The prescription for the white, for curing bologna and smoked sausages, indicates the same quantity.

We have no positive knowledge of the action of large quantities of borax upon the human organism, when taken internally, though there can hardly be any doubt that if taken even in small doses continuously for a considerable time its effect must be hurtful. This question, however, I leave to the decision of others better qualified for passing judgment upon it than myself. It was simply my intention to call to your notice the common use of borax as a preservative for meat, and especially the misuse of anilin red to replace in such mixtures the use of saltpetre.

THE UTILIZATION OF THE BYE-PRODUCTS OF THE COKE INDUSTRY.

BY DR. BRUNO TERNE.

[Read at the stated meeting of the Chemical Section, held Oct. 20, 1891.]

About a year ago I had the honor to speak in the lecture course of the Franklin Institute on ammonia, its sources and technical uses.

I dwelt for reasons which I thought of sufficient importance, especially on the production of ammonia as a bye-product of the coke industry.

We have now entered upon the beneficial workings of the new policy of furthering industrial developments in new branches in a period which requires the technical men in all branches, and especially in the chemical industries, to call the attention of the capitalist to the points in which we are behind the times in our developments, to the points where the resources of our own land are neglected, and we are far behind the more progressive European manufacturers.

I thought it of sufficient importance to ventilate the same question before the Chemical Section of the Institute in order to create an interest in the circle of the members of the Institute, who are the best judges of such questions, in order to provoke criticism of my views.

I have revised the part of my lecture referring to the development of the ammonia industry for this purpose, not in the expectations of claiming new and original ideas, but to secure your attention to a point which I consider of great importance for the development of an important branch of the chemical industries.

We are surrounded by an immeasurable quantity of nitrogen gas in the atmospheric air.

The weight of the atmosphere surrounding our earth is calculated to be ten trillions of pounds, of which 7.77 trillions pounds are nitrogen; but in spite of this inexhaustible source of nitrogen, we are not able in a direct way to use a single pound for the production of ammonia.

It has long been the endeavor of the technical chemist to convert the nitrogen of the air into ammonia, but up to this hour none have succeeded in doing it with practical results. We are still compelled to use as sources for the production of ammonia, the products of plant or animal life.

The nitrogen of the air must pass through the channels of plant life to reach in the products of the animal body their highest degree of concentration.

Hoofs and horns with fifteen to sixteen per cent. dried blood, with nineteen per cent. hair and wool waste, with ten per cent. bones, with five per cent. of ammonia, are the richest sources.

But the products of animal life, however, even if they were not too valuable otherwise, are by no means sufficient to satisfy the wants of the present day for the products of ammonia. But Nature has provided an inexhaustible source for hundreds of years to come, in the residuum of plant life of former periods. In the bituminous coal fields and in the deposits of brown coal are lying stored up, billions of pounds of nitrogen waiting to be converted into ammonia.

The process of gaining this ammonia is incidental to the production of illuminating gas, to the production of coke, and to the production of animal charcoal.

In distilling the bituminous coal we obtain of the weight of coal used :

4-6 per cent. of tar and 6-10 per cent. of ammoniacal water of 1°-8 B.

As Prof. Lunge has shown, the nitrogen contained in the coal does not yield the amount of ammonia which we might expect :

<i>Name of Coal.</i>	<i>Yield of Nitrogen. Per Cent.</i>	<i>Possible Yield of Ammonia. Per Cent.</i>	<i>Possible Yield Ammonia Water. 1020 spec. grav. Per Ton of Coal. Gallons.</i>
Wales,	0.71	1.10	142
Lancashire,	1.25	1.52	196
Newcastle,	1.32	1.60	206
Scotland,	1.44	1.75	226

But instead of these figures, the practical yield per ton of coal at the best is only forty-five gallons of gas water of 1020 sp. gr., generally only twenty-five gallons, and in some instances, as low as thirteen gallons.

The ammoniacal liquors from distillation of animal refuse are much richer, but the small quantity produced allows us to ignore the same as a very insignificant factor in the production of ammonia salts.

The consumption of ammonia in its various forms has grown enormously in the last twenty years, and the manufacture of illuminating gas is no longer sufficient to supply the increasing demand for ammoniacal liquors. On the other hand the inroad which electrical plants for illumination have been making yearly on the production of illuminating gas, has already been felt, and will be more so from year to year. The production of water gas and oil gas are other factors which are cutting down the amount of ammoniacal waters produced.

