The chlorination process, as it is variously applied according to the different patents granted for it, has a drawback in the treatment of these ores in its restriction to those only in which the metals are in a state of fine division, therefore in ores like some of ours in which the metals are in larger bodies it is rendered useless; but in any case the ores must first be roasted to get rid of the arsenic and sulphur, as they form troublesome salts with the chlorine. Now, it is quite apparent that if part of the treatment could be dispensed with, it would be the means of increasing the returns in a great many mines at present in operation. Why then could we not dispense with the chlorination and do the work with the roasting alone. It may seem impossible at first, as the roasting is merely a preliminary to the chlorination, which is the principal.

There is a law of metallurgy which has been greatly neglected, and I may say has not been paid the attention or given the research due to it. That law expressed is that when a metal is alloyed with one or more of the other metals, that the resultant alloy has a lower melting point than the mean of the several melting points of the constituents taken together. Let us take an example, for instance, an alloy of one part lead, one part tin and two of bismuth. The melting point of lead is 325° C., tin 227·8° C., bismuth 259° C., their sum is 811, their mean 270° C. This will melt at 100° C., which is just 170° C. below the mean. Is this not sufficient proof for this law? Let us take another example, that of an alloy of lead and platinum. Platinum does not melt even in the highest temperature obtainable in a blast furnace, but only in the flame of the oxyhydrogen blowpipe. Now the calorific intensity of oxygen burned in hydrogen = 3,154° C. Now if we take for granted that the heat absorbed by the nitrogen of the air is equal to the extra heat generated by the blast caused by the forcing of the gases through the nozzle, which consequently causes a more rapid combustion, hence a higher temperature, these figures represent the blowpipe-flame's temperature, hence the melting point of platinum. Those calculations of mine are not mathematically correct to the fraction of a degree or so, but are quite accurate for our purpose. Now the melting point of lead added to that of platinum = 3,476; therefore the mean = 1,739° C. I have melted such an alloy at 1,000° C., that is 739° C. below the mean. Is this not a good example? This law is confined to no special one but holds good for all alloy.

Why, then, if this is a general law of alloys, is it not applicable in the case of arsenic, sulphur, silver, and gold? You will object, as arsenic and sulphur are not metals proper. That is quite true of the sulphur, but not so of the arsenic; but still that would not incapacitate them to form alloys with the metals. They may either be as a salt, such as a sulphide, or arsenide, or be in molecular proportion, to form chemical compounds, or in excess or deficient, for such and only form mechanical mixtures, or one contained in solution in another, or in an allotropic state; but still they are alloys, and in proof of this we have only to look at shot lead, which is an alloy of arsenic and lead. Copper also alloys with arsenic forming a greyish, brittle metal; and does not galena have the resemblance and properties of an alloy.

In consideration of this I hold that arsenic, sulphur, silver, or gold do alloy, and that therefore the temperature at which they melt is lowered in virtue of their being alloyed with the sulphur and arsenic.

In accordance with this, we will now consider the following data:

As. melts at 220°C.

| S. | " | " | 115°C. |
| Au. | " | " | 1102°C. |

We will say, although it oxidizes at that temperature, therefore its melting point must be lower.

Their sum is 1,437, their mean 479°C.; therefore this would seem to indicate the melting point of this alloy. This corresponds to a temperature below incipient red, as it is, according to Pouillet, 525°C.; dull red being 700°C. I do not mean to insinuate that gold alloyed with arsenic and sulphur will be reduced to such a ridiculously low melting point, but I do mean to say that it is lowered considerably, as I have melted them at about an incipient cherry red, corresponding to a temperature of about 800°C., and perhaps a few degrees lower, so that I can vouch for it as being correct. If the melting point of silver be added —namely, 1,023°—the sum will = 2,460, the mean 615°C. I may say I have melted them at such a temperature, and below it.

Many of our ores carry sufficient S. and As. for this law to be taken advantage of in their treatment; but before we can see in what way it would be advantageous to us we must consider another law. That law is, namely, the spheroidal form given to small portions of metals, or alloys, under three different modes.

This is a law which none of the works as yet published on Metallurgy have mentioned, and I don't think that any of our profession have paid any attention to it, and that some are even ignorant of its existence. We shall consider the modes under which this form is given:

1st. When metals in a thin body or sheet, such as gold leaf, are exposed to certain temperatures the sheet breaks up and forms into globules. This may be proven by taking any gilded work—say, for instance, on wood—and place it on the lid of a furnace or common stove. When the wood begins to char the gold will be seen to form into globules. This is caused directly by the heat.

