

A NEW PROCESS FOR THE PRODUCTION OF THE METALS  
OF THE ALKALIS.

BY HAMILTON V. CASTNER, of New York.

[*A Paper read before the Chemical Section of the FRANKLIN INSTITUTE,  
October 12, 1886.*]

MR. H. W. JAYNE, President, in the Chair.

DR. WAHL, Secretary of the INSTITUTE, presented the following communication from Mr. Castner.

MR. PRESIDENT AND GENTLEMEN:—I shall first proceed to give a brief description of the process heretofore employed for manufacturing the alkali metals, together with the defects of the same, which prevent an economical production of metal, before explaining the method I have invented for their reduction, and its advantages over the older process. Although in the following paper mention is only made of sodium, the same remarks are intended to apply to potassium, the process being practically alike in the production of either metal. The method formerly used consists in igniting, at an intense heat, an intimate mixture of nine parts of sodium carbonate, four parts of charcoal, and one part of lime in wrought-iron vessels, cylindrical in form, placed horizontally in a furnace, the said cylinders being furnished with a small tube to conduct the metallic vapors and gases produced during the reduction, into the attached condenser, wherein the vapors are condensed and the sodium obtained. The cylinders must be constructed of wrought-iron, this being the only metal possible to use that will stand the heat, and the dimensions of the same not exceed a diameter of 6 inches, or a length of 5 feet. The mixture of sodium carbonate, charcoal and lime must be finely ground and calcined, to render it more compact, previous to placing it in the cylinders. Lime is added to make the mass refractory, otherwise the alkali would fuse when the charge is highly heated, and separate from the light, infusible carbon. The carbon must be in the proportion to the sodium carbonate as four is to nine, which is found needful in practice, so as to assure each particle of soda in the refractory charge having an excess of carbon directly adjacent or in actual contact. Notwithstanding the well-known fact that sodium is reduced from its oxides at a degree of heat but slightly

exceeding the reducing point of zinc-oxide, the heat necessary to accomplish reduction by this process and to obtain even one-third the metal contained in each charge, closely approaches the melting-point of wrought-iron. Any process devised for the manufacture of sodium, by which its cost could be reduced, would have to be an improvement over the older method in one or more of the following directions, namely :

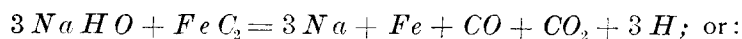
(1.) The process should be more simple in its details, and not require the care and management necessary in carrying on the process or method now used.

(2.) Performing the reduction at a comparatively low temperature and so save in the fuel and prevent the excessive destruction of iron, which at present stands for one-half the cost of the sodium produced.

(3.) By increasing the yield of sodium, as in the old process, when one-third the metal contained in the charges, is obtained, the result is considered very satisfactory.

The process which I employ consists in reducing either the hydrate or carbonate of an alkali, when in a fused state, at moderate temperatures, by the use of the carbide of a metal or its equivalent, whereby an excess of carbon is avoided and the use of lime is rendered unnecessary. The reducing substance, due to its composition and gravity, remains below the surface and is therefore in direct contact with the fused alkali. By the equivalent of the carbide of a metal, I mean, a mechanical compound of carbon and metal from which the metal cannot be separated, excepting by the aid of acids or intense heat. Such a compound I produce by coking a mixture of tar and iron (previously reduced in a fine state of division, by carbonic oxide or hydrogen). From experience, such proportions of tar and iron are used, as will produce, when the mixture is coked, a heavy mass of metallic coke, having about the composition of, iron seventy per cent. and carbon thirty per cent., equivalent to the formula,  $Fe C_2$ . This mechanical compound, after being ground, is ready for use and consists of fine particles of iron, coated with carbon, fully answering the purposes of a true carbide. I prefer to use caustic soda in the preparation of sodium, on account of its fusibility, and with it mix such quantity of the so-called "carbide;" that the carbon contained in the mixture shall not be in excess of the amount, theoretically required to