But there is another source for tar and ammonia, which, so far as my knowledge goes, has, with a single exception, not been worked in our country.

Rich as are our resources, we are not rich enough to waste continually.

It seems strange, and nevertheless it is a fact, with all the ingenuity of the American people in the advancement of the purely mechanical part of the technical industries, we have been and are yet slow in the development of the chemical industries.

The acid manufacturer of Europe, especially of England

and Germany, had commenced in the beginning of this century to make himself independent of the sulphur mines of Sicily by using the sulphurous ores of his immediate neighborhood, and to utilize the pyrites for making his sulphuric acid. It has been only within the last twenty years that our people commenced to use the ores which had been lying under their feet, and to-day even, the United States consumes more sulphur for the manufacture of sulphuric acid than any other nation.

It is the same with productions of tar and ammonia as a bye-product of the manufactures of coke.

If you will visit our coal region to-day, you will find the nightly sky illumined from the fires of the coke ovens, and every one of the brilliant fires bears testimony that we are wasting the richness of our land in order to pay the wiser European coke manufacturer, who saves his ammonia and sends it to us in the form of sulphate of ammonia; and who also saves his tar, which, after passing through the complex processes of modern organic chemistry, reaches our shores in the form of aniline dyes, saccharin, nitrobenzol, etc.

As far back as 1768 tar had been produced as a bye-product of the coke industry by a chemical process at Fishbach, in the coal district of Soarbrücken on the Rhineland.

The general opinion of the consumer there was then, and most likely will be here at the present time, that the coke produced will be of inferior quality. Against this opinion of the practical coke men, it has always been held by technical chemists, that the process can be so conducted as to yield all the bye-product and still make a first-class coke.

Since about 1850, the producers of coke in France, Belgium, England and Germany commenced simultaneously the saving of the bye-products.

At St. Etienne, in France, a system of furnaces was at work in 1862 for which great success was claimed at that time. The gas and other volatile products of the coke oven were conducted to an air condenser, in which the tar and ammonia were condensed; the non-condensable gases were returned to the furnace as fuel.

Scrubbers and condensers have been improved to insure complete condensation.

The following average results have been claimed :

	<i>Per Cent.</i>
Coarse coke,	70
Small coke,	1½
Waste coke,	2½
Graphite,	½
Tars,	4
Ammonia water,	9
Gas,	10.58
Loss,	1.92

The net gain after deducting all expenses and without reckoning in the coke was, per oven, in Bessèges which has eighty-five ovens in operation, 111,446 francs. For eighty-five ovens this saving amounts to 94,690 francs or about \$18,938.

I give you in the accompanying table, the results reported from two establishments in France.

I will not endeavor to cover the development of the coke industries of Europe for the whole period since 1850. I have had occasion to familiarize myself with all the conditions of this industry, and am in possession of figures and plans of Dr. Otto's successful ovens, a view of which I show you. (See accompanying plate.)

In 1883, a system of twenty ovens were built at the coke works of Gottesberg, Silesia, the results from which were so encouraging, that in the following year 120 ovens were built.

I will give you a report from a manufacturer, who, two summers ago, visited the Dahlhausen works of Dr. Otto, at the mines of Millensiven near Dortmund. Here, there are two sets of thirty ovens each, which are charged alternately every other day. The gases are conducted by large iron pipes to a large basin, where a part of the tar will be condensed. From there it is led to the coolers, where the remaining tar and ammoniacal products are absorbed, and the gas purified is returned to a gas holder, and from there is redistributed to the coke ovens, to the boiler fires and utilized as illuminating gas throughout the works. The gas returning to the coke ovens is mixed with hot air, and enters the flues

of the bottom and sides. The coke produced is an excellent product, and finds a ready market everywhere. It has not

NAME OF WORKS.	Number of Ovens.	Tons of Coal Consumed.	YIELD OF COKE.			TAR.		AMMONIA WATER.		SULPHATE OF AMMONIA.		
			Total Tons.	Prac. Per Cent.	Per Oven.	Total Tons.	Per Cent.	Per Oven.	Hectolitres.	Per cent.	Per Hectolitre.	Per Oven. Tons.
1879. Bessèges, Terrenoire, April 1 to December 31, 1879. . . Per annum calculated, .	85	46,902	33,092	70.55	389.3	1,096	2.23	12.89	44,932	9.6	6.5	3,435
	100	38,427	26,293	68.42	—	966	2.50	—	36,205	9.72	7.6	—
	—	—	—	—	350.57	1,288	—	12.88	—	—	—	3,374
												Per Ton of Coal Killo Grams.
												6.22
												—
												6.54

the silver gray or steel color of our Connellsville coke, but it is quite as good in quality as ours.

