CHEMICAL SECTION.

Stated Meeting, held Thursday, October 13, 1904.

Industrial Notes.

DR. BRUNO TERNE.

After an absence of nearly four years from Philadelphia, it affords me great pleasure to accept the invitation of my esteemed friend, Dr. Wahl, your Secretary, once more to address the Chemical Section of the Institute.

I can offer you no new discoveries, but I would like to call your attention, briefly, to some topics of technical chemistry which I have followed with special interest for years.

It is just about thirteen years ago (October 20, 1891) since I addressed this Section on the Utilization of the By-Products of the Coke Industry. We had quite an interesting and lively debate that evening.

Dr. H. W. Jayne said, in opening the discussion: "No one will deny the importance of the subject presented to us this evening, and I am aware that it has been carefully investigated by a number of large firms in the country, but as yet nothing has been done."

I took the broad view that no local interest, nor all the influence of all the gas-works combined, would be able to stop the development of the by-product coke-oven industry in this country.

My closing words in the records of this debate were: "The development of these industries is bound to come in spite of all opposition, nor will it be so far off. The right start is the most difficult point."

Now let us see where we stand to-day. It has been my personal good fortune to come in close contact through having business transactions with the present General Manager of the United Coke and Gas Works, Dr. F. Schniewind, the foremost leader of the modern coke-oven industry in this country, and by this means to follow the development of this industry step by step.

Dr. F. Schniewind represents the Otto system, whose patents are controlled by the United Coke and Gas Company of New York. The system has been greatly improved and made adaptable to the special wants of the different coal districts. We have one plant of this system in full blast on the other side of the river, in Camden, and a much larger one in operation at the steel-works at Sparrow's Point, Baltimore.

Interested parties will find no difficulty in getting permission to study these monuments of technical chemical engineering skill.

A close second to the expansion of the Otto system is the Semet-Solvay system, under the management of the Solvay Company, of Syracuse, N. Y. These two systems together have already made such progress that their output of by-products induced the parties controlling the output from the gas-houses to pool their interests and form a sales agency under the name of "American Coal Products Company," at 17 Battery Place, New York.

For fuller information on the statistics of this industry I refer you to the excellent essay of Dr. Schniewind, published in *Mineral Industry*, Vol. X, page 135, 1901-02.

The figures of the consumption and production of ammonia, as sulphate equivalent, for 1903 are as follows:

Imports.	Sulphate Equivalent.
Sulphate	16,770 net tons.
Muriate	2,813 "
Carbonate	2,636 "
Other forms	Insignificant.

22,219 net tons.

Domestic Production.	
Coke Works	} Estimated 40,000 net tons.
Gas Works	
Carbon Plants, }	

Total domestic consumption about 62,000 net tons.

In the paper above referred to Dr. Schniewind estimates the production of sulphate of ammonia equivalent from the gas-works at 12,000 net tons. G. N. Parker, in *Mineral Resources* (1902), estimates the production at 15,641 tons.

Even if we allow the higher figures as correct and rounding up, allowing for the carbonizing plants with 17,000 tons, the sulphate of ammonia equivalent produced from the coke-ovens is 57½ per cent. of the total domestic output.

The increase of consumption has been, as compared with 1901, 14,178 tons, which mainly has been caused by the increase of the output of the coke-ovens.

To-day the Semet-Solvay Company has 650 ovens in operation in eight localities, and 120 ovens in course of erection.

The Otto system, represented by the United Coke and Gas Company, has 2,753 ovens in operation, with an output of 16,825 tons sulphate equivalent.

Taking these figures as a basis, they would leave for :

Gas-works	15,000 tons.	} . . sulphate equivalent.
Otto system	16,825 "	
Semet-Solvay	8,175 "	
	<hr/> 40,000 "	

These figures may not be absolutely correct, but they are near enough to give you a true estimate of the relative proportion of the sources of ammonia production.

