

ing laws. The building has the ordinary studding, about 4 feet apart, covered with tarred paper; over the tarred paper chicken fencing wire with open mesh is placed. On this is squirted a mixture of sand, cement and water, the mixture in one hose, and water in the other hose. It is fire-proof and, if necessary, can be made water-proof, and if you want to pull it down you can do so with a pickaxe. The walls of cement are made  $\frac{1}{4}$  inch thick on either side. The cement may be a beautiful white or gray color, and is practically impervious to moisture. The two hoses are carried around easily; the sand nozzle is lined with rubber; the sand does not affect the rubber as it does a nozzle made of steel without the rubber protection. The man stands and squirts this mixture on as you squirt with a garden hose. A square yard of surface is covered in a couple of minutes.

#### NEW USES TO REDUCE ABUSES IN CONSERVATION.

By W. R. WHITNEY.

I believe the unmodified word conservation is an unfortunate choice. To conserve is "to keep from loss, decay or injury; to preserve." Conservation is defined as the act of conserving, and to be conservative is to be "adhering to the existing order of things, opposed to change or progress." No good research chemist can afford to stop at such conservation. There is an active as there is a passive conservation; this could probably be defined as efficient utility. Considering the mineral resources of our country, we will concern ourselves with the maximum in efficient utility or be left behind. A certain well-known Corsican once said: "You cannot make an omelet without breaking an egg." There are plenty of signs that birth and growth in everything calls for the breaking of eggs and the question of efficiency is the one of interest. If you merely save your eggs, they will rot. I have collected a very few of the cases illustrating the trend of chemical work towards such active conservation.

During the past ten to twenty years, the chemists have been developing new uses for new materials very rapidly. A few years ago titaniferous iron ores were useless. Today those containing the highest proportion of titanium oxide are being mined and the ferro-titanium sold by the thousand tons. A few years ago quartz could hardly have been considered an ore. Today thousands of tons of silicon and ferro-silicon are being sold annually.

A few years ago tantalum and columbium ores were merely of interest as museum specimens. Now they are being worked for the tantalum, and doubtless the niobium will soon be utilized.

A few years ago rutile was used only in collections of minerals. It is now mined in large quantities and used in various forms in arc lamps and ought to find use in alloys.

A few years ago chromium had little use and metallic manganese was a curiosity. Now the two metals are used by the ton as pure metals in alloys for electrical resistance. They replace much greater quantities of German silver and other expensive alloys.

Ten years ago tungsten was conserved in tool steels only, while today it is saving the equivalent

of millions of dollars annually in power used for lighting.

A few years ago emery was mined and was our best abrasive. Today we have artificial fused alumina and artificial carborundum, and emery is being conserved for those who later may want to see the natural material. Here, too, time and energy are being conserved with the same output of grinding.

A few years ago extensive mining operations had to be carried on to supply the graphite we use. Today that material is artificially produced from coal, which can be mined very much more economically.

It is not far back to the time when aluminum was brought into use. It now greatly helps the conservation of copper.

Poor farming land in our southern states is being worked for monazite sand, and our houses are being lighted by its use in gas mantles. This use of an ore is of our decade.

#### MINERAL LOSSES IN GASES AND FUMES.

By F. G. COTTBELL.

In considering the mineral wastes passing out of the stacks of our smelters and metal refineries, we must distinguish clearly between the gases themselves and the clouds of suspended solid and liquid particles which they mechanically carry along with them. In which class a material belongs, often depends, to be sure, on temperature. Many metallic compounds are actually vaporized in the furnaces and gradually condense from gases into clouds of solid particles with the progressive cooling of the gas streaming through the flues. Arsenic in the form of the trioxide is usually the last of these materials to condense, since even down to  $150^{\circ}$  its vapor tension is sufficient to permit the loss, in the gaseous state, of several tons a day from the largest plants. But below, say  $125^{\circ}$  C., we may fairly consider for ordinary technical purposes that the only important element in the gaseous state is sulfur, in the form of dioxide. Detailed consideration of these losses of solids is given elsewhere in this issue of *THIS JOURNAL* as well as in a previous article by the author<sup>1</sup> and still earlier by W. C. Ebaugh.<sup>2</sup>

For many centuries the material nature of gases and the fact that they actually possess weight escaped the chemist. Even to-day a distinct effort of mind is required to sense the vast tonnage of the clouds we see floating away so lightly from smelter and power-house stacks. There are many single stacks in this country, from each of which over five tons of gas issue per minute, while in isolated instances this is exceeded several-fold.