The person who pronounces this verdict was then, and

is now, connected with one of the largest iron works of our state, and thoroughly well informed upon every point of blast furnace produce, and familiar with the qualities of coke produced and used in the Connellsville region.

He repeated, after having explained to me how even the same color could be made, that the quality of this coke is in every respect equal to that of Connellsville. "But," he added, "I desire to call your special attention to the statement, 'The oven of Dr. Otto yields seventy to eighty per cent. of coke, while our Connellsville 'Beehive' oven will only yield fifty-five to sixty per cent.'"

Dr. Otto builds these ovens at his own expense, runs them for twelve years, taking the coal from the mines and delivering the coke to the mine company, for the yield of tar and ammonia, and at the end of the term surrenders the whole plant to the mine owners. He must make in this time from the value of the bye-products alone, the cost of the ovens, the interest of the capital invested and the legitimate profit of a manufacturer, and he is successful in doing it. Don't you think that we can achieve the same results here?

In the year 1887, there were in operation in 279 establishments in the United States, 26,001 ovens, and 3,594 ovens in course of erection.

These ovens consumed 11,859,753 tons of coal, producing 7,611,705 tons of coke, a percentage of 64.2. Calculated on the basis given in the table before you, the possible yield of sulphate of ammonia from this quantity of coal, *i. e.*, 12.8 pounds per ton, will give us the enormous figures of 151,804,838 pounds of sulphate of ammonia, which at three cents per pound only is equal to \$4,554,746.

Pennsylvania is the principal coke-producing State in the Union.

Seventy-six and six-tenths of the coke used in the United States is made within her borders.

The number of establishments were, in 1887, 151, with 18,294 ovens, which produced 5,872,847 tons of coke, a yield of sixty-five per cent. The Connellsville district, of Pennsylvania, is one of the most important of the world. The Connellsville basin is in the southwestern part of the State,

some fifty or sixty miles from Pittsburgh. In this district were made 4,146,989 tons of coke, or 57·4 per cent. of all the coke made in the States.

At three works, during the year 1886, careful weighings were carried on, with the following results :

	<i>Coal Charged.</i>	<i>Coke Produced.</i>	<i>Per Cent. Yield.</i>
No. 1,	230,585	157,070,40	68,118
" 2,	60,934	40,947,09	67,188
" 3,	63,893·2	42,927,24	67·2
Total,	355,421·2	240,944,64	67·8

The coal used in Pennsylvania in 1887, for making coke, was 8,938,849 short tons.

If this had been done, with saving of the bye-products, 178,776 tons of tar and 114,417,267 pounds of sulphate of ammonia, or $7,208\frac{1}{2}\frac{267}{1000}$ tons of sulphate of ammonia could have been produced, which represents in ammonia salt alone a value of \$3,432,480; or, to illustrate in another way, 28,604,316 pounds of ammonia, which has an agricultural valuation of eighteen cents per pound, have been lost to the industrial and agricultural interests; or, at the valuation of the agricultural experimental stations, the loss of a single year was \$5,128,776 $\frac{88}{100}$.

I am very well aware that these figures are imaginary, as under the best possible circumstances not all the coke ovens could readily be arranged for the saving of bye-products but if one-eighth or one-half of the total production were united with saving of the bye-products, from one to two millions a year on ammonia only could be produced in this State alone.

You will ask, Will the Connellsville coal give the same result as the German coal? Without hesitation, I answer, it will.

There are here five samples of coal from the Connellsville district, which have been analyzed in my laboratory, with the results given below :

	<i>Per Cent.</i>
No. 1,	1·76 ammonia.
" 2,	1·26 "
" 3,	1·90 "
" 4,	1·80 "
" 5,	1·80 "

These analytical results place the coal of the Connells-ville region on an even footing with the bituminous coal of the district, where the bye-products of coal are gained in making coke.