reduce all the soda to sodium, according to the following reaction,



to every 100 pounds of pure caustic soda, fifteen pounds of "carbide," containing about twenty-two pounds of carbon, is added. The treatment of this mixture is carried on in large cast-iron crucibles, in a furnace, the general arrangements of which are as follows: The heating space of the furnace is divided into separate chambers, the dimensions of the same depending upon the size of the crucibles to be heated, and the number of these compartments are in proportion to the capacity of production desired for the furnace. An aperture is provided in the bottom of each chamber, through which the crucible may be raised by mechanical means into its position in the furnace. The necessary cover for the crucible is fixed stationary in each chamber, and from this cover projects the tube to the outside of the furnace into the receptacle for the condensation of the metallic vapors. When operating, the crucibles are charged with the mixture, made as before described, placed upon the lift, which is situated directly below the aperture made in the bottom of the chamber, and raised into the furnace. The edges of the covers are made convex, while the edges of the crucibles are concave, so that when the crucibles are raised the edges come together, and, being held from below, form a tight joint, preventing the exit of gas and vapor, excepting through the tube provided from the cover. Gas, which is used as a fuel in connection with heated air, is allowed to enter the chamber, after the crucible containing the charge is in place, and the reduction and distillation commences as soon as the crucible contents have reached the temperature of  $1,000^{\circ} C.$ , the sodium being reduced in the crucible and distilled therefrom into the condenser, by passing through the tube projecting from the crucible cover. As soon as the operation is finished, the crucible is lowered and a new one containing a fresh charge is raised in its place, while the crucible just removed is cooled, cleaned and recharged. The appliances, which hold the cover in place are so arranged, that the cover may be removed whenever necessary without interrupting the process, which is practically continuous. By avoiding the careful mixing and calcining of ingredients, preparatory to charging the cylinders, and in carrying out generally the mechanical

part of the old process, the details of which require the most careful management, the method just described will be seen to have many advantages. As the charge is fused, the alkali and reducing material are in direct contact, and this fact, together with the aid rendered the carbon by the fine iron, in withdrawing the oxygen from the soda, fully explains the chemical reasons why the reduction is accomplished at a moderate temperature. Furthermore by reducing the metal from a fused mass, in which the reducing agent remains in suspension, the operation can be carried on in crucibles of large diameter, the reduction taking place at the edges of the mass, where the heat is greatest and the charge flowing thereto from the centre to take the place of that reduced. By the old process, the heat required to penetrate to the centre of the refractory charge and reduce the soda there situated in addition to the heat absolutely needful to bring about reduction, necessitates the use of wrought-iron vessels, and even when these are made small in diameter, which partially removes this great disadvantage of the method, the expensive cylinders are rapidly rendered worthless from the effects of the intense heat.

In doing away with the use of lime and an excess of carbon, the main causes which have hitherto prevented a full yield of metal are removed, and thus, with the aid of other advantages described, I am enabled to obtain fully ninety per cent. of metal, instead of thirty per cent., as formerly. By the old process, lime must be added to prevent fusion, to insure any reduction, yet at the same time it forms, with a portion of the soda, the compound known as soda-lime, and from this substance carbon reduces sodium only at the most intense heat. In practice, according to the old method, four pounds of carbon are used to every nine pounds of sodium carbonate. This is twice the amount theoretically required to reduce all the sodium, even assuming the gas resulting from the reduction to be wholly carbonic-oxide. When, however, but one-third the total amount of sodium is all that is obtained from a charge, the proportion between the sodium produced and carbon used becomes as one is to six. The effect of an excess of carbon in the mixture, which, as previously explained, is really necessary, is to produce an excessive amount of carbonic-oxide, and this, together with the excess of carbon, combines with the metallic vapors of sodium, forming various compounds, from which

the metal cannot be distilled. By reducing caustic-soda with the carbide of a metal, or its equivalent, and using only sufficient carbon to carry out the reaction stated above, the gases given off consist of hydrogen, carbonic-oxide and carbonic-acid, which mixture has little or no effect upon the vapors of sodium. The crucibles, after treatment, contain a small amount of carbonate of soda and all the iron of the "carbide" still in a fine state of division, together with a very small percentage of carbon. These residues in the crucibles are treated with warm water, and the solution of soda evaporated to recover the carbonate of soda, while the fine iron is dried, mixed with tar and coked to produce more of the so-called "carbide equivalent."

---

## TURBINES.

---

BY J. LESTER WOODBRIDGE, M. E., Stevens Institute of Technology.  
[With an Introduction by DE VOLSON WOOD, Professor of Mechanical Engineering.]

---

### (INTRODUCTION.)

TO THE COMMITTEE ON PUBLICATIONS :

I forward to you, for publication, the graduating thesis of Mr. Woodbridge, upon "Turbines." The first well-grounded theory of these wheels was by M. Poncelet, who read a paper upon this subject before l'Academie des Séances, Paris, entitled "La Théorie des Effets Mécaniques de la Turbine-Fourneyron," published in *Comptes Rendus*, Paris, 1838. This solution was so thorough and elegant that it is often referred to as "historical" and "classical." The analysis was founded on the principles of work and energy, and his methods have been followed by many writers since his day. Rankine, in his *Steam Engine and other Prime Movers*, has given a partial solution of a special case founded on the principle of the *Moment of the Momentum*, and he has been followed by Unwin, in his article on "Hydro-mechanics," in the *Encyclopædia Britannica*, IX edition. It will be seen that Mr. Woodbridge's solution is founded upon the resolution of the pressures of elementary volumes and their moments, and is more general than either of the preceding, if not the most general solution of the frictionless turbine yet made. Yours truly,

DE VOLSON WOOD, *Prof. Mech. Eng.*

*Hoboken, June 25, 1886.*