Thirteen years ago there was not a pound produced by the coke-ovens; to-day they yield from 25,000 to 30,000 tons per annum. This is only the beginning of the by-product coke-oven industries. At the present moment there is a stagnation in the steel industries, and consequently during the last two years very little has been done toward development of new systems. Those under contract have been finished or are nearly finished. This dullness will shortly disappear, and with the revival of the steel industry, the extension of the by-product coke-oven will go on step by step. The system has been firmly established, the prejudice against it proven by practical experience to be without basis, and the beehive oven will gradually be replaced.

I cannot help looking back to our meeting thirteen years ago with some satisfaction, knowing that I have been supported in my prediction by the actual facts of progress of which I have laid figures before you.

The production of coke may play an important part for domestic fuel, as well as for factories to help to minimize the smoke nuisance. The time is rapidly approaching when the home production of sulphate of ammonia, or its equivalent, will exclude importation, and further on will reverse the statistics of trade. The fear has been expressed that over-production would ruin the prices of the by-products to such an extent as to make the process unprofitable. There need be no fear on that score. Not only is the domestic market daily extending, but the foreign market also will, in the near future, come in with large demands.

The most powerful competitor of sulphate of ammonia in the broad field of the fertilizer trade is the nitrate of soda of Chili.

The source of this raw material is rapidly nearing complete exhaustion, and as nitrate of soda is consumed not only as a fertilizer, but also for other uses in the arts, it is to be expected that it will presently cease to play an important role as fertilizer material. Something else will have to take its place. The most available substitute is sulphate of ammonia.

You all know that a complete fertilizer must contain :

Nitrogen, or its equivalent in ammonia ;
phosphoric acid in available form, and
potash.

But all the different brands are wholly or partially mechanical mixtures, and the idea occurred to me, why should I use sulphate of ammonia in dry mechanical mixture, when I could make a better and cheaper compound of ammonia phosphate by using directly the ammoniacal liquors with the acid phosphate while in process of making it?

I made experiments on the manufacturing scale, and succeeded in producing a high-grade ammoniated phosphate at figures which will allow its profitable production. I secured by letters-patent, No. 709,185, the principle of the direct use of the ammoniacal liquors for this purpose. Without going into details, I will say that I have the endorsement of the leading agricultural chemists, as well

as the endorsement of the leading dealers for this product, of which I show you a sample.

Pending some negotiations, I expect presently to develop this process on a large scale, thus opening a new and direct use of the ammoniacal liquors of the by-product coke-oven in large quantities.

While I was engaged as chemical manager with several large companies for the utilization of garbage, and trying to improve the utilization of this material on a rational basis, I made experiments to produce the ammonia from it by destructive distillation.

In 1897 I communicated with Mr. R. M. Atwater, then secretary of the Semet-Solvay Company, Syracuse, N. Y. My suggestion was well received, and induced the Semet-Solvay people to make some preliminary tests in an experimental retort with material furnished by me. On the basis of these results, which confirmed my own, the Semet-Solvay people desired to make a large run in their regular coke-oven, for which purpose I furnished, from the Barren Island Works, a carload of pressed garbage.

At the time of working our material I was in Syracuse and witnessed the work, which was in charge of Mr. W. F. Blauvelt, now Chief Engineer of the Solvay Company, Syracuse.

The following is the summary of the report made:

The garbage was tested under various times of coking, and with varying percentages of moisture, with the result that there is no doubt that the full charge of 4 tons of dry garbage can be coked in twelve hours, or two charges per day. The average percentage of moisture in the garbage was 27.2. The total amount of garbage tested was 26,940 pounds, equivalent to 20,420 pounds of dry garbage. The maximum charge in any oven was 7,645 pounds. Total dry residue, 6,580 pounds, 32.3 per cent. of the moist garbage charged. The residue was composed of fine granular carbon mixed with bits of coking, wire, tin cans and other refuse material. Upon screening over $\frac{1}{4}$ -inch screen, 26.5 per cent. coarse material remained. Of this screened material, 25 per cent. was carbon.