There are numerous systems of coke ovens in Europe, but none has been more successful than the ovens mentioned above. Whatever the system may be, the products of condensation must be separated; the tar from the ammoniacal waters, and each worked according to its specific requirements. In England, the escaping gases of blast furnaces have in two instances been worked for ammonia. I am unable, however, to say anything about results.

The interest of the manufacture of ammonia requires that the liquors should be as concentrated as possible, and still leaving the gases escape as free as possible from ammonia. To accomplish this, certain improvements in apparatus have come into use. The older construction of scrubbers, or apparatus for washing the gases, has been superseded by mechanical scrubbers. One of the latest constructions of such a scrubber is the one represented in the accompanying illustration. It is the form constructed by the Director of the City Gas Works, in Chemnitz, Saxony, and adopted by the best authorities of Germany as one of the most economical working forms of the apparatus.

The mechanical scrubber of E. Ledig* is based on the principle of the rapid absorption of ammonia by water distributed over a large surface, which is heated by a system of plates alternately dipping in water and raised out again, thus offering the gas the large surface of the combined plates. This up and down movement creates new surfaces for absorption with each motion, and secures a complete washing of the gas. The ammoniacal liquor so gained has now to be worked so as to gain the ammonia from it in order to prepare the different ammonia compounds.

The ammoniacal liquors contain free ammonia, carbonate of ammonia, sulphide of ammonium, sulphocyanide of ammonium, tartrate of ammonia, sulphite of ammonia, chlor-

* U. S. Patent, No. 407,937, July 30, 1889.

ide of ammonium, sulphate of ammonia, organic ammonia compounds, such as amin, pyridin, etc.

The ammonia waters contain in one litre, from coals of the

	<i>Grammes.</i>
District Zwickau (Saxony),	37,943 ammonium salts.
" Ruhr (Rheinland).	29,402
" Saar "	43,225
" " "	9,506

You will notice that the differences in yield are very wide, but nevertheless the smallest amount named is sufficient to make the gain, the bye-products, in the commercial scale, a profitable operation.

The oldest methods of gaining the ammonia were to saturate the liquors directly with sulphuric acid in large tanks. The cost of evaporating such enormous quantities of water and the impure condition of the product soon led to the invention of improved methods.

Tanks, or a system of tanks, were heated directly by fire or steam, and the volatile ammonia driven out to be absorbed by the acids in the receivers.

The newest improved forms of apparatus are those constructed by the well-known manufacturer of chemical products, Dr. Grüneberg, of Cologne, and by Dr. Feldmann, of Bremen. Both of these are constructed on the same principle, viz: a current of steam moves in opposition to the movement of the liquor. The richest liquor comes in contact with the nearly saturated vapors and the weakest liquor with the fresh steam.

These forms of apparatus have superseded in Europe, especially in England and Germany, the older devices.

The accompanying engraving (*Fig. 1*) shows the construction of the Grüneberg apparatus.

The apparatus of Dr. Feldmann is still simpler and is, therefore, preferred by a great many manufacturers of ammonia salts. (*Fig. 2*.) Both of these devices are patented in the United States.

The Feldmann apparatus cannot be excelled for economy of steam and reliability in service; its capacity for working five to twenty-five tons of liquor daily makes it likewise

desirable for a rural gas works as well as large establishments.

The question Will it pay to gain the bye-products of the manufacture of coke? has been practically solved in the affirmative. The numerous objections have, step by step, been overcome. The industry of the coke production com-

FIG. 1.—The Grüneberg Ammonia Still.

bined with the saving of the bye-products is an established fact in Europe, and will be here also in the near future. What system of ovens will be found best adapted to our wants, may be an open question to decide, which rightly will require the consideration of a great many points of local importance.

The system which I have described is one of the most successful of those used in Germany to-day.*

I advocate the Otto system because I know of its merits and advantages from a careful study of it, and lengthy correspondence with the inventor.

The results obtained by Dr. Otto, Copper and others, exhibit such decided progress over the past, that it is only

FIG. 2.—The Feldmann Ammonia Still.

a question of time when the coke producers of the United States must fall in line.

