ter. Through the latter hole passes a wing-headed screw bolt which enters a female screw threaded into the oil hole found at the upper end of the sleeve. The head of the bolt plays on a countersunk iron washer. The container to be shaken is secured in place by a leather band and clamp permanently attached to the cradle.

With proper speed adjustment the shaking is thoroughly effective, while either form of cradle is quickly demountable if the machine is wanted for its originally intended use as a flask-shaker.

A minor drawback to this type of machine is a tendency to pound sometimes under an imperfectly balanced heavy load. It would seem that this might be overcome by better designing of the cogs. Meanwhile the pounding may be considerably lessened if a cup made from a pipe cap is fitted around the lower cogs, and filled with grease mixed with sawdust or granulated cork. In extreme cases a clamp or other weight may be fastened to the light side of the platform.

BIOCHEMIC DIVISION, BUREAU OF ANIMAL INDUSTRY,
U. S. DEPARTMENT OF AGRICULTURE, WASHINGTON

ADDRESSES

ACID-RESISTING ALLOYS¹

By W. C. CARNELL

Received June 19, 1916

The development and progress of the Chemical Industry is vitally dependent on the development of materials out of which the plant equipment may be constructed. A process that is a success in the laboratory will be a success in the factory, if conditions are duplicated. Platinum and glass are available in the laboratory, but may be prohibitive in the factory. Platinum at \$30.00 per Troy oz. was used for the manufacture of concentrating stills for sulfuric acid; platinum at \$95.00 per oz. cannot be considered. Glass has its place, but at best is unsafe for extensive processes.

The branch of the chemical industry that suffered most for materials out of which to construct apparatus was the mineral acids division.

For many years various metals and alloys were offered for which more or less acid-resisting properties were claimed. They had their uses but as complete acid-resisting materials they were not successful. With the advent of fused silica a decided advance was made, and it successfully replaced platinum in a number of processes.

In 1911 a basin of fused silica was tried out at the factory with which the writer was connected; so successful were the results that a 10-ton cascade concentrating plant for sulfuric acid was erected to replace a platinum outfit. The results were all that could be desired. The acid made was even better than that made in platinum. Fused silica is brittle and costly and must be handled with as much care as glass.

In 1913 a material under the trade name of "Feralun" was tried out. This was a mixture of cast iron and an abrasive, the abrasive being an alloy of aluminum and silicon. The surface of the iron was covered with the abrasive. The abrasive was acid-resisting, but the acid soon destroyed the iron, leaving a porous mass. However, we found "Feralun" useful for nipples on acid tank cars.

FUSED SILICON—Silicon has acid-resisting properties that are all that could be desired for sulfuric acid, but it is more brittle than fused silica, and its use has not been very extensive.

"FERRO CHROME"—This alloy is made by the Electro Metallurgical Co. of Niagara Falls, and is a very promising product. Glacial acetic acid does not attack it; 56 and 28 per cent acetic acid attacked it slightly. Strong and weak nitric and sulfuric acids have practically no effect on the alloy. Hydrochloric acid attacked it readily. The experiments were carried out in a bowl 18 in. in diameter and 6 in. deep.

SILICON AND IRON ALLOY—The materials thus far mentioned are valuable for specific purposes. The real dawn of acid-resisting alloy came with the use of "silicon iron" alloy. The beginning of the use of this alloy was about 6 yrs. ago. The

first advertisement the writer observed of this alloy was in the *Journal of the Society of Chemical Industry*, January 15, 1912. This was of a silicon iron alloy, "tantiron," put out by the Lennox Foundry Co., Ltd., of London, England.

In May, 1912, after a year of experimenting, the first silicon iron alloy in the United States was put on the market under the name of "Duriron," by the Duriron Castings Co. of Dayton, Ohio. In 1913 the American rights for "Tantiron" were taken over by the Bethlehem Foundry and Machine Co., of South Bethlehem, Pa.

"Ironac" is another trade name for a silicon iron alloy made by the Houghton Co., Ltd., of London, England. While these are all alloys of iron and silicon, their composition is not the same.

