as decided as it was when the cloth, very perfectly wet, had air on each side of it.

Once more, putting the cloth end under water, holding the tube nearly horizontal, and blowing by the mouth applied to the other end, the water which had risen into the funnel before the mouth was applied was expelled. After that no air escaped until the air-pressure within exceeded the water pressure on the outside of the cloth by the equivalent of a little more than nine inches of water; and when blown with a pressure just a very little more than that which sufficed to produce a bubble from any part of the cloth, bubbles escaped in a copious torrent from the whole area of the cloth.

The accompanying sketch represents the application to the navigational depth gauge. The wider of the two communicating tubes, shown uppermost in the sketch, has its open mouth guarded by very fine cotton cloth tied across it. The tube shown lower in the diagram is closed for the time of use by a stopper at its lower end. A certain quantity of water (which had been forced into it during the descent of the gauge to the bottom of the sea) is retained in it while the gauge is being towed up to the surface in some such oblique position as that shown in the sketch. While this is being done the water in the wide tube is expelled by the expanding air. The object of the cloth guard is to secure that this water is expelled to the last drop before any air escapes; and that afterward, while the gauge is being towed wildly along the surface from wave to wave by a steamer running at fourteen or sixteen knots, not a drop of water shall re-enter the instrument.

A NEW PROCESS FOR THE METALLURGIC TREATMENT OF COMPLEX ORES CONTAINING ZINC.*

By EDWARD A. PARNELL, F.C.S.

THE subject to which I have the gratification of inviting your attention, namely, the effective and remunerative treatment of certain complex ores containing zinc, has been an important problem in metallurgy. It is well known that the presence of zinc in considerable quantity in ores containing other metals has a very injurious influence in the ordinary smelting processes for the extraction of the latter. In the case of copper ores, for example, the presence of much zinc necessitates additional operations in order to obtain copper of good quality; and all the zinc originally present in the ore is lost. Of still greater inconvenience is the presence of much zinc in lead ores, when the ordinary smelting processes are pursued; not only are the operations impeded thereby, but there is also a considerable loss of lead. Hence it follows that copper ores containing much zinc are rejected by the copper smelter, and lead ores containing much zinc are rejected by the lead smelter.

Further, ores of this complex character are not adapted to the use of the zinc or spelter manufacturer. From the peculiar character of his reduction process, in which the cost of earthen retorts forms a considerable item in his working charges, it is essential that his raw material contain a considerable proportion of zinc; less than 25 per cent. would be regarded as unsuitable. Not only so, but the presence of certain other metals, especially lead, is highly objectionable to the spelter maker from their injurious action on the earthen retorts. Zinc ore containing 8 per cent. of lead would be discarded.

Hence the necessity of resorting to some means of separation before having recourse to the ordinary smelting processes. Of course the mechanical method of "dressing" is always adopted wherever it is practicable. In ordinary mixed ores containing galena and blende, this is easily accomplished by the great difference between the specific gravities of these two minerals; but in many cases separation by dressing is impracticable. Thus blende and copper pyrites resemble each other in density too closely to allow of separation by dressing. Again, blende and galena are often found so intimately mixed or combined (forming apparently a homogeneous mineral) that their separation by dressing is too difficult to be practiced on the large scale; in fact, this is in some cases quite impossible. The plumbiferous blende found in Anglesea, commonly known as "bluestone," is of this character. Enormous quantities of copper ores also exist, the raising of which would be very profitable were it not for the contaminating influence of 20 per cent. and upwards of zinc; but hitherto the highest prices paid for such by the smelter have been unremunerative to the miner. The cuprififerous blende found in great quantities at Ain Barbar, in Algeria, is of this kind.

The extraction of zinc from such ores in a useful form has often been attempted by means of hydrochloric acid, after calcination of the ore, with the view of decomposing the chloride of zinc by lime. Serious impediments, however, to this method have prevented it from being adopted, especially the difficulty of washing the oxide of zinc from the chloride of calcium and obtaining it in a dense form, suitable for the spelter manufacturer; also, the injurious influence of the presence of chlorine in any form in the subsequent smelting of the residue containing lead and silver.