Aside from carbon, the element which is lost in the greatest tonnage is unquestionably sulfur. Many of our western ores will run from 25 to nearly 40 per cent. sulfur and a plant smelting 1,000 tons of ore per day is at present considered to have a very moderate capacity. The largest plants will easily touch

<sup>1</sup> *THIS JOURNAL*, 3, 543-550 (Aug., 1911).

<sup>2</sup> *Ibid.*, 1, 686-689 (Oct., 1909) and 2, 372-3 (Sept., 1910).

the 1,000 mark in tons of sulfur passing up their stacks when at full capacity. When we stop to think that this represents three times the same weight of concentrated sulfuric acid, were it made into such, and that one such plant could have supplied all the acid used in the whole phosphate industry of the United States a year ago, we can better realize the skepticism of the Smelter Companies regarding acid manufacture as a general solution of the sulfur fume problem.

The disposal of this sulfur presents unquestionably the gravest problem confronting the metallurgical industry to-day.

Suggestions have not been wanting for methods of direct absorption of this gaseous sulfur dioxide by water, limestone, lime or charcoal either as a means of final disposal or as a step in its concentration and final liquefaction under cold or pressure. One of the most ingenious and attractive is that it be used for decomposing finely granulated and moistened slag,<sup>1</sup> thus fixing the sulfur in harmless compounds and, at the same time, leaching out any metal values still held in the slag.

While many of these are perfectly practical on a laboratory scale, the tonnage to be handled and the cost, either in first installation or operation, have prevented them from producing any practical results up to the present.

From a chemical standpoint, the other obvious alternatives consist either in oxidation to sulfuric acid or reduction to elementary sulfur. Of these two, the first has the advantage of requiring no additional substance save the oxygen of the air, and of running itself, when properly catalyzed, without need of external energy, but unless an immediate market is at hand for the sulfuric acid, its disposal in turn becomes difficult and often impossible.

The greatest consumption of sulfuric acid in this country to-day is in the manufacture of superphosphate fertilizer, but, until very recently, the chief demand for fertilizer has been in the Southern and Atlantic States; here, too, were the chief known deposits of phosphate rock, while, on the other hand, the great smelting industry is for the most part in the far West, and cut off by high transportation costs. The recent discovery and description by the U. S. Geological Survey,<sup>2</sup> in Idaho, Wyoming and Montana, of what promises to be the largest phosphate deposits in the world, will, it is hoped, materially change this condition.

Much of the land in the West is still practically virgin soil; where crops are falling off, the reasons for this and their relations to different kinds of fertilizers, to tillage and crop rotation, are still so much in dispute that if we are to build a rational and permanently helpful phosphate industry, we must first have our facts well established from the standpoint of agriculture, manufacture and transportation. At present, these are not available to any extent justifying an immediate general development of the phosphate

industry in the West; but coöperative work, aimed at a broad and practical study of these conditions, is already well under way between the U. S. Department of Agriculture, the Agricultural Experiment Stations of various western states, the U. S. Bureau of Mines and the large metallurgical interests of the West, and it is hoped that the results may soon justify and lead to a healthy development of the industry.