The yield of by-products is as follows:

Yield of ammonium sulphate per 2,000 pounds moist garbage, 61.3 pounds.
Yield of gas, 6,840 cubic feet.

ANALYSIS OF GAS.

	No. 1.	No. 2.	
CO ₂	16.9	16.1	Carbon dioxide.
C ₂ H ₄	0.0	0.7	Illuminating gas.
CO	37.0	28.7	Carbon monoxide.
O	.2	.6	Oxygen.
CH ₄	7.6	10.5	Marsh gas.
H	32.8	36.	Hydrogen.
N	8.5	7.7	Nitrogen.
	100.0	100.3	

Total combustible, No. 1 = 74.7 per cent.; No. 2 = 75.2 per cent.

The results in the experimental retort were higher.

Sulphate of ammonia obtained by this test was 65.25 pounds for 2,000 pounds moist garbage.

The dry residuum was 43 per cent.

The large difference between the residue obtained in the retort and in the ovens is doubtless due to the amount left in the ovens after pushing, and the loss from blowing away and washing away with water while quenching.

It was now a matter of calculation to see if the higher yield of sulphate of ammonia could balance the lower yield of gas and the absence of coke as a marketable commodity.

The gas produced reaches within 1,000 cubic feet per ton of material. The gas production from an average bituminous coal will be sufficient to serve as fuel to keep the oven going without any extra fuel supply.

If the ovens are in proper order there will be sufficient surplus of gas to produce the steam required for the ammonia plant. The solid residuum contains sufficient phosphoric acid and potash to make it valuable as a fertilizing material, which, by mixing it with the concentrated tank-liquors, will be greatly improved.*

After going carefully over all these points and calculating closely in comparison with the older method, the New England Sanitary Product Company, of Boston, and the Semet-Solvay Company made an agreement the 22d day of April, 1898, to erect jointly a plant to take care of the garbage of the city of Boston with the production of ammonia by the

* See United States Patent No. 619,056, February 7, 1899.

adoption of the Semet-Solvay coke-ovens modeled for this purpose. The plant, which should have been ready in July, was not finished until late in the fall. It consisted of a complete system of seven ovens with all auxiliary apparatus for the production of ammonia liquors and sulphate of ammonia, with a capacity of 45,000 pounds for the ammonia department.

The general plant was designed by the engineer of the Sanitary Company, Mr. Charles Edgerton, of Philadelphia. The coke-ovens and apparatus pertaining to them were designed and built by the Semet-Solvay Company. A detailed description of this plant, with drawings, is given in the *Engineering Record*, September 14, 1901, page 251, by Mr. C. G. Atwater, who represented the Semet-Solvay Company at the Boston plant.

You will have noticed that the moisture in the material for the Syracuse test is a little lower than 25 per cent. This is lower by 10 per cent. than the average of the fresh material from the presses at that time in use at Barren Island. The press work was the most objectionable part of the utilization plants from a sanitary point of view, and it was the steady aim of the engineering force to overcome the nasty work of charging the old knuckle-joint screw process.

We have made numerous experiments with many different kinds of presses, with centrifugals of different styles, but not with success. Finally, Mr. Charles Edgerton designed a roller press which, from a sanitary point of view, overcomes all objections, and as a labor-saving device cannot be excelled; but it had one great fault—it did not give the same result either in moisture or in grease.

In eleven tests which I made from December 10 to 31, 1898, the result was:

Moisture	52.38
Grease	5.84

In January, 1st to 7th, stock taken from storage on top of the oven ran as high as 62.84 per cent. moisture. This excess of moisture was death to the work of the ovens. We simply could not keep up the heat in the ovens; the retorts were changed to boilers. It takes not much argu-

ment to convince any one that under such conditions the ovens could not give satisfactory results. It was a most deplorable condition of circumstances that the introduction of the new presses absolutely spoiled the well-calculated work of the ovens.

