

THE FRANKLIN INSTITUTE.

*Stated Meeting, Wednesday, April 18, 1900.*RECENT PROGRESS IN THE ALUMINIUM
INDUSTRY.

BY PROF. JOSEPH W. RICHARDS,
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Professor Richards spoke in substance as follows:

It is not yet seventy-five years since aluminium was first isolated as a metallic powder, and not yet fifty years since it made its appearance as a true solid metal, while until fifteen years ago its price was counted in dollars per pound, and it was used only for articles of luxury or for purposes where lightness was a desideratum and expense was not considered. From 1884 to 1891 several new processes of production followed each other, reducing the price nearly 50 per cent. each year and causing the output of metal to increase nearly 100 per cent. each year, until with the present decade aluminium became a metal of every-day life, for it began to compete with such ordinary metals as German-silver, britannia, pewter, bronze, copper and even brass. To-day sees this new metal firmly established among the every-day metals, known to and used by the general public, and destined to ever-increasing usefulness until its only rival will be iron and steel.

My further remarks will concern only *recent* advances; and in the line of pure metallurgy, that is, reduction and refining, there is little to chronicle. The process of reduction has certainly been somewhat improved in details, but in principle it is the same as the Hall process of ten years ago. The operators of the process are naturally averse to publishing the details of their operations, and the outside public is vouchsafed information only upon the properties and utilization of the metal. About all there is to be said is that during the last few years all the items of expense of the process have been gradually notched down—bauxite is

being mined and prepared better and more cheaply; its conversion into alumina is probably improved; electrolytic carbons are being made cheaper and more durable; electric power is being obtained more cheaply, and, finally, the doubling and doubling again of the size of the works has reduced correspondingly the cost of superintendence and office expenses. These, and probably several other items of saving, have altogether reduced the cost price of aluminium to probably about 20 cents per pound, while its selling price is slightly over 30 cents in the United States and 25 cents abroad.

I could wish to be free to give more information on these metallurgical details, but since that is denied, I will pass on to the various uses of aluminium which have recently appeared.

Here is a small box containing a dozen aluminium thimbles, which was sold in the largest store in this city, this week, for 5 cents. This furnishes me a good text to talk about the displacement of other common metals by aluminium. These dozen thimbles weigh less than $\frac{1}{2}$ an ounce, and the aluminium in them cost the manufacturer just 1 cent. If he had made them of common brass, they would have weighed $1\frac{1}{2}$ ounces, and the metal in them have cost $1\frac{3}{4}$ cents, which is an increased cost of metal of 75 per cent. Or, stating it another way, to manufacture \$1,000 worth (selling price) of thimbles, the manufacturer would have to buy to make them (allowing 25 per cent. for waste clippings) \$250 worth of sheet aluminium or \$437.50 worth of sheet brass. The general public considers brass as a cheap metal, and such facts as the above are rather startling when first grasped.

Coming to the city in the train to-day, I estimated the amount of brass fittings on one railway car as about 300 pounds. Without exception, they were replaceable by light aluminium alloy, which, fully as strong, would weigh only 100 pounds and cost only two-thirds as much. The difference in cost would probably amount to \$20 per car, in favor of aluminium, while the saving in dead-weight hauled would be more than the average weight of one passenger per car.

Such instances as the above could be multiplied *ad libitum*, but these suffice to prove the point, little apprehended by the general public, that for almost every practical purpose aluminium is cheaper than all the common metals excepting zinc, lead and iron. Brass, tin, copper, are of approximately the same specific gravity, and in comparing their costs we usually think only of their relative cost per pound; but aluminium is entirely in another class. It takes only one-third of a pound of aluminium to take the place of one pound of these metals, and the proper basis of comparison here is to compare the price of one-third of a pound of aluminium with that of one pound of brass, etc. The comparison, therefore, stands as follows:

One-third pound of aluminium	\$o 11
One " " brass	15
" " " copper	17
" " " tin	30

The next great improvement, after that of the fall in price, has been in the successful manufacture of light, strong alloys. This has been a subject at which metallurgists have worked hard and long, and their labors are bearing fruit in abundance. Pure aluminium has many resemblances to pure copper. Take away the red color of copper, and its softness, malleability, toughness, silky fibrous fracture are almost exactly duplicated by aluminium; but they are both soft, rather weak, metals. Five per cent. of aluminium, silicon or manganese or 30 per cent. of zinc added to copper make famously strong bronze or brass. Similarly, 5 per cent. of copper, nickel or manganese, or 30 per cent. of zinc, added to aluminium, make strong metals as rigid as bronze yet only one-third as heavy. Such light, strong, good casting and machining alloys have an extremely large field of usefulness, and will receive a very large application in the near future. It would be possible for me to consume half of the time at our disposal this evening telling alone of the various strong, light alloys which have approved themselves in very recent years; but, as an illustration, I will mention the alloy made by the Delaware Metal Refinery, of this city, and which is one of the best. It is a hard white

alloy, specific gravity 3.1, melts clean, runs fluid, makes beautifully sharp and perfect castings, turns and machines like the finest brass, polishes well, and, to conclude, is fully as rigid and strong as gun-metal or the best of the ordinary bronzes. I do not enumerate this catalogue of virtues merely from my own knowledge of the alloy, but could substantiate it from the experience of Philadelphia firms who are using it regularly and are quite enthusiastic over its possibilities. This alloy is principally of aluminium and zinc, and sells at the same price per pound as pure aluminium. The field of application of light alloys with such properties to light-running machinery, portable apparatus, vehicles, instruments, etc., is almost immeasurable, and the next few years will see its use very general for such and similar purposes.