An encouraging example is before us in the work already accomplished by the Tennessee Copper Company at their plant at Copper Hill, Tennessee. They are successfully treating the weak gases from copper blast furnaces on a scale for which many predicted failure, and which certainly did require time, courage, ability and indefatigable effort to perfect. The very difficulties and delays which the work had to encounter have in one sense been a help to the industry, as their present annual capacity of 250,000 tons of chamber acid has been gradually reached over a period of some years and while it has materially reduced the price of acid in the South, the market has had a chance to adapt itself with the minimum of hardship to those already in the field and with great gain to both the metallurgical and agricultural communities.

Although much may undoubtedly be done, not only to increase the consumption of sulfuric acid in superphosphate manufacture, but also in developing other and newer uses, still we should not rest content with this.

Up to the present, we have considered only the results of oxidation of the sulfur dioxide. On the other hand, it may also be reduced to elementary sulfur, for which purpose a number of methods have been proposed, some depending on the action of solid carbon or of carbonaceous reducing gases, while others use hydrogen sulfide generated by the action of steam or acids on alkaline or metallic sulfides. An interesting general discussion both of the possibilities and the limitations of these methods together with some very suggestive new facts<sup>3</sup> has recently been attracting considerable attention and may not improbably lead to practical results, at least in certain special cases.

This naturally leads to the inquiry: "Why should all the sulfur of the ores be oxidized in the first place?" This question comes home still more forcibly when one looks through the charge doors of a pyritic copper blast furnace shortly after a fresh charge of ore has been dropped on the column and sees the great clouds of unburnt sulfur subliming out from the charge itself and burning above it, while all the heat thus produced is wasted.

If we could run our copper blast furnaces with gas-tight tops, as is the case with iron blast furnaces, and had full utilization of the air blown in on the lower part of the charge column, it certainly seems as though a far better thermal efficiency should be attainable, besides the possibility of delivering a very consider-

<sup>1</sup> "The Westby-Sorensen Process," E. P. Jennings, *Eng. and Min. Jour.*, **86**, 418-19, Aug., 1908.

<sup>2</sup> U. S. Geological Survey, *Bull.* **430**, "Phosphates," by H. S. Hale and R. W. Richards.

<sup>3</sup> "The Thiogen Process for Reduction of SO<sub>2</sub> in Smelter Fume," S. W. Young, *Min. and Sci. Press*, **103**, 386-387, Sept. 23, 1911.

able proportion of the sulfur of the ore to the flue in unburnt form, either as a gas or cloud of flowers of sulfur, depending on how cool the top of the ore column could be maintained.

That such a mode of operation is not entirely impossible is curiously evidenced by the fact that the first pyritic copper blast furnace ever run<sup>2</sup> was operated under these very conditions, the run finally terminating, after a few hours, by so much free sulfur accumulating in the flues as to stop the furnace.

In this classic article of John Hollaway's, particular stress was laid upon the recovery of the sulfur, but the development of smelting practice soon began to follow other aims. It was naturally in the hands of the copper men and sulfur did not so directly interest them. Then, too, in the far West, where pyritic smelting was first carried on successfully on the large scale and where even today probably ninety per cent. of it is still located, the limited market for sulfur and the high cost of transportation and low value per ton, as compared with copper, have naturally influenced metallurgical development to strain for the least degrees of economy in copper production, with absolute disregard for sulfur as a by-product.

In working the vast tonnage of low-grade sulfide ores of the West, effort is concentrated on burning out and slagging off the maximum amount of iron in the blast furnace in order to produce as high a percentage of copper as possible in the resulting matte, as it is much more expensive to burn out a pound of iron in the converter than it is in the blast furnace. This greater cost is due chiefly to two items, *viz.*, the cost of the refractory linings, and the greater power consumption due to the higher pressure of air in the converter. Hollaway looked on his blast furnace simply as a means of melting the ore into low-grade matte, the remaining iron of which might then be burnt off in some of the then well-known processes or in a converter which he was also the first to use in copper metallurgy.