The separation of oxide of zinc from the calcined ore can of course be easily effected by sulphuric acid, but the great objection to this method has been the difficulty (hitherto generally considered insuperable on the large scale) of obtaining oxide of zinc from the sulphate, in a form suitable for the spelter manufacturer. In the process to which I would now invite your attention this difficulty is completely overcome.

When heated alone, sulphate of zinc requires a very high temperature to effect its decomposition. Such a method is impracticable on the large scale; but when mixed with a small proportion of a deoxidizing agent, sufficient to take one equivalent of oxygen from the sulphate, it is easily decomposed with the production of oxide of zinc and sulphurous acid. A mixture of 2 equivs. of zinc sulphate with 1 equiv. of carbon, heated to dull redness, affords oxide of zinc. With a larger proportion of carbon, sulphide of zinc is produced. Sulphide of zinc, whether artificial or native, is also well adapted for decomposing the sulphate. 3 equivs. of sulphate and 1 equiv. of sulphide produce 4 equivs. of oxide and 4 equivs. of sulphurous acid ($3\text{ZnSO}_4 + \text{ZnS} = 4\text{ZnO} + 4\text{SO}_2$). Native sulphide of zinc is the reducing agent, which I prefer on the large scale for making oxide of zinc suitable for the zinc manufacturer.

I will now briefly describe the routine of operations at present pursued at the works of the Swansea Zinc Ore Company, which have been erected for carrying out the process on an extensive scale.

The principal ores operated on are the following, neither of which is "dressable."

1. Complex ore from Cavalo (Algeria), containing, as sulphides—Zinc, 17 per cent.; lead, 16 per cent.; silver, 20 ounces per ton.
2. Cuprififerous blende from Ain Barbar (Algeria), containing—Zinc, 23 per cent.; copper, 6 per cent.; silver, 6 ounces per ton.
3. Complex ore from Italy, containing—Zinc, 20 per cent.; lead, 12 per cent.; copper, 5 per cent.; also silver.
4. "Bluestone" from Anglesea, containing—Zinc, 28 per cent.; lead, 12 per cent.; silver, 12 ounces per ton; also gold and copper.
5. Ore from Constantine (Algeria) containing—Zinc, 12 per cent.; lead, 5 per cent.; copper, 1.5 per cent.; silver, 12 ounces per ton; also gold.

After having been ground sufficiently to pass through a sieve of six or eight holes to the linear inch, the ore is calcined with exposure to air, at a moderate heat. This calcination is effected in large muffle furnaces, the gas from which, when containing a sufficient proportion of sulphurous acid for making sulphuric acid, is conveyed to leaden chambers for that purpose. The sulphides of the various metals are thus converted into oxides and sulphates. A dull red heat is found by experience most favorable to the formation of sulphate of zinc; but it must be sufficient for the decomposition of ferrous and ferric sulphates. The calcined ore is next mixed with weak sulphuric acid in a revolving pan lined with lead (invented by Mr. J. W. Chenall); neutral liquors are first run off; afterwards excess of acid is introduced, and the acid liquors thus obtained, together with subsequent washings by water, are used for producing neutral liquors from a fresh charge of calcined ore.

The solution of sulphate of zinc thus obtained of course contains copper when that metal was present in the ore. Of iron it contains very little, provided the ore had been properly calcined, so as to peroxidize all that metal, the sulphuric acid combining by preference with oxide of zinc. I may mention, in passing, that a solution of ferric sulphate is decomposed when warmed with oxide of zinc, with precipitation of ferric oxide and production of sulphate of zinc.

From the clear neutral liquor copper is next precipitated in the usual way, either as metallic copper by means of iron or zinc, or as sulphide. The solution of sulphate of zinc is then concentrated by evaporation, and mixed when it begins to thicken with finely ground blende, in the proportion of one equivalent to three equivalents of zinc sulphate. This mixture, after being further dried, is lastly heated to redness in a muffle furnace. The mutual reaction which I have already described takes place with production of oxide of zinc and sulphurous acid. The latter, having no admixture of gases derived from the fire, is conveyed to leaden chambers for the reproduction of sulphuric acid.

