

THE ECONOMIC IMPORTANCE OF FIXED NITROGEN.

BY L. HEIMBURGER, M.S.,

FIRST ASSISTANT STATE CHEMIST.

Mr. President, Ladies and Gentlemen:

Of the three natural elements so often deficient in our soils combined nitrogen is the one most easily exhausted, the most costly and the most rare.

Every crop removes its aloquent portion of combined nitrogen from the soil, and if not returned by the grower leaves the soil proportionally poorer. Every battle results in the waste of hundreds even thousands of tons of nitrogen that could be used in supporting instead of destroying human life.

Again our sewers are delivering untold millions of dollars of nitrogen annually into the sea.

Every pound of coal or wood as ordinarily burned, results in the return to the atmosphere of a definite amount of nitrogen.

The problem is to replace this annual loss of combined nitrogen and as our two chief sources at present are neither inexhaustible, it becomes a serious matter. These two chief sources are our coal beds and nitrate deposits. Of the coal burned only a comparatively small amount of the nitrogen content is saved and our visible supply of Nitrate is being rapidly exhausted.

At the present increasing rate of exportation, now one and a half million tons annually, the Chili nitrate deposits cannot last more than another twenty years.

Nitrogen is one of the least active

chemically of all the elements, and for this reason, it is found in nature principally in its free uncombined or elementary form. It is only by the most drastic of chemical or physical methods that elementary nitrogen can be made to combine with other elements. The ultimate source of all our nitrogen combined and uncombined is the atmosphere where it is present in its elementary form to the extent of about 79 per cent. by volume. The remaining 21 per cent, is principally oxygen.

The greatest direct economic value of elementary nitrogen in the atmosphere is to act as a delutant to the oxygen. Incidentally it is the source of all combined nitrogen.

Elementary or uncombined nitrogen has no neutrant value to the higher organisms and therefore is of no direct value to the plants and animals we are most interested in.

In its combined forms nitrogen is one of the bases of life among higher organisms being a principal constituent of protoplasm; the others being Carbon, Hydrogen, Oxygen, Sulphur and Phosphorus.

If it were not for combined nitrogen, life as we now know it would be impossible.

Here the question may be asked, how is the free or elementary nitrogen which is so inactive chemically, made to combine in nature with other elements so that higher life may be possible?

This is a most difficult question to answer, and at present can only be answered in part by Science. It is along this line that bacteriology together with chemistry and physics have accomplished great work in recent years.

Bacteriology, the youngest of all the sciences has shed the greatest amount of light upon this question. During the last two decades this science through its many researches tells us of a great number of micro-organisms that have the power of fixing nitrogen; that is, they are capable through unknown processes to cause elementary nitrogen to combine with certain other elements present to form compounds of Nitrogen which are available as food for higher plants.

These nitrogen fixing micro-organisms may be divided into two classes, symbiotic and non-symbiotic.

The greater amount of research has been devoted to the former, and therefore they are best known at present.

These symbiotic micro-organisms are always found intimately associated with certain higher plants especially the papilionaceae or leguminosae (beans, peas, clover, etc.) in whose roots they reside. The amount of nitrogen that may be fixed by these micro-organisms is large and the cultivation of legumes should always be encouraged.

Of late years our National Department of Agriculture has been making great efforts to devise a reliable method by means of which the micro-organisms above mentioned may be readily distributed in a commercial way.

The method of drying the cultures on cotton, recommended so highly not longer than a couple of years ago, has recently been shown to be but at best partially suc-

cessful. Still a reliable method will undoubtedly be forthcoming before long.

To the second class or non-symbiotic nitrogen fixing micro-organisms belong those of bacteria that have the power of fixing elementary atmospheric nitrogen unaided by any host. These organisms have not as yet been studied extensively, still a large number of forms have been discovered.

Besides the nitrogen fixing bacteria just discovered, there are forms of micro-organisms that have an opposite function, that is, they have the power of breaking up nitrogenous compounds with the liberation of elementary nitrogen. Therefore the action of these bacteria result in the loss of fixed nitrogen in the soil. These organisms can, however, be readily controlled by the proper drainage and cultivation of the soil, for they are as a rule anarobic, (not capable of existing in the presence of air) or at best but slightly facultative (capable of existing in or not in the presence of air.)

Another natural agency by means of which atmospheric elementary nitrogen is fixed is through electrical discharges.

For many years it has been known that lightning discharges cause atmospheric nitrogen to combine with oxygen to form oxides: These in turn unite with aqueous vapour to form nitric and nitrous acids, which are washed out of the air into the soil by the rain.

It must be borne in mind that but a very limited amount of atmospheric nitrogen is fixed in this way.

As far back as 180 years ago Cavenish, one of the founders of modern chemistry, predicted the commercial fixation of atmospheric nitrogen and a few years later contemporaneously with Priestly

showed that electric sparks under certain conditions oxidized atmospheric nitrogen.