Silicon iron alloy as put out under the above names is very resistant to all strengths of sulfuric acid, and apparatus made of this alloy is used in all forms of concentrating vessels and cooling devices for the concentration of sulfuric acid. By the use of the so-called "cascade basins" set in a proper furnace, full strength oil of vitriol is made from 50° Bé. acid. If all the fittings and coolers are made from this alloy the resulting oil of vitriol is practically free of iron after the plant has been in operation a few weeks. Where brimstone acid is used the resulting oil of vitriol should not contain over 0.0002 per cent iron. For sulfuric acid concentration, the alloy is durable and the breakage is very small. A plant properly handled will run for months without a shut-down. The success of the modern tower system for concentrating sulfuric acid has been due largely to the use of pipes and fittings made of this alloy.

Silicon iron alloy castings have extensively replaced stoneware parts for the manufacture of nitric acid. Early in 1916 the demand for nitric acid increased to enormous proportions; extensions to old nitric acid plants and the erections of new and larger plants was immediately demanded. The capacities of the stoneware factories of the country were soon taxed to their limit. Deliveries could not be made under 6 months, if at all. Had the production of nitric acid been dependent upon stoneware as it was a few years previous, the production of nitric acid would have been greatly curtailed and the story of the World's War would probably be different.

The silicon iron alloy is resistant to nitric acid of various strengths. It can be cast into all the various forms required for nitric acid apparatus. Castings can be made as readily and as quickly as can those made of cast iron. Here was the ideal substitute for stoneware. Necessity compelled its use and to-day it has largely superseded stoneware for nitric acid production.

A large nitric acid plant equipped entirely with this alloy in the form of "Duriron" was in service for 8 mo. and the alloy showed no indications of corrosion or deterioration. There was practically no breakage. Fire destroyed the building housing the plant and most of the supports for the apparatus. The fire did not harm the castings, though they were exposed to intense

¹ Read before the Eighth Semi-Annual Meeting, American Institute of Chemical Engineers, Cleveland, June 16, 1916.

heat. Eighty per cent of the castings were recovered and put into service and are in use at the present time. Ninety per cent nitric acid made in a plant equipped with "Duriron" castings showed an average iron content of 0.0014 per cent iron while 36 Bé. nitric acid (52.30 per cent) showed 0.0042 per cent iron.

The silicon iron alloy was developed to resist acid. It not only resists acid, but it is resistant to erosion and to rust. Ground surfaces, representing the true alloy, are practically immune from rust. The rough casting may show some rust on exposure, but this is due to impurities in the surface caused by contact of the alloy with the molding sand; this is a surface rust only and will not penetrate. The alloy is also heat-resisting, when made of suitable design. For very high temperatures, the walls must not be too thick. Castings do not distort on heating but hold their form up to the melting point.

The following data are given for "Duriron":

TABLE I—ANALYSIS (APPROXIMATE) OF DURIRON

	Per cent		
Silicon	14.00 to 14.50	Melting point	2500° to 2550° F.
Manganese	0.25 to 0.35	Specific gravity	7.00
Total carbon	0.20 to 0.60	Compression strength	70,000 lbs. per sq. in.
Phosphorus	0.16 to 0.20	Tensile strength	25 per cent less than cast iron
Sulfur	Under 0.05		

A bar of "Duriron" was compared with a bar of equal size of the best grade of chemical pottery, under equal conditions; the earthenware test bar broke so quickly that the testing machine gauge did not record any pressure. The "Duriron" bar broke under a load of 1000 lbs. By using a suspended vessel on an earthenware bar and gradually loading it with small pieces of metal and sand, a breaking test of 100 lbs. was obtained for the earthenware bar.

TANTIRON—Tantiron was first produced by Mr. Robert W. Lennox of the Lennox Foundry Co., of London, England, about 1908. In 1913 the rights for the use of this alloy in the United States, Canada and Mexico were acquired by the Bethlehem Foundry and Machine Co. of South Bethlehem, Pa.

TABLE II—ANALYSIS (APPROXIMATE) OF TANTIRON

	Per cent		
Silicon	14.00 to 15.00	Melting point about	2550° F.
Sulfur	0.05 to 0.15	Specific gravity	6.8
Phosphorus	0.05 to 0.10	Tensile strength	6 to 7 tons per sq. in.
Manganese	2.00 to 2.50		
Carbon (graphite)	0.75 to 1.25		

The alloy is not suitable for apparatus in which high internal pressures are to be used, unless it is strengthened by a protecting jacket. Forty to fifty lbs. is given as the maximum working pressure for an autoclave made of Tantiron.