The condition in Boston was such that the award of the contract depended on the performance of the new press, and there was nothing left to be done but to try to improve the work of the press to reduce the moisture, but it seemed absolutely hopeless to reduce the moisture to much less than 50 per cent.

We went to the limit to close the presses down, but we could not afford to keep it up—first, because the rollers would not get sufficient material through; and second, the breakage of the driving gears was so bad that it would have necessitated a special machine-shop and foundry to keep us going. Under these circumstances we came to the conclusion to put up a revolving drier, heated with the waste heat from the boiler, to improve the condition of the pressed garbage. After much loss of time we succeeded in reducing the moisture to such a degree that the ovens commenced to show results, and we accumulated ammoniacal liquors, which gained in strength from day to day. Improvements in the gearing of the presses at the same time helped to get a better raw material, and supported the drier in its work. Everything pointed to the way of final success. We had filled our weak-liquor storage tanks, and commenced to concentrate for shipment. We had made several hundred tons of fertilizer ready for the market when fate threw us down and out.

On the morning of February 10, 1899, a disastrous fire destroyed the plant. The whole by-product plant, with the exception of the ovens, lay in ruins, and therewith ended the chapter of our attempt to utilize the coke-ovens for the utilization of garbage, at least for the time being. But by no means had our well-calculated plan, based on a different condition of the raw material, been proven to be incorrect. It was the one change in the condition of the raw material which caused all the annoyances and delays, and it was this point which frustrated the rebuilding of the plant.

Rather than go on again under the same conditions, the Solvay Company accepted their loss and canceled their contract. The plan to utilize the coke-oven product for the utilization of garbage is to-day as correct as when we made the tests in Syracuse, but the material must be of the same consistency as that which I sent to Syracuse.

The roller-press, even to-day, is not an efficient machine because it does not give sufficient pressure, and also leaves too much moisture and grease in the product. As I said before, the press works clean, it creates the least nuisance, it takes fewer men to work it, but the product cannot be compared with the product of the hydraulic presses at work with the same material at Barren Island and Philadelphia.

If the ammonia market is favorable, pressed garbage with 25 to 30 per cent. of moisture will form a good raw material for its production. I would, if I should build another plant, modify the system of horizontal retorts to vertical ones, as both charging and discharging can be more easily arranged and the loss of material in discharges greatly reduced; the material should come from the presses by all means with no more than 30 per cent. moisture, which can then easily be reduced 10 to 15 per cent. more before entering the retorts.

There is a disposition among the large companies controlling the utilization of garbage to be satisfied to produce only grease and allow the rest to go to waste. An exception is the Barren Island plant, where the fertilizer is made in both conditions, improved with the tank liquors or in the original state. The plants in Boston and Philadelphia either sell the pressed garbage or use some under the boilers for fuel. In either case it is a waste, and the plant is not worked as it should be.

It is a miscalculation to lose the fertilizer; all figures to the contrary are based on wrong premises. It is certainly easier to handle, but it is incorrect and not to the manufacturers' interest to throw away these products for which there is a large demand.

I may be allowed to make one more remark about the peculiar ideas in existence regarding the garbage business.

There is annually a great outcry in Philadelphia when the contracts for the following year have to be given out. We are going through this again, and the newspapers have an easy time filling their columns. As usual, some one is kind enough to help them out by making some nonsensical proposition.

The most nonsensical error made in this proposition is, to pay for each ton of garbage, delivered to an imaginary plant, \$1 per ton to the city. I take from the *Ledger* clip-pings the following figures :

The writer places the total number of tons of garbage collectable at 380,000 tons per annum ; this means 1,200 tons per day of 300 working days. There are not 500 tons a day to be found in Philadelphia ; the whole case is built on talk of the wildest kind, and with it the whole calculation falls like a house of cards. It is only surprising how the Department of Public Works, which has access to the statistics of the works, can be led astray by such wild talk of imaginary profits and give color of approval to it by their vacillating action.