The use of aluminium for culinary utensils is extending steadily, as their merits become better known. A brief statement of what they are for this purpose is that they possess all the advantages of copper utensils, with none of their disadvantages. The first aluminium utensils put on the market, ten years ago, were generally too lightly made, and were consequently easily dented and bent out of shape. The manufacturers have learned by experience, and the ware now being sold is fully as durable as the best copper ware. An aluminium kettle in my father's house has been on the stove constantly for seven years, boiling Schuylkill water, and is apparently uninjured and unworn. The inside has a brownish adherent skin of oxide which seems to be continuous and to efficiently protect the metal beneath from further oxidation. It bids fair to become an heirloom in the family. [In reply to a question: "The aluminium goods need only as much attention as ordinary tin ware to keep them bright and clean. Bath-brick dust, such as is used for polishing knives, is as good a scourer as can be used on them."]

There are at present a full dozen firms engaged in manufacturing this culinary ware, and it is now so generally known that it was unnecessary for me to display any here as a novelty. This small "bonbonnière," made by Hill,

Whitney & Co., of Waltham, Mass., and modelled after the famous silver porringer hammered out by Paul Revere, is interesting as to its shape, as well as showing the beautiful finish, inside and out, which can be given aluminium ware.

As a distinct novelty in aluminium goods may be mentioned the beautiful ware being made by the native metal-workers in the bazaars and industrial school at Madras, under the leadership of Mr. Chatterton. These native workmen are probably the most skilful metal-workers in the world, and their work is principally confined to steel arms, silver ornaments and copper and brass utensils. The fact that aluminium sheet blanks can now be purchased cheaper than similar sized blanks of copper or brass has given the opportunity to introduce the working of aluminium. The natives have easily mastered the peculiarities of the new metal, and take most kindly to it. The native Indian troops are largely supplied with aluminium ware, and it is coming into favor in all castes, from the lowest to the highest, on account of its lightness and cleanliness, whilst costing no more than copper or brass utensils.

[There were here shown on the screen a number of photographs of the bazaar workshops and their ware, loaned for the lecture by the *Aluminium World*, of New York. The scenes were most realistic, and, judging from the photographs, the ware is equal in construction and superior in artistic finish to any other aluminium ware made anywhere.]

There are upon this table many small articles and novelties in aluminium, loaned by Mr. Mertz, of your city. It would be useless for me even to attempt to name all the various goods which are now being made of aluminium, in which its lightness and prettiness are much in evidence. The toilet goods and pocket articles are especially in favor, and aluminium combs are being made by tens of thousands, and consuming a generous share of all the aluminium sheet made. An equally large use is for fruit-jar caps, for which aluminium is superseding zinc, although more expensive, because of its harmlessness.

In the artistic branch of *lithographic printing* aluminium is rapidly winning an important place. Nearly two years

ago, speaking in this hall about the progress of aluminium industries in Europe, I spoke of the establishment I had visited at Mainz, which printed altogether from aluminium plates. The process was then quite new, but since that time about thirty firms in the United States alone have taken up the aluminium plate printing, and are using it regularly, while the number in Europe is probably forty or fifty. Here is a trade catalogue printed by the Sackett & Wilhelms Company, of New York, which is probably as fine a specimen of commercial color work as was ever printed, and this firm prints exclusively from aluminium plates. The printing is entirely surface work, and is being generally done on cylinder presses instead of flat-bed machines, the aluminium sheets being bent onto the cylinder, and thus allowing of fast running. This is, indeed, a most promising infant industry, which cannot but grow to large proportions, seeing the advantages of aluminium plates over lithographic stone.

Electric conductors can now be laid more cheaply in aluminium than in copper. This is indeed a startling statement when first heard, for almost every one is wont to consider copper as the metal *par excellence* for conductors. But, pure aluminium has over 60 per cent. the conductivity of pure copper, and is fully as strong and resistant to atmospheric influences. It is therefore only necessary to take an aluminium wire one-fourth as large again in diameter as a copper wire (giving a little over 50 per cent. more section) to get equal conductivity. Such a wire weighs one-half as much as the copper wire it replaces, and costs only two-thirds as much. Long-distance transmission lines and trolley-line feed wires are being put in in aluminium as fast as the makers can supply the metal. Over 500 tons of aluminium were used for this purpose last year, and probably double as much will be used this year. As 500 tons supplants 1,000 tons of copper, it will not be long before the copper industry will begin to feel the competition of aluminium, but will probably be unable to meet it. This one use of aluminium promises in the near future to consume its thousands of tons a year. What a contrast to the

industry fifteen years ago, when two and one-half tons of aluminium was the output of the whole world in one year!

