THE SMELTING FURNACE OF THE U. S. MINT.

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Its capacity and economy.—The experience of over thirty years in using the gold and silver smelting furnace of the mint at Philadelphia, has gradually led to so many and such thorough alterations in its construction, that nothing remains of the original furnace except the cast iron plates forming the front, sides and top—the mere outside shell, introduced by the late Mr. Franklin Peale, in 1835, the result of his observations and reflections made in Europe on behalf of the U. S. Mint. I can suggest no improvement in the outer form, but confirm Mr. Peale's conclusion of the superiority of the sloping top, which we employ, over the flat top of many European furnaces, because of the greater facility of access offered by the sloping top to the melter in dipping out the liquid metal.

Having carefully studied and modified the interior of this furnace with especial reference to economy of time and fuel in melting—to convenience in melting and casting, and above all, to avoidance of wastage of the precious metals, I deem it desirable to publish drawings of the present furnace, with some details of our mode of working it, for the possible benefit of those interested in works for smelting the precious, or even the commoner metals.

Melting of Steel.—Furnaces for melting steel in crucibles are sometimes sunk beneath the pavement of the melting room, to allow the fullest application of human strength to lift out, by hand, the melting pot, with its heavy contents of melted metal at a bright red or white heat, and pour it rapidly into the molds in a gushing stream, so as to relieve the caster of too long exposure to the intense heat.

Melting Gold and Silver.—Silver and gold are cast at a red heat by dipping up from the pot a few pounds of the melted metal at a time in a small black lead dipping cup, held with tongs, and by carefully pouring it in a small stream into the open gate of the mold, sedulously shunning the loss of a drop by spilling or splashing. A single flashing coruscation is sufficient to alarm the responsible melter for the safety of his account. The heaviest convenient weight to handle and cast safely, is about 120 oz. (over 8 lbs), so that it would require 50 dips to cast out a melt of gold of 6,000 oz. (about 400 lbs.). In like manner the usual silver melt of 3,600 oz., requires about 40 dips to cast out all the metal, except the small amount left in the pot to start the next melting. The frequent dipping and carrying the dipped metal from the pot to the mold, jealously guarding against loss, the deliberate pouring of a small stream into the narrow openings of the mold, the number of pourings required to discharge one melt, and the necessity of frequently stirring the residue in the pot during the whole casting, to secure uniformity of composition and prevent segregation—all these requisites show the necessity, or great advantage, of having the surface of the metal to be dipped at the height of about 30 inches from the floor, the most convenient height for a workman to employ his force with steadiness, and to continue it for fifteen minutes, the usual time of casting, with the least fatigue.

The views presented above may prove a sufficient answer to the question, often asked, why we prefer melting the precious metals above instead of below the floor of the melting room. One of the above reasons, the convenience of dipping and ladling, applies equally well to copper and its alloys, except for large castings.

Risk of Melting Precious Metals by Blast.—A recent improvement in melting metals is the use of gas and a blast of air, whereby many crucibles are heated at once as in regenerative furnaces, etc., whether the fuel be coal, or artificial, or natural gas. The system seems admirably adapted to steel, and no one thinks of charging loss of metal to the brilliant sparks of fire that illuminate the foundry during casting. Who then would dream of loss of steel in vapor, which has never been seen or heard of? While a single irregular spark in casting gold or silver might make the melter tremble for serious loss, great care can prevent it; not so, however, with the vapor of these metals, which often constitutes a serious loss to the melter, the more so because entirely invisible. That this vapor does constantly rise from the surface of these melted metals in a crucible, over which the draught of the chimney is passing, is clearly proved by the weight of the metal in the crucible constantly diminishing in direct proportion to the length of exposure to the melting heat. An exceedingly thin covering of glass, or even of borax, on the metal in a crucible, diminishes, but does not prevent, volatilization. The more quiet the movement of air, the less the volatilization. Hence the object of the smelter should be to avoid currents of any kind of air or gas moving around the melted precious metals. They should be melted, with their covering fluxes, in a closely covered crucible, as remote as practicable from gaseous currents. Hence my conclusion that the blast to produce heat should not be employed with gold or silver.