The utilization of the garbage of our great cities can be the basis of a well-paying business if the material is brought to the works free of cost ; the gathering of the material is a department of this business which must not only be self-sustaining, but should show profit in itself. The products possible must all be made in the most economical way ; but there should not be for manufacturing reasons a break in the chain. The more complete the yield of marketable products is made, the larger the profits. If, at the beginning of new enterprises—like the whole garbage industry—obstacles common to all new enterprises have to be overcome, they have already, for the largest part, been met successfully, and should by all means, by steadily improved methods, be overcome without difficulty.

The fertilizer produced from garbage, while only of a low grade, 3 to 4 per cent. ammoniacal tankage, has a wide field in the trade because of its physical qualities, as an excellent filler and for which there is a great want. The farmer who spreads his fertilizer over a large area likes to

have a large volume to work on. At the same time the demand is for a low-priced product. Consequently the manufacturer of fertilizer must look for material which fills the double requirement of "cheapness and volume." Nothing can fill the bill better than the garbage tankage.

It is to be hoped that the former policy of using everything will be restored where it has been suspended. The demand for cheap tankage has caused the utilization of other waste material such as cheap manure products, etc. In Illinois, in the center of the corn-belt, where the great distillers are situated, in Peoria and Pekin; in Terre Haute, Ind., and other places, the feeding of cattle forms an important factor for disposing of the waste from the distilleries. In the stables of Peoria and Pekin there are from 20,000 to 30,000 head of cattle. You can imagine what a quantity of manure material the animals produce. So far all this material goes to waste and simply helps to contaminate the Illinois River.

While St. Louis is trying to control the Chicago Drainage Canal, claiming that the contamination of the Mississippi River is caused by it, they would better look further down the river and examine the water above and below Pekin-Peoria before pressing their fight against the drainage canal.

I was lately interested in an attempt to utilize the stable offal for the manufacturers of sulphate of ammonia and manure tankage in Pekin, Ill.; this attempt, however, was unsuccessful.

It is a very nice problem in technical chemistry which can without doubt be solved financially, if the necessary capital for the right equipment *is forthcoming at the start*.

In the atmosphere surrounding our globe we have an inexhaustible source of nitrogen, but we have thus far failed to make these riches serviceable to the cultivation of our soil. It seems now that we are in a fair way to accomplish this object in a practical way by two entirely different modes of procedure.

Numerous attempts have been made without practical results, but at last the work of the electric furnace seems to be on the point of being successful.

I will read to you an abstract from a recent report of F. H. Mason, U. S. Consul-General at Berlin:

NEW ARTIFICIAL NITRATE.

The gradual but ultimately inevitable exhaustion of the known nitrate deposits of South America lends a growing interest to the methods which have been devised for obtaining a supply of nitrogen for fertilizing purposes from the inexhaustible storehouse of the air. That this can be done as a scientific process has long been known. The first method was by passing a current of air over red-heated copper, whereby the oxygen combined with the metal to form oxide of copper, leaving the nitrogen free. At first the nitrogen thus produced was fixed by combination with calcium carbide to form . . . (Kalkstickstoff) or calcium cyanamide, a combination of lime, carbon and nitrogen, which had all the essential properties of a nitrate fertilizer. But as the use of calcium carbide rendered the product unduly expensive, a method was sought which would employ a substitute for that material, and this was found by Dr. Erlwein, who brought the nitrogen into combination with a mixture of powdered charcoal and lime in an electric furnace. The product of this combination is a black substance containing, besides the lime and carbon, from 10 to 15 per cent. of nitrogen in perfect condition to be used as a fertilizer. From the experiments thus far made with this new article—which is known in commerce as calcium cyanamide—it appears that its nitrogen acts upon plants quite as effectively as that contained in a proportionate quantity of nitrate of potassium or sodium nitrate (Chili saltpeter). The scientific problem of obtaining nitrogen for fertilizing purposes from the atmosphere would seem, therefore, to be satisfactorily solved. Whether it can be done on a very large scale and at a cost which will make it economically available for general agricultural purposes remains to be demonstrated by practical experience.