2nd. When certain metals are alloyed with others they cause a shrinkage concentrated to a certain spot, which acts as a nucleus around which another portion of the alloy forms a globule when cast upon a cold surface, into

water, or when pressed from under or through a crust of part of the alloy solidified. This is caused, first, by one of the constituents cooling quicker than the rest; second, when one of the constituents has a greater shrinkage power than the others.

We can, again, take shot lead into account. As I have said, it is an alloy of arsenic and lead: arsenic is by nature a great shrinker or contractor, and thus it is used to give the rotund form to the lead, as it causes it to contract when it touches any solid body, and form a ball. We may further prove this law by taking an alloy that is known to shrink, melt and cast into an open mould; let the top solidify, strike it two or three gentle taps with a hammer or die having a broad striking surface, when the metal will be seen to force its way up through the crust and form globules on the surface.

The third mode really belongs to the former two, but we will consider it as an independent one. It is the action of the atmospheric pressure in the promotion of a spherical form in molten metal, when in small quantities. It is the best known law of Hydrostatics that a fluid will flow until it finds its level; but pour water on any highly heated surface, and instead of flowing until it finds its level, and keeping in a body, it will break up into little globules, and either roll about or stand still until the atmosphere in its vicinity is cooled sufficiently, when it evaporates in steam.

The same may be said of the metals with a little modification, the surface will do as well if it is cold, and not so well if it is at too high a temperature, unless there be a good supply of cold air playing on the surface; but it all depends on the melting point of the metal and the rapidity with which it cools. On studying this, I have come to the conclusion that the heat radiated from the metal or alloy heats the air in its vicinity, that by the law of gravitation the heated air having expanded, and thus having a lower density than the cold air, ascends to make room for the same, that the rapidity with which it ascends partly breaks the equilibrium of the atmospheric pressure, that the pressure being less on the upper surface it is inclined to rise and thus partly kept from spreading or finding its level, that it is aided in this by a lateral pressure, if I may so express it, which is not disturbed by the ascension of the heated air. That this is true may be seen by a great many metals when cooled suddenly by artificial means, or not formed into the globules until on the point of solidifying; they will be seen to have their tops (the globules) very much flattened; this shows at once that it is the exertion of the atmospheric pressure, as if they had been hot or not cooled so suddenly their tops would not have been flattened.

Why then could not these laws be applied in the metallurgical treatment of our gold and silver ores? The sulphur and arsenic would assist to lower the temperature at which they melt, by alloying with them and any portion that did not combine with them would act as a flux. I need not extol the virtue of such a flux, it would collect any fine gold and bring it in conjunction with more forming a globule, while at the same time the sulphur would act as fuel and produce heat, the arsenic according to its nature would cause any body of metal it happened to be in to shrink and form a globule, thus all the fine and leaf gold would be collected into bodies large enough to be easily worked, and this could be done by roasting; but not roasting as it is practised at the present day as arsenic and sulphur are considered a disadvantage, and it is to get rid of them that it is practised. Allow me to quote a passage from Overman the late American metallurgist, as it will show us the object of roasting as it exists; he says, "Roasting means to heat a metallic ore or matte to at least a red heat or such a heat that the mineral does not melt but only the volatile or combustible substances are expelled, and as much oxygen becomes combined at the same time with the ore as it possibly can absorb." But we are aware of the weak affinity of the precious metals for oxygen, they are therefore reduced direct to the metals. In accordance with this he says further on that; "sulphuret of silver is easily liberated from its sulphur, and forms metal; the same is true of gold." Roasting was resorted to but very little in the treatment of ores of the precious metals until lately, and even where it is used the benefit that might accrue from it is lost by restraining the temperature from rising above a certain point, for fear of sintering and thus causing extra expense in the working of it.

Well, to go into details of how I intend to roast these ores. They must either be roasted in piles or kilns; I prefer the pile, as a larger portion of ore can be operated on at once and easier manipulated than if in kilns, and also very little outlay in preparing the bed to receive the same; but it all depends on the metallurgist who is considering the question, as one man can see an advantage where another could not. I shall go no further into details than to say that the pile will be merely the ordinary one with special attention paid to its draft canals which shall be two feet apart. We shall commence by building up the foundation from eighteen inches to two feet in height of hardwood, the height it is to be built depending on the amount of sulphur contained in the ore, the more sulphur the less fuel, and vice versa for the other extreme. The top should be easily reached so that the fines that form the covering can be easily manipulated. When the pile is all ready for lighting, we shall light it at one end only and not all round as is usually done, as the fire will spread soon enough for our purpose. When the end is well lighted, let it have the benefit of a full draught by opening four draught canals (two on each side) and clearing the fines of the top for four feet, when the ore having this great draught will sinter; when it has pretty

well sintered, turn three or four jets or streams of water on it, this will cause it to crack and crumble, then let men with long iron hooks pull the crumbling parts away so that the water may the better get at the other parts, and keep continually clearing away as it is possible to do so; when within one foot of that part of the pile, whose draught canals are not open, stop putting on water, open two on each side, pull fines of top as before, let sinter, put on water, and pull and clear away as ready, repeating this until the pile is finished.