The samples of aluminium cables before you were kindly sent by the Pittsburgh Reduction Company, which has been foremost in developing this use of aluminium.

It is now necessary for me to rapidly bring my remarks to a close, and to leave unnoticed many interesting items which might be mentioned did time permit. I will close by referring to *powdered* aluminium and the many applications it is receiving. Aluminium can be rolled out to $\frac{1}{1000}$ of an inch in thickness, and then beaten out to $\frac{1}{4000}$ or even $\frac{1}{7000}$ of an inch. As thin sheet it has found some application in place of cardboard, for business cards, etc., but as leaf it has entirely superseded silver-leaf in decorating. This leaf can, moreover, be ground to powder, and in this condition is used by printers for silvery printing, and as a paint. For the latter use it is simply mixed with a varnish, like ordinary bronzing powders, and has already proven its beauty and utility on Uncle Sam's letter-boxes. Every one here has had the opportunity of seeing this use and judging for himself of its practicability. It is to be hoped that the Public Buildings Commission of your city will not overlook this material when considering the painting or refreshing of the metal work on the City Hall tower. It is not likely that a more suitable, durable or beautiful covering can be obtained than this would give, whilst the cost would certainly be moderate.

The powdered aluminium has recently received an extremely interesting metallurgical application, in the reduction of refractory metallic oxides to the metallic state. Over forty years ago Tissier proved that aluminium energetically reduces some metallic oxides. He mixed the metallic oxide with aluminium powder, heated it in a furnace, and generally succeeded in reducing the oxide to metal and, in some cases, reducing the furnace to ruins. Our esteemed Secretary, Dr. Wahl, with Dr. Greene, made use of the same energetic reducing power of aluminium to produce carbonless metals, by incorporating with the finely-divided metallic oxide the needful quantity of granu-

lated aluminium and reducing the mixture with the aid of heat, in magnesia-lined crucibles, adding a certain quantity of flux to this mixture to facilitate the reduction. They found this process to be specially applicable to the production of carbonless manganese and chromium of a high grade of purity. This is indeed a practicable method of operating the reaction under control.

A further improvement is the method of Goldschmidt, of Essen, Germany, who mixes the metallic oxide with powdered or granulated aluminium and ignites the cold mixture in a cold crucible. The heat thus generated is sufficient to melt the reduced metal and even the resulting alumina, and the danger of explosion is very small. To ignite the mixture, a small hole is scooped in its upper surface, into which is put a mixture of barium peroxide and aluminium powder, which is relatively easy to ignite. A strip of magnesium ribbon or flash-light paper is stuck into this mixture, and lit by a match. The magnesium sets the peroxide mixture off, and this starts the oxide mixture reacting next to it, and the heat thus spreads through the whole mass. In five to ten seconds the entire contents have reacted; the generation of heat is so rapid that the crucible does not become warm outside for some minutes, and is so intense that it is unbearable to the eye, and is probably between $2,500^{\circ}$ and $3,000^{\circ}$ centigrade. In operating on a large scale, a small amount of the powder is first ignited in the crucible, then more is continually added and the reaction kept up until the crucible is full. Then the melted alumina slag is poured off and the melted metal beneath poured out. The method is applicable to reducing to metal almost all metallic oxides, except those of magnesium, the alkaline earths and earths, and has been applied to the more expensive metals which are ordinarily considered as difficult to reduce, such as manganese, chromium, titanium, tungsten, molybdenum, vanadium, uranium, boron, etc. In some cases the ferro-alloys are made, which are an easier form to introduce the metals into steel, melting easier and diffusing quicker in the steel. At Krupp's works, at Essen, many such alloys are made for use in armor-plate steel, and a

similar class of alloys is being made here in Philadelphia, probably by the same method.

[A mixture of 8 ounces of green chromium oxide with 4 ounces of powdered aluminium was ignited by the lecturer, in the manner described. The heat developed in the crucible was intense, while yet it was cool enough outside to handle, and there was obtained a slag of melted alumina containing buttons of melted metallic chromium. The theoretical amount of the reducing agent in this case was 1 pound of aluminium, in powder or granulated form, to produce 1 pound of chromium. Granulated aluminium costs at present about 40 cents per pound; the powder, \$1.25.]

Stated Meeting, April 25, 1899.

ELECTROMAGNETIC MECHANISM, WITH SPECIAL REFERENCE TO TELEGRAPHIC WORK.

BY R. A. FESSENDEN.

INTRODUCTION.

In designing electromagnetic mechanism, we should take as our motto "*cherchez l'erg*," and, having found the way the energy is distributed, we should always keep it in view. It is on these lines that I have written the present paper, and, as we shall see, this method leads to several very simple and useful rules.

As regards the nomenclature used, I have taken the units adopted by the American Institute of Electrical Engineers; *i. e.*,

P = Webers = number of lines of magnetic induction.

G = Gilberts = difference of magnetic potential.

N = Oersteds = magnetic reluctance,
the defining equations being

$$P = \frac{G}{N} \text{ and } G = 4 \pi n I,$$

where n is the number of magnetizing turns, and I the current in them, all units being in the absolute electromagnetic system.