The oxide of zinc thus obtained is in a condition well suited for the manufacture of metallic zinc in the ordinary way. Its strength and purity of course depend to some extent on that of the blende used as the reducing agent. When the latter contains about 45 per cent. of zinc, the oxide as withdrawn from the furnaces contains about 62 per cent. of zinc. It contains no impurity which is of any inconvenience in its application for making metallic zinc. The principal impurity is oxide of iron, derived partly from the blende added in the process, and partly from the use of iron as a precipitant for the copper. The impurity which the zinc manufacturer regards as most deleterious—namely, lead—is reduced to a minimum, being only the small proportion contained in the added blende. The same may be said respecting calcium.

Occasionally the oxide of zinc contains a little magnesium, owing to the presence of magnesian minerals in the raw ore. But this metal is not present in the oxide in the objectionable form of sulphate, but in the innocuous form of oxide. It may be interesting for me to remark here that sulphate of magnesia is easily decomposed by blende and other reducing agents in a manner corresponding to sulphate of zinc. When a mixture of single equivalents of sulphate of magnesia and carbon is moderately heated, magnesia is obtained mixed with very little undecomposed sulphate. Magnesia thus prepared corresponds in density to what is known as "heavy" calcined magnesia. It will be obvious that this method of preparing that article will be found far more ready and economical than the common method of precipitation as carbonate and calcination.

I have now to revert to the portion of the ore left undissolved after treatment with dilute sulphuric acid. This of course, contains all the lead originally present in the ore. The same may be said of the gold and silver. It might be expected that a portion of the silver would be sulphated and rendered soluble during the calcination of the ore. This is doubtless the case to a small extent, but I have always found that the minute quantity of silver thus rendered soluble is less than corresponds to the trace of chlorine present in chamber sulphuric acid, and chloride of silver is quite insoluble in solution of sulphate of zinc.

For the further treatment of this residue the ordinary well-known smelting processes are resorted to, the products being argentiferous and auriferous lead, and also copper regulus, which generally contains both gold and silver. At the works of the Swansea Zinc Ore Company, the smelting of the residue is effected in cupolas; an important appendage to which is the lead fume condenser patented by Messrs. Wilson and French, of Sheffield (brought before the notice of the British Association last year), in which the gases from the furnace are forced under water and allowed to pass through layers of fine copper gauze. I am happy to be able to state that this condenser is now being worked very satisfactorily.

In conclusion I would remark, as will doubtless have occurred to you, that this mode of treating sulphate of zinc is capable of other applications besides the complex ores I have referred to. Such, for example, as the residue of blende after the richer portion has been separated. Immense quantities of such residue exist containing 22 per cent. of zinc, the further dressing of which is not profitable. This is of no value in its present condition, but capable of profitable application by the process I have described. It may also be applied to lead fume containing zinc, and to the crude sulphide of zinc derived from burnt iron pyrites containing blende, of which a large quantity is used in Germany for making sulphuric acid.

In reply to inquiries respecting the density of the oxide of zinc thus prepared (a matter of great importance to the spelter manufacturer), Mr. Parnell stated that it is rather greater than that of ordinary calcined calamine. The oxide is in every respect admirably suited to the manufacture of zinc.

ELECTRO-CHEMICAL ANALYSIS OF METALS.

THE convenience of the port of Swansea, Wales, together with the extensive anthracite mines in the neighborhood, has made the town the principal seat of the copper trade of Great Britain; in fact, it has been estimated that nine-tenths of the copper used in England is from Swansea and its environs. Enormous quantities of copper ore are brought hither for smelting from Cuba, North and South America, Australia, Spain, Algeria, etc. With the manufacture of copper is also associated that of other metals, precious or rare, such as tin, silver, nickel, and cobalt. The ores as they arrive are placed in piles under sheds on the wharves, and, before being sold, are analyzed on the spot by the consignees. In analyzing the ores, some of the larger houses have adopted an electro-chemical process which is remarkable for its power, rapidity, and simplicity. It has been in use for about a year, and bids fair to entirely replace the old processes by dry way. The copper ore is dissolved in nitric acid, and the solution, properly neutralized, is submitted to the action of a thermo electric pile, heated by a gas flame. The constancy of this pile is tested by means of a voltmeter, which, in construction, is something like that of Mr. Warren de la Rue, and in which is decomposed a definite number of cubic centimeters of gas per minute. When the electro-chemical decomposition does not give the requisite number of cubic centimeters the pile is changed. The pile is formed of two alloys of bismuth the proportions used