The ore which has been done in the meantime is carried off to the mill and fed to the stamps; there may be sluices having hardwood riffles leading from the mill to settling tanks, or it may be stamped dry, and the work of cleansing left to the buddles, but the wet way is to be recommended as it will save a great deal of work in the buddles. The battery may be cleaned out every hour or a less period of time according to the amount of ore that has accumulated in it, and carried to the round buddles to be selected. All the gold and silver will be left in the battery, except perhaps those fine shots which may be ejected by the stroke of the stamps, and which will be intercepted by the hardwood riffles; as for the tailings, they will be found to contain practically nothing.

Naturally, you will have come to the conclusion that the arsenic and sulphur, which were alloyed with the gold and silver, will still remain with them, and be troublesome impurities, which can only be got rid of by refining, thus causing a further outlay of time and capital. This will depend principally on the temperature to which the ore has been exposed. If the temperature is only risen to that point at which the gold and silver melt, they certainly will contain these elements as an alloy, but if, on the other hand, they are risen to that temperature which is attainable in any roast pile, the gold and silver will be found free of even traces of these elements. In proof of this I shall make mention of an experiment by which I demonstrated it.

I took ore known to contain both arsenic and sulphur and divided it into two portions, which we shall call A and B. I rose A in temperature until the gold was seen to form on the surface in globules and no higher. B I rose in temperature until it sintered. I afterwards made analysis of several of the globules from each portion in A. I found both arsenic and sulphur, and in further proof of my statement that arsenic and gold alloy, I found it (the arsenic) in the metallic state. I do believe that this could not have been confirmed more conclusively than by the finding of the metallic arsenic present. In the several globles from B I found neither arsenic nor sulphur, thus showing that the high temperature to which the ore had been exposed had oxidized them.

The oxidization is accomplished as follows:—The extreme heat of the roast pile, when sintering, sets the sulphur and arsenic on fire, producing arsenical and sulphur fumes; that the arsenical fumes combine with the oxygen of the air forming arsenious acid, As. O.$_3$, of the old nomenclature, or arsenious anhydride of the new, As.$_2$, O.$_3$, and with the sulphur as sulphur dioxide, or sulphurous anhydride S. O.$_2$, and also combine together to form the sulphides. The orange realgar As. S.$_2$, and the yellow orpiment As. S.$_3$, I found the former predominated. Also when the water is thrown on the ore it helps greatly the oxidization of these elements, and clears away almost all traces of them.

Now allow me to draw your attention to the advantages to be derived from this process. In the first place you must all be aware that the matrix of an ore, it matters not whether it be quartz, calc spar or any other mineral, when heated to redness and either suddenly immersed in water or water thrown over it, will be rendered quite brittle, and fall to pieces with the least concussion or blow, and even with some the disintegration is so great that they will break up during their immersion or while the water is thrown over them.

Now, this would be a source of great and general economy, the stamping expenses would be reduced; for instead of each stamp doing one ton per diem they would do five tons; five days' work would be done in one, consequently saving five days' tear and wear of plant, also five days' steam and fuel, besides five days' wages to the workmen and other items of which I shall make no mention, unless to say that the returns would be quicker, thus making it a point of great importance.

I am of the opinion that many men of our profession are ignorant of the cause of the loss of a portion, if not all of the gold and silver in an ore, by assay, when treated by the amalgamation process, and which they call free gold, and which appears so to the eye, but in reality is covered with a thin film of sulphur which renders it impervious to the mercury to form an amalgam. It seems strange this has never been discovered before, but my father and I have proved it to be true, and were intending to publish a paper on it, but were anticipated by Mr. Skey, analytical chemist for the New Zealand Geological Survey, who published a paper on this subject under the title of "The absorption of sulphur by gold and its effects in retarding amalgamation." Now, this sulphur can be got rid of by roasting at the proper temperature, and as to expenditure have I not shown the advantage in less labour and mechanical power being required in the further treatment of these ores?

Another cause of great loss is the carrying away by water of the float gold. The cause of its floating is that although it has the highest specific gravity or density of all the metals except platinum, iridium and osmium, which are 21·50, 21·15 and 21·4 respectively, gold being 19·50