As we have seen, it has been the cost of converter practice which has led to crowding as much of the work of oxidation upon the blast furnace as possible, and this insures the burning up of all the sulfur instead of recovering a good portion of it. Within the last few years, one of the two items of converter cost, that of linings, has been greatly reduced by the practical development of basic linings, so that to-day this factor is rapidly becoming almost negligible and all that stands in the way of shifting most of the work of oxidation from the blast furnace to the converter is the cost of the high-pressure air (10 to 15 lbs. per sq. in. as against say 3 lbs. for blast furnace) required to force its way in against the hydrostatic pressure of the deep liquid bath in the converter. If we could get a mechanically more efficient way of mixing this air with the molten matte in the converter it would mean the opening of a new chapter in metallurgy.

Even with the greater cost for air, the relation be-

tween blast furnace and converter operations is already steadily changing in the sense of taking a lower-grade matte to the converters, and this in turn may be expected to react in a study of the blast furnace from a somewhat different point of view than has hitherto obtained.

The copper blast furnace is to-day confessedly one of the crudest agencies of engineering practice, and we know with less certainty the mechanics and chemistry of its inner workings than of almost any other apparatus of equal industrial importance.

The slow development of a really fundamental scientific basis for this field of metallurgical engineering has undoubtedly been due in great part to the exceptional difficulty, 'if not impossibility, in this particular subject, of interpreting small scale experiments in terms of full scale operation, and the great expense of full scale experiments.

Another reason for metallurgy having lagged behind other engineering branches is perhaps to be found in the fact that commercially it has usually been pursued as an adjunct to the private ownership of some natural resource. If the mine were a rich one, the ultimate economies of smelting practice were apt to be overshadowed by the more immediately attractive study of increasing tonnage; if, on the contrary, the low grade of the ore made careful smelting necessary, the company felt it could seldom afford to go into expensive experiments for radical improvements of the art, but must stay close to standard practice and make its improvements on minor details.

Even if elementary sulfur were produced its present consumption outside of sulfuric acid manufacture is too small to be at all significant, but it at last has the advantage over acid of permitting safe accumulation and storage to an unlimited extent, as illustrated by the practice in Louisiana, where it is cast into blocks some two hundred feet square and fifty feet high.

What is really most needed for the solution of the sulfur fume problem is the discovery of new uses and a wider extension of existing uses for both elementary sulfur and sulfuric acid. We have become accustomed to looking at sulfur almost exclusively from its chemical aspect, but if it is ever to be utilized in anything like the proportions in which it is now being thrown away, we would do well to consider possible mechanical uses, as, for example, a binder for sand or wood fiber. Experiments on the manufacture and use of drain tile made of such material are at present being carried out in the West where the recent rapid development of irrigation is constantly bringing new and special demands for material of construction.

If metallic sulfides are dissolved in molten sulfur, its toughness and other mechanical properties are greatly improved as first pointed out by J. B. Spence.<sup>1</sup> A detailed study of this form from the standpoint of structural materials has long awaited the investigator and seems much to be desired.

<sup>1</sup> John Hollaway: "A New Application of a Process of Rapid Oxidation by which Sulphides Are Used for Fuel," *Jour. Soc. Arts, London*, **27**, 248-270, 292-295, 488-495, 606-607, 728-730.

<sup>1</sup> "A New Metallic Compound" (Spence's Metal), Granville Cole, *Jour. Soc. Arts, London*, **28**, 225-229 and 279, Feb. 13, 1880. See also Thurston's "Materials of Engineering," Vol. III, p. 205.

If a sufficiently large and permanent outlet for sulfuric acid, on the one hand, and elementary sulfur on the other can be assured reasonably near the sources of supply, the metallurgical industry itself can be safely relied upon to meet the demands and find the way to supply them.

#### MISCELLANEOUS MINERAL WASTES.

By CHAS. L. PARSONS.

As the hour is so late and I have brought out a good many applications in the preceding discussion, and as a considerable portion of the subject is already in type for the February number of *THIS JOURNAL*, under the title, "Mineral Wastes: The Chemists' Opportunity," I will present a few additional facts in the form of brief notes.

There are several kinds of waste—waste of material, waste due to inefficient methods of preparation, waste by use of unsuitable material, waste from lack of use of abundant material.