ELECTRO-CHEMICAL ANALYSIS OF METALS.

being unknown, since the alloys are manufactured in Germany by a French electrician, who withholds his secret. It might, however, it should be understood, be replaced by any pile which is sufficiently constant. The essential part of the process, outside of the art of making the solutions, lies in the form given to the poles and in the manner of using them: The negative pole, C (see cut), in which the copper is deposited, is shaped like an inverted funnel, and into its interior passes a platinum wire enclosed in a glass tube, B, designed to prevent contact. The deposit of copper takes place on the internal as well as the external surface of the funnel. When the pile is sufficiently weak and constant the deposit formed is very adherent and possesses a magnificent metallic aspect, and may be dried and assayed without any sort of difficulty. The operation usually takes from six to seven hours, and, when finished, there is nothing to do but weigh the platinum cone carefully, and thus determine the weight of the copper deposited. To ascertain whether any copper still remains in the liquid, the funnel is again immersed therein, when, whatever metal is present, will form a thin film at the upper part of the cone. If no deposit forms, it is a sure proof that no copper remains, and the operation is, therefore, practically finished. This same process may serve for the analysis of any metal whatever, provided the other metals present be precipitated, and that no solutions containing chlorine be used, since this element would form a certain amount of platinum chloride, which would injure the pole and vitiate preceding determinations.

LEAD—HOW TO COAT ARTICLES THEREWITH—THE GALENIZING PROCESS.

PROFESSOR EMERSON REYNOLDS thus describes one of the best methods of applying his new process of galvenizing, or covering with lead various substances: Take 16 grammes of solid sodic hydrate (NaOH) or an equivalent of other suitable hydrate, dissolve it in 1.75 liters of water, and add to the liquid 17 grammes of lead nitrate (Pb_2NO_3), or an equivalent of other lead salt, with 250 cubic centimeters of water; raise the temperature of the mixture to 90° C. If sufficient lead salt has been added the liquid will remain somewhat turbid after heating, and must then be rapidly strained or filtered through asbestos, glass-wool, or other suitable material, into a convenient vessel. The filtered liquid is then well mixed with 100 cubic centimeters of hot water containing in solution 4 grammes of sulpho-urea or thio-carbamide. If the temperature of the mixture be maintained at about 70° C., deposition of galena in the form of a fine adherent film or layer quickly takes place on any object immersed in or covered with the liquid, provided the object be in a perfectly clean condition and suitable for the purpose. When the operation is properly conducted a layer of galena is obtained, which is so strongly adherent that it can be easily polished by means of the usual leather polisher. It is not necessary to deposit the galena from hot liquids, but the deposition is more rapid than from cold solutions.

The most convenient solution for deposition on brass is thus prepared: Take a quantity of soda lye containing 1½ ounces of real soda (NaOH); dissolve in this, with the aid of heat, 3 ounces of tartate of lead, and just before diluting the solution to one gallon of cold water, add 5 drachms of sulpho-urea previously dissolved in a small quantity of hot water. The articles are to be immediately immersed in this bath, and the temperature raised to boiling. When the desired tint is obtained the articles are to be removed, washed, and polished. The above solution can be used for glass or porcelain, hot or cold, if the proportion of alkali be reduced one-third or thereabouts.

SOAP IN POMADES.

THIS is a decided improvement. Before the perfume an ounce of soap, dissolved with 2½ grains of borax in hot water, should be added to 3 lb. of the pomade. This makes the pomade snow white and very unctuous. Another advantage is that a third of its weight of water can be incorporated with it.—*Zeitschr. d. österr. A. V.*

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