I have not been able, in the short space of time allowed for the preparation of these notes, to find specific reports of the work of Dr. Erlwein so as to form an idea of the practical success of this process. The wonderful success of the electric furnace in other branches of applied chemistry permits us, however, to anticipate the solution of this problem also, and we may not unreasonably hope for the successful production of artificial nitrate in the near future on a practical basis.

Ever since the soil has been cultivated the farmer learned to know that after a crop of leguminous plants, such as beans, clover, peas, etc., the soil seemed to be benefited by it; not only that these plants required less fertilizer than others, but also that they directly helped to fertilize the soil for the succeeding crops.

Based on this experience, a rotation of culture has been established, and is used by every intelligent farmer. It is only recently that the reason for the beneficial action of these plants has been clearly established.

The investigations of Dr. Fr. Nobbe, a noted agricultural chemist, of Germany, were the first to call attention to the fact that the peculiar formation of nodules or tubercles on the roots of these plants was due to the action of innumerable bacteria, and that, unless these tubercle bacteria exist, the plant is no more able to fix the nitrogen of the air than any other plants which do not have such nodules on their roots. This fact established, it was the aim to cultivate such microbes to insure the formation of the tubercle.

Several years ago German investigators put upon the market a product known as nitragin, which purported to be a pure culture of the root-tubercle organism.

The results, however, were disappointing. In a few instances, in Germany, excellent results were obtained, but in the majority of cases the crop was not better than without inoculation. The preparations of nitragin were sold in bottles prepared for each different crop. The result here, with the nitragin imported, was still worse; fully 80 per cent. of the culture turned out to be a failure. The nitragin has now disappeared from the market. The failure to give permanence to the microbes in the fluid preparation was the reason of the uncertainty in its application to the soil. At this juncture the Laboratory of Plant Physiology of the Bureau of Plant Industry in Washington took up the research. It was soon found that the method in use by the German investigators was not adapted to maintain the life of the organism; that is to say, the use of nitrogenous food material, such as decoctions of the host plant, was not calculated to produce an organism which would fix free nitrogen from the air.

It was found that, while the bacteria grew luxuriantly upon such media, they became less and less active, until eventually they lost completely the nitrogen-fixing power. It seemed as though the large amount of nitrate in the media upon which they were grown made it no longer

necessary to draw nitrogen from the air. It was found, however, that by gradually reducing the amount of nitrogen in the culture medium it is possible to greatly increase the nitrogen-fixing power of these germs, and that by proper manipulation this may be increased from five to ten times that which usually occurs in nature.

The attainment of these remarkable results is the work of Dr. George T. Moore, in charge of the Laboratory of Plant Physiology, U. S. Department of Agriculture. They place him in the front rank among plant physiologists and as a benefactor to mankind. With unexampled liberality he has given the results of his researches for free use by the farming communities of the United States.

He filed a patent application May 4, 1903, and letters-patent were granted to him March 22, 1904. The patent is of such importance and gives so clear a description of the process that I introduce it as part of this paper.

UNITED STATES PATENT OFFICE.

No. 755,519.

Patented March 22, 1904.

George T. Moore, of Washington, District of Columbia.

Process of preparing for distribution organisms which fix atmospheric nitrogen.

Specification forming part of letters-patent No. 755,519, dated March 22, 1904.

Application filed May 4, 1903. Serial No. 155,695. (No specimens.)