Saving Volatilized Metal.—Extreme care to avoid loss has been extended a step further at the U. S. Mint than is done elsewhere, I believe, and I have reason to know that wastage is thereby diminished. When dipping melted metal out of the large crucibles in the fire, we not only keep the surface constantly covered with borax, powdered charcoal, etc., but since that surface is more or less exposed to the draught of air and products of combustion of the fuel escaping up the chimney which are liable to carry up volatilized metal, we take the precaution of closing a damper in the chimney just above the furnace during the whole time of casting, so that any possibly volatilized metal is thrown out and condensed in the air of the melting room, where it settles on the floor and is recovered with the sweepings at the close of each day.

Cast Iron Ash pit.—Since the smelting furnace of the Mint is presented in considerable detail in the accompanying engraving, I shall only draw special attention to parts that seem to require fuller explanation. The furnace consists of the front, sides and top of cast iron plates, bolted to a square cast iron base, as seen in plan and both elevations. The most striking peculiarity is the cast iron ash pit, which I planned and introduced some thirty years since, in place of the fire brick ash pit and hearth, because these became richly charged with gold and silver grains, and required to be broken up and ground several times in the year in order to procure the grains. Now we gather up these grains daily and in a few minutes' time. The form of the ash pit can be gathered from both elevations, and from sections on A B and C D. It is cast on the middle of the base of the furnace, and in one piece with it, as shown in Sec. A B. It is of uniform height on sides and back (see C D and A B), but the front is depressed nearly to the base (A B) making easy access from the front to the space beneath the fire. (*See elevations*). The peculiar curved form of the bottom facilitates the accumulation of ashes toward the front, and their frequent removal by a shovel. Sec. A B shows the back part of the ash pit strengthened by heavier iron at top and bottom, as more fully exhibited in Figs. 1, 2 and 3, the top being liable to burn from exposure to intense heat, and the bottom liable to fracture.

The *Fire Chamber*, built of ordinary fire brick in square form. as being more readily constructed, and because its corners act as a reservoir of fuel and heat, stands on a square cast-iron base, shown in Fig. 4. Three sides of the square are cast in one piece, and the fourth side, being liable to burn out first, is a separate casting and can be replaced without disturbing the rest. Its position is seen in all the large drawings, but best in Sections A B and C D, where it rests on the top of the ash pit, and just above the grate bars. Section C D alone shows the pile of firebricks on their flat side and flush with the cast-iron base, with large fire slabs of 1½ inches thickness between them and common red brick. The convenience of this arrangement is that when the fire space is to be renewed, the firebricks only are removed and quickly replaced by new bricks set against the slabs. Section C D alone exhibits the true arrangement and dimensions of the fire space and its linings, the others being a vague, typical representation of brickwork without dimensions or special aim. The fourth side of the bed-plate will last three or four weeks, and when burned out is easily replaced, the renewal of the whole requiring only part of one day. The surface of the fire chamber is picked daily for grains of gold and silver, and if the virtue of gentle care in this operation were more in vogue, the life of the lining would probably be doubled in time. The whole of the cast iron bed-plate is replaced once or twice a week. The whole ash-pit enjoys many years of life.

Grate Bars.—While there is nothing peculiar in these bars, which are given in front elevation, and both sections resting close together on their two bearing-bars, Fig. 10 and Section A B, the position of the back bearing-bar is important. It should be brought forward an inch or more from touching the back part of the ash-pit, so that the cooling air passing up behind the bar will insure a prolongation of life.

Furnace Working-Door.—The sliding-top door of the furnace is worth noting. When I first took charge of melting 35 years ago, this door was a massive, curved slab of iron, of great thickness, as if designed to keep the heat in and to last forever, and required considerable force to move it by its heavy handle. Moreover, when the furnace was at its high melting heat, the door was also hot. To economize heat and protect the men I contrived the door represented in Figs. 5, 6, 7, 8, a combination of cast and sheet iron with a fire tile lining and a space between it and the cast iron top for a cooling current of air, so that when the furnace is at almost a white heat, not even redness can be seen, and the door may be touched without burning. Moreover, instead of requiring much force to move it, a boy can slide it on its little railway. (*Front elevation.*)

Since a small part of the cast iron furnace top, just in front of the center of the fire, is liable to be burned out, it is made replaceable. See Plan, Section A B, and Figs. 11 and 13, noting that 13 is inverted. This small piece, detailed in Fig. 11, and in place in Section A B, will last several months and can be replaced in a few minutes.