In general, silicon iron alloy cannot be cast in rectangular shapes or flat surfaces. The chemical engineer should collaborate with the foundryman in order to design shapes which can be produced in the foundry, and still serve the purpose of the operating conditions required.

CONCLUSION

While there is still opportunity for improvement and while there is much more to be desired in an acid-resisting material out of which to construct apparatus for the acid industry, yet, the silicon iron alloy or silicide of iron, as it has been called, has proven a boon to the acid industry; without it many things could not have been accomplished. It is more efficient than stoneware. At best, chemical stoneware if made properly should take 10 to 12 weeks for its production. Castings of this alloy can be made and delivered in the same time it takes to make castings out of cast iron. The limitation to castings made of this alloy are those of shop and foundry alone. One company has a foundry with a furnace capacity of 72 tons per day. To-day thousands of tons of castings made of this alloy are in use. It is finding its way in all branches of chemical industry. Since its introduction new chemical processes have been started which were impossible before, because of lack of suitable apparatus.

Silicon iron alloy is being improved upon rapidly and the time does not seem far distant when all sorts of vessels will be made of this or a similar alloy that will give to the chemical industry the ideal non-corrosive material that may be fabricated into all the shapes peculiar to the needs of the industry.

1108 S. 46TH STREET
PHILADELPHIA

COKE-OVEN AMMONIA FOR MUNITIONS

By J. W. TURRENTINE

It is a very healthful reconnaissance that the nation is now making of its resources and industries in relation to national preparedness for defense. For the first time it has become recognized in this country that successful wars are to be fought as much with mine, factory and skilled labor as with gun, battleship and armies. The nation finds itself peculiarly independent of foreign sources of materials essential to a state of preparedness: of food materials, the metals, fuels, fabrics and—we hope to show—explosives.

Since for the manufacture of the various explosives for munitions purposes we have been using nitric acid obtained exclusively from sodium nitrate imported from Chile, the impression has come to prevail that we have no domestic source of nitric acid, and, therefore, that in case of war with a nation of sufficient maritime strength to enforce a blockade, we would be seriously embarrassed.

Upon investigation it develops that we have a domestic source of raw materials from which nitric acid may be prepared; that this source is now large and rapidly growing, and that it is susceptible of a practically unlimited development should necessity or public exigency demand. The source meant is the ammonia recovered as a by-product in the distillation of coal for the production of coke and gas. That it has not become more generally recognized as a source of nitric acid is because it has found a ready market in that other great industry dependent on cheap nitrogen compounds, the fertilizer industry, to which it contributes about 40 per cent of the nitrogen now consumed therein, and because commercial methods of converting ammonia into nitric acid are new and imperfectly understood. The explosives industry has been content with its abundant and convenient supply of raw materials obtainable from Chile and, therefore, has not demanded the development of an additional supply. The question has never before arisen in a popular way; hence, the popular misconception.

In time of blockade, with Chilean nitrate no longer available, ammonium sulfate would be the main nitrogenous compound available in this country for munitions and fertilizer purposes. To what extent would this be adequate to meet the demands of the country in such an emergency?

PRESENT DOMESTIC PRODUCTION OF AMMONIA

The present production of ammonia in this country is from two main sources: (1) By-product coke ovens, and (2) coal-gas and bone carbonizing works. The production of by-product ammonia has developed from an output of 13,800 tons in 1900 to 153,000 tons in 1913. The details of the record are set forth in Table I; likewise are presented, figures showing the production of ammonia from coal-gas and bone-carbonizing works. From these figures it is evident that the by-product oven is not only the chief source of domestic ammonia, but that it is rapidly overshadowing the other two sources.

Bituminous coal contains 1.2 to 1.34 per cent combined nitrogen. By ordinary methods of coking and from the average coal, a yield of 20 lbs. ammonium sulfate is expected per ton of coal. This is realized when the coking is done in the so-called by-products oven, that type of oven which makes possible the recovery and utilization of the surplus gas (*i. e.*, the gas not needed in the process itself to produce the heat for the coking).