To all whom it may concern :

Be it known, That I, George T. Moore, a citizen of the United States, residing at Washington, in the District of Columbia, have invented new and useful improvements in the process of preparing for distribution organisms which fix or gather atmospheric nitrogen, of which the following is a specification :

This application is made under the Act of March 3, 1883, Chapter 143, and the invention herein described and claimed, if patented, may be used by the Government of the United States or any of its officers or employees in prosecution of work for the Government or by any other person in the United States without the payment to me of any royalty thereon.

The invention relates to the process of growing these organisms and preparing them for distribution.

The invention has for its object the production of more highly effective organisms and their distribution in a form preventing deterioration, and easily applied in agriculture. All work that has heretofore been done in the cultivation of nitrogen-gathering root-tubercle organisms for use in agriculture has been done in culture media containing either decoctions of the leguminous

plants, from which these specific organisms in each case were obtained, or in media containing some other available form of combined nitrogen not free or atmospheric. When there is available combined nitrogen in the medium, the organisms, instead of depending solely upon the atmospheric nitrogen for their nitrogen supply, draw upon the nitrogenous materials of the culture medium, such, for example, as proteids, nitrates, ammonium compounds, etc., for which reason they do not develop their full nitrogen-gathering power and rapidly deteriorate.

By my process the organisms are first obtained from the tubercles or swellings on the roots of the leguminous plants, such as clovers, cow peas, beans, etc. After the tubercles are thoroughly washed and surface sterilized in the ordinary ways, the interior of the tubercle is cut out under sterile conditions and mixed in a medium consisting of water containing about 1 per cent. commercial agar-agar, about 1 per cent. maltose sugar or cane sugar (the former being the better), about .02 to .05 per cent. magnesium sulphate and about 0.1 per cent. monobasic potassium phosphate. This solution is made up in the ordinary way, and sterilized according to ordinary bacteriological processes. It differs from ordinary culture media for bacteria only in the absence of a source of combined nitrogen. The agar may be varied above or below the amount suggested. The maltose or cane sugar may be increased to 10 per cent., the magnesium sulphate to 1 per cent., the monobasic potassium phosphate to 2 per cent., or the amounts may be lowered below the quantities first mentioned. In the latter case, however, the food materials are more quickly used up. The organism multiplies as long as the materials in solution are not exhausted. Other compounds may be used as sources of magnesium, potassium and phosphoric acid. Although I usually leave nitrogen out of the culture medium at this stage, its absence is not essential, as the object of the first step is simply to separate the organisms into pure cultures, free from mold or other contamination, the process of separating out in this fashion being familiar to all bacteriologists and in common use. They grow best between 20° and 30° C., and light or its absence is immaterial. When pure cultures are thus obtained, the organism is transferred immediately, or after several weeks, if desired, by any of the bacteriological transfer methods in use, to water containing about 1 per cent. cane sugar or maltose (the latter being the better), about .02 to .05 per cent. magnesium sulphate and about 0.1 per cent. monobasic potassium phosphate, or equivalent sources of magnesium, potassium and phosphorus, as in the case of the first-described medium. The quantities used may here also vary, as stated above; but the per cents. given have been found to be the most favorable for growth under ordinary conditions. One cubic centimeter of the culture will suffice for impregnating 100 liters of the fluid. Any kind of container or vessel that can be easily cleaned will serve for this purpose; but Erlenmeyer flasks are best where small quantities are to be cultivated under antiseptic conditions. In this solution, which should be kept between 20° and 30° C., in light or in darkness, as desired, the organisms increase very rapidly, and have to obtain all of their nitrogen in the free state from the atmosphere or from the atmospheric nitrogen in solution in the medium. This liquid culture solution, even when in large quantity, will in a few days become milky in appearance by the presence of immense numbers of the developing organisms. The