One of the great losses taking place at the present time in this country is through the destruction of valuable metals due to electrolysis induced by leakage of electric currents. The loss is difficult to estimate, but it undoubtedly means millions of dollars a year.

A good example of waste due to inefficient methods, of which there are many, is the failure to utilize modern methods in the hardening and tempering of steel. One of our large manufacturers of steel blades, making at the present time some 300,000 blades a day, has reduced their cost in the last few years, through the employment of an expert, by more than half. They use now some three tons of steel per week and the blades were formerly hardened by using sixty-five machines, utilizing gas and blast for the heating process, running day and night and requiring fifteen men for their control. This company is now using six electrically heated furnaces, giving double the capacity, in an 8-hour day, with two men doing everything. For purposes of tempering, the blades are dipped, seventy pounds at a time, into an electrically heated salt bath and held for a definite time at a temperature definitely controlled with pyrometers. Per contra, another of our largest manufacturers of small steel articles is still to my knowledge hardening each article separately by blacksmiths by hand, getting a much more variable result at many times the cost. They, too, are working up hundreds of thousands of dollars' worth of material each year. Examples illustrating this kind of waste could be almost indefinitely multiplied.

#### ALUMINUM.

Twenty years ago aluminum sold for five dollars a pound; today it can be bought for less than twenty cents and still is obtained only from one ore, bauxite, the deposits of which are far from inexhaustible. Bauxite has many other uses and is needed for the manufacture of alum and aluminum salts in the chemical industries. Any method for producing aluminum

cheaply from clay would be of inestimable advantage. Several new patents have recently been issued, experiments are under way in this country and a prominent chemist of this Society tells me that he expects one of these processes to become a success. The methods of mining bauxite have apparently been but little studied. There are reputed to be considerable deposits in Wilkinson County, Georgia, that may pay for further exploitation. Aluminum has grown from a consumption of 83 pounds in 1883 to 47,734,000 in 1910.

#### ARSENIC.

According to Harkins and Swain, about thirty tons of arsenic trioxide go out of the stack of the Washoe Smelter daily. This means perhaps 80 to 90 per cent. of the total arsenic coming into the plant and amounts to over 10,000 tons a year that is being thrown out into the atmosphere from this one smelter alone. Similar losses are taking place in almost every smelting plant in the country and there is little doubt that 25,000 tons of arsenic go to waste each year. The amount recovered in 1911 increased nearly 300 per cent. over 1910, chiefly due to requirements put upon smelters for its collection. Although its price has been greatly reduced, the over-supply is not being fully taken care of. It is used in large quantities in combination with lead as an insecticide and it would seem worth while to have experiments inaugurated to determine if arsenic sulfide or calcium sulfarsenite, both of which are probably quite harmless to plants, may not be substituted as an insecticide, giving a much cheaper material, using more arsenic and conserving lead. It should be noted particularly that any proposed insecticide must be effective as a poison but must not injure the foliage of the plant upon which it is placed.

#### ANTIMONY.

Some losses of antimony are taking place from the flues of our smelters, but the loss is not so severe as with arsenic. Antimony lithophones are stated to have been successful in Germany, made by treating barium carbonate and antimony sulfite. The oxide itself may be used as a white paint and sodium metantimonate is a valuable constituent of enamels. Its use, however, is forbidden abroad in enamels placed on cooking utensils, but so far these enamels have not been extensively prohibited in the United States.

#### ASBESTOS.

The uses of asbestos are rapidly increasing and are a real conservation of lumber and a protection against fire loss. Asbestos shingles and asbestos lumber are of the utmost importance and their use should be encouraged. This country, however, produces at the present time but a very small proportion of the asbestos it uses, although very extensive deposits are known to exist in Wyoming. Anything that enables man to supplant wood with a non-combustible and cheap material is of the utmost importance to the country, for it is not only much less destructible from atmospheric agencies, but tends always to decrease our enormous fire losses.