Having noticed the prominent features of the furnace with special reference to its economy and utility, I merely note, in closing the description, that in our closure of accounts (at least annually) to determine the losses in working the precious metals to the utmost nicety, we make a thorough cleansing of all the apparatus, furnaces, floors, etc., even to chipping the surface of bricks, etc. These pickings, etc., are ground and sifted repeatedly, until reduced to two conditions, one consisting of grains of precious metals, large and small, which are melted into masses, weighed, assayed, and their value credited to the operator, and the other being "sweep" or fine dust, from which we can extract no more gold or silver, and which is sold to sweep smelters at a fair discount from its assayed value.

Recovery of Gold and Silver from Metallic Iron.—There is a third form of residue, the pieces of iron, tools, grate bars, etc., which always have grains of gold and silver on them and in them, and which cannot be ground to powder. How shall we recover the valuable metals from these?

It was answered thirty years since by heating the iron in the fire (oxidizing it), and making it scale off by beating it with hammers; for gold seems to cling to iron with great tenacity. Thus by alternate heating and hammering all the precious metal was obtained, except what rose up in fine powder up the chimney where the iron was heated, and what remained invisible in cracks and holes in the iron itself. Such a gigantic operation required a force of a dozen men, seated near the furnaces in the melting room, each with heavy hammers in hand, scaling the hot metal as it came from the fire, and creating a bewildering din, during three or more days of ten hours each.

My first improvement of this process was to convert all the iron into sulphuret of iron, treat it by cold dilute sulphuric acid, and purify the gold and silver residues before melting. Although the process was a marked improvement on the noisy nuisance of the old method, yet it required too long a time and too much space.

My last improvement, which is still practised, consists in the very simple operation of melting all the iron residues from the furnaces, even including grate bars, and keeping them in a quiet melted state, so as to allow the heavier gold and silver to settle out of the iron. When the mass is cold, the precious metal is knocked off the bottom by a hammer as a single, tough king with scarcely a trace of iron in it, while the iron mass above it has never yielded a race of gold or silver to the assayer. Instead of spending three weeks of annual vacation from melting, in hammering tons of accumulated iron, we now melt through the year, whenever convenient, from five to fifty pounds of iron residues at a time. We gathered in one melting last Autumn, a cake of a few ounces of gold and silver from a mass of over fifty pounds of iron in part of a day, and the latter was entirely free from the precious metals. When I first succeeded with this process, I could hardly believe in the perfect separation from iron, and the late Mr. J. Eckfeldt, the best assayer in the United States, doubted it, until by numerous tests made from a piece of some thirty pounds of iron, he found the total absence of gold and silver.

The question may be asked, Is there not a loss by volatilization of gold or silver, even if there is a perfect separation from iron? I can only say that we have found none, but at the same time, I have not yet made crucial experiments to determine this question. I will, however, express the opinion that there is none, because the specific gravity of the two metals carries them rapidly below the iron without alloying with it.

I will now add but a remark on the execution of this process. Since much of the iron from such a source is burnt metal, much oxidized, which therefore obstinately resists melting, or if melted, is rather too thick and viscid to let the gold through it, the simplest remedy is to add more iron that is not burned, especially some that is highly carbureted, and to assist fluidity by adding little common salt. I need hardly say that the metal must be kept for hours in the liquid state to allow fully for settling.

It remains to state the amount of gold and silver operated on in the U. S. Mint at Philadelphia, in five or six furnaces for silver and one or two for gold.

Taking the last fiscal year (July 1, 1883, to June 30, 1884) we operated on 26,370,821$\frac{45}{100}$ standard ounces of silver (= 1,808,284$\frac{90}{100}$ avoirdupois pounds), and on 764,264$\frac{231}{1000}$ standard ounces of gold (= 52,406$\frac{690}{1000}$ avoirdupois pounds).

The value of the silver is approximately the same number of dollars as of ounces. The value of the gold was $14,218,869$\frac{41}{100}$.

The wastage on the gold was 18$\frac{184}{1000}$ st. ozs., equivalent to $\frac{24}{1000}$ of the legal allowance, which is $\frac{1}{1000}$ of the whole amount operated on.

During the same period we made 107,527 lbs. of sweep, containing 242$\frac{196}{100}$ st. ozs. of gold, and 8,991$\frac{71}{100}$ st. oz. of silver. One pound of the general average of sweep contained $\frac{2}{3}$ of one grain of pure gold, and 61$\frac{7}{8}$ grains of pure silver.

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