red heat, and allowed to cool quietly, so as to make a king of all the reduced metal, with a cinder or slag above it. When cold, the slag and cinders were ground and sifted to recover metallic grains. The cold kings were put into a crucible, and gradually heated, by a long continued heat, from below the melting point of lead, to a full red heat, and the eliquated metal, at different heats, collected separately. The first runs were nearly pure lead, so as to be cut with the same facility as the soft lead of commerce.

There was only a slight wastage of silver in all the above operations, and but little loss of lead. I found the whole process a very short method of procuring nearly the whole of the silver from its obstinate alloy with lead, and attended with a trifling wastage; and I have good ground for believing that a little experimental practice might easily lead to its further improvement, so as to be substituted for cupelling, where the latter is not convenient. The depressed hearth of a reverberatory might readily be used as the black lead crucible, and other modifications devised according to the exigencies of the case. These remarks are not designed to disparage the admirable process of cupellation, but merely to show that we are not necessarily confined to the last. In fact, the process I have indicated *is* cupellation, with a movable cupel, and oxysalts used instead of a blast.

It is hardly worth drawing the plain conclusion that where lead is thus removed from silver, zinc, tin, antimony, &c., will be oxidized at the same time, and caught either in the metallic residues (kings,) or as oxides in the cinders. So efficient, economical and easy of execution, is the process, that one leaps to the conclusion that where silver contains one or more of the above oxidizable metals, lead may be added and the whole worked off with ease. Direct trial has proved it.

PURIFICATION OF PHOSPHOR-BRONZE.

The question having been propounded to me about a year ago by a worker in copper alloys, of removing the phosphorus from phosphor-bronze, I applied the principle herein developed, of using the greater oxidizability of the phosphorus and skimming it off, with a cover of lime on the melted metal. Although I had the time of but a half day to test the process, and in spite of no previous experience in skimming, I succeeded so far as to prove that a simple and effectual process can readily be evolved from the hints I have given in this paper.