water containing the organisms, where direct use is desired, is then sprinkled upon seeds or soil ; but for the purposes of preservation and distribution the following steps are taken : Absorbent cotton or other equivalent material is dipped into the water containing the organisms, or the water containing the organisms is sprinkled upon the cotton or other material, and the same thoroughly air-dried in a chamber free from dust or contamination from molds. The drying is facilitated by forcing a current of air through the chamber by aspiration through sulphuric acid, potassium hydroxide, sodium hydroxide or any of the other ordinary materials used in laboratories for drying. In this dry form the organisms may be kept indefinitely without deterioration or change, and may be safely, easily and cheaply transported to any distance, either through the mails or otherwise. In using the organisms preserved as above described the dry absorbent material containing them is simply dropped into a water solution of the same composition as above described. Where the purpose is to treat soil or seed, it is not necessary to observe strictly antiseptic precautions. Ordinary clean vessels or tubs may be used, simply protected from dust, and ordinary well-water or rain-water is used in making the culture solution, as the amount of nitrates or ammonia which such waters ordinarily contain does not interfere with the vitality of the organisms at this stage of the process. The temperature and light conditions should be as previously stated. In from twelve to forty-eight hours the organisms will have increased in the water culture, as in the first instance. At this stage, in order to stimulate a very rapid division of the bacteria, about 1 per cent. phosphate of ammonia is added to the culture solution. The quantity of liquid culture that may be thus obtained is limited only by the amount of water used containing the sugar, magnesium sulphate and potassium phosphate or other equivalent sources of magnesium, potassium and phosphorus, as above described. After thus obtaining the liquid culture, it is then necessary only to sprinkle the seeds or soil to be treated with water containing the organisms, or to dip the seeds into water containing the organisms, and then dry them in the ordinary way to facilitate planting. The propagation of the bacteria should not be continued longer than from twelve to forty-eight hours after the addition of the phosphate of ammonia ; otherwise they will deteriorate in nitrogen-fixing power, as previously explained, and organisms thus stimulated should be used only for seed or soil impregnation, and not for preservation or distribution.

Having thus described my invention, what I claim, and desire to secure by letters-patent, is:

The process of preparing for distribution nitrogen-gathering organisms, which consists in moistening suitable absorbent material with a solution in which such organisms are suspended, and afterward thoroughly drying the said material substantially as hereinbefore described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

(Signed) GEORGE T. MOORE.

Witnesses:

(Signed) A. F. WOODS,
 GEO. P. McCABE.

The Department of Agriculture, recognizing the importance of this investigation, has set out at once in the most practical way to make it possible for any progressive farmer to reap the fruits of this discovery, and make his barren land serviceable. For full information I refer to the "Year Book of Agriculture" for 1902, and in more popular form to the October *Century Magazine*. Through the kindness of Prof. H. W. Wiley I received a day ago a sample of the material as sent out by the Department, which I have now the pleasure to present to you.

The practical results achieved in the short time since the development of this industry of our Agricultural Department are of inestimable importance to the farming interests of our land. The cultivation of the nodule-producing bacteria and their preparation for distribution the world over without deterioration is a wonderful discovery. The first attempt to make the nitrogen of the air serviceable to the cultivation of the soil has been successfully made. Although limited to the cultivation of leguminous plants, it is of invaluable benefit to all crops by their judicious rotation.

As the experiments with the electric furnace to utilize the nitrogen of the atmosphere indicate coming success, and with the assurance of a steady increase in the production of ammoniates by the coke-oven process, and the utilization of all organized ammonia sources, we need not fear that the exhaustion of the South American nitrate beds will injuriously affect the fertilization of our land with nitrogen.

It has always been, and will always remain true, that as one material is exhausted it will be replaced by the utilization of others.

ELECTROLYTIC CONVERTER.

In certain branches of Röntgen-ray work, particularly in the medical department it is desirable to secure very rapid pulsations of the current, and also to provide an interrupted direct current instead of an alternating current. For this purpose, W. B. Churcher makes use of the ordinary Röntgen-ray bulb connected to the well-known induction coil, but as a source of interrupted current for the primary of the coil he employs a special type of electro-