Later the noted chemist Bunsen did more valuable work in the electro-thermic fixation of atmospheric nitrogen.

Until very recently the yield of oxides of nitrogen has been very poor by electro-thermic methods being only in the experimental stage. The principles upon which are based all electro-thermic methods for the fixation of free nitrogen are in general as follows:

When air is subjected to silent electrical discharges of high potential, the oxygen is ozonized and the nitrogen is oxidized most largely into nitric and dinitric oxides (NO , NO_2) the former can be further oxidized to dinitric oxide.

Dinitric oxide or nitrogen preoxide in the presence of water forms nitric (HN O_3) nitrous acid (HN O_2) as well as nitric oxide (NO) depending on the relative proportions of peroxide and water present.

These acids, nitric and nitrous, combine with bases to form nitrates and nitrites.

To oxidize nitrogen requires a very high temperature. It has been shown in recent years, that the percentage of nitrogen oxidized is very largely dependant upon the temperature the gases are exposed to. Nernst determined that at 1,811 degrees C. only .37 per cent. of the Nitrogen supplied was oxidized, while at 3,200 degrees C. 5 per cent. of the nitrogen was oxidized.

If the oxides formed are not rapidly removed, this high temperature causes their decomposition.

Electricity is the best source of heat for obtaining the high temperature re-

quired for the oxidization of atmospheric nitrogen.

Of the large number of electro-thermic methods for the fixing of free nitrogen, but one, the Birkeland-Eyde process, has proven a complete commercial success.

In the Birkeland-Eyde process the inventors use magnetic blow-pipe electrodes with an alternating current, this gives a flame disk of large surface.

The air enters from both sides of the flame disk and is drawn off from below in such a manner that it has passed directly through the plane of the flame.

Only about two percent. of the nitrogen is oxidized in the flame. After passing through the flame, the air is cooled in a suitable chamber where the nitric oxide (NO) is further oxidized to peroxide, (NO_2). From the cooling chamber the gases are conducted through absorption towers, eight in number, where they come in contact with water. The dilute nitric acid is drawn off from below, raised again, and allowed to trickle down again from tower to tower, until upon flowing from tower number eight the formerly very dilute acid has been raised to about 50 per cent.

The last traces of acid are removed in towers irrigated with lime water and finally in a dry lime chamber.

The nitric acid thus obtained is neutralized with calcium carbonate (limestone) Ca CO_3 , and the resulting calcium nitrate (Ca NO_3) is evaporated and fused using the waste heat from the electric furnace.

The factory at Nottodden, Sweden using the Birkeland-Eyde process, obtains a yield of from 11 to 13 hundred pounds of nitric acid per kilowatt year, equivalent to about 1 1-3 horse power year.

At these Nottodden works cheap water power is to be had, and in many places in Sweden power may be produced for the very low rate of \$3.00 per horse power year.

With the above figures in mind i. e. \$3.00 worth of power for the production of one half ton of nitric acid, it is proven that the nitrate of lime as produced at Nottodden can successfully compete with Chili nitrate of soda at current prices.

The Birkeland-Eyde process being new, is susceptible to material improvement.

A new improved plant, recently put up, turns out over fifteen hundred pounds of nitric acid per kilowatt year.

The much dreaded nitrogen famine so often predicted of late years, may in the very near future be entirely eliminated by electro-thermic methods for the direct fixation of atmospheric nitrogen.

FERTILIZING MATERIALS.

BY LORENZO A. WILSON

Mr. President, Ladies and Gentlemen:

The fertilizer question has been so ably handled before this Association during its nineteen meetings it would appear there was very little left to be said regarding it. My friend, Mr. Painter has told you some of the things he knows on several occasions and has also issued some very intelligent books that nearly all of you have read. During the past twelve years I have written articles myself, sending them broadcast over the State to nearly every one of you I think, and there is only left for me now the rehashing of the same matter.

There are so many growers in the State who have made such a close study of the question of plant foods and are so well-posted on it that I find it a very difficult matter to-day to get a traveling salesman to work for me, who knows as much on this subject as many members of this Association do. I have always said it was a bad plan to put a fertilizer manufacturer on this Committee as it is almost im-

possible for him at times to leave out some of the good things he might say of his own brands when he writes or talks on fertilizers. In the following article I have tried to write with the idea before me all the time, that I was a fertilizer broker in New York, selling materials to the manufacturers of Florida.

First I would like to say that the fertilizer industry has been very thoroughly developed in Jacksonville during the past two years. To-day the fertilizer factories of this city have a capacity for making approximately two hundred thousand tons of complete goods, if they had the market for them the year round, and the equipment to move them with.

PRICES.

The small growers of Florida buy their fertilizers cheaper to-day in this State than many of the larger buyers do on Long Island, New Jersey or Connecticut or Massachusetts. All of this has been made possible by the development of the fertilizer business in Jacksonville; the