The advance in the coke industry will cause an advance in the tar color industry, and will further the growth of the soda industry based on the ammonia process.

* The latest improvements are covered by D. R. P. 52,206, Universal coke-oven, C. Otto and F. W. Larmann.

If I have succeeded in adequately exhibiting the importance of saving the valuable products at present wasted in our coke industries, I shall have accomplished my purpose.

Until every pound of ammonia used in our land is produced in our land, until every pound of soda is made from our own salt wells by the ammonia process, we will continue to be dependent upon the chemical markets of Liverpool and London.

DISCUSSION.

Dr. H. W. JAYNE: No one will deny the importance of the subject presented to us this evening by Dr. Terne, 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.

Coke operators fear that it would be difficult to overcome the prejudice against the coke as it has not the silvery appearance of the Connellsville article.

The great first cost of the plant is another serious obstacle. An ordinary beehive oven to work about 480 tons per year costs about \$280, while a Carves oven of the same capacity costs complete with the coolers and all appliances \$845 each, and Otto ovens of 1,000 tons capacity would cost \$750 for ovens, and \$1,450 for coolers and all other machinery and buildings. The above figures were furnished by the respective inventors.

In addition, the present beehive oven is of extremely simple construction, and can be run by the most unskilled labor, while the improved ovens are complicated and require nice working and constant repairs to prevent loss of gas, and consequent loss of the bye-products.

There can be no doubt that eventually such ovens will be introduced, and when in successful operation, other coke producers will be compelled to erect them, as they could not possibly stand the competition caused by ovens producing not only such valuable bye-products, but also such a greatly increased yield of coke.

Dr. TERNE said: I would like to state, that according to Dr. Otto's figures in my hand, the cost per oven, without condensation apparatus, is 1,508 marks (\$377.) Or, for a battery of thirty-eight ovens, with complete condensation apparatus:

(1) 38 ovens,	57,304 marks.
Condensation apparatus,	117,683 "
	<hr/>
	174,987 "
Equal to,	\$43,746 75
Or, per oven,	1,151 20

It is well to state here that the apparatus of condensation for the winning of the bye-products will outlast the life of the ovens many times; the first cost will, therefore, be limited to the first system erected.

Mr. HENRY BOWER referred to a short article which he had recently seen in the *Chemical Trades Journal* of Manchester, England, in which it was stated that it was not certain whether certain firms of speculators were not contributing to the depression in the prices of anthracene and benzole in the hope of frightening investors from opening additional carbonizing works. Mr. Bower also referred to the depression existing in the prices of sulphate of ammonia, and the influence of tar-producing concerns in Philadelphia against the carbonizing process.

Dr. JAYNE: The statement, referred to by Mr. Bower, which appeared in the *Chemical Trades Journal*, of Manchester, referred to the fact that the large production of benzole by the coke carbonizers prevented the extreme prices which would otherwise prevail owing to the great consumption of this article at present, especially in the preparation of medicinal articles.

Before the carbonizing plants were in operation benzole fluctuated very violently, ranging from thirty cents to \$1.25 per gallon in one year.

The large amount of benzole produced by the coke plants is not obtained from the tar, which contains only a small quantity, but from the gases, which contain about twenty-five times as much as the tar.

In our cities it is impossible to remove this benzole from the gas, as it would at the same time remove most of the illuminating properties, but the coke gases can be cooled and washed with oils removing most of the benzole.

The inventors of the Simon-Carves oven claim that they can thus obtain three-fourths of a gallon of a high grade benzole from one ton of coal. It may be interesting to note in this connection that there are, or were, several plants running in England carbonizing coal in gas retorts entirely for the bye-products, as such coke is of little value. One of these works at the "Talk of the Hill" Collieries had 300 retorts in use producing 12,000 gallons of benzole per month.

Dr. TERNE: In reply to the remarks of Mr. H. Bower, I beg to say that the influence of the tar-producing companies of Philadelphia will not be dominant enough to prevent the development of this branch of chemical industries.

The combined interest of the larger producers and consumers of tar and ammonia will finally regulate the development of this industry.

To the further remarks of Mr. H. Bower, I should answer that I desire it distinctly to be understood that I do not advocate the producing of coke only for the gain of ammonia.

The higher yield of coke, the gain of the tar, with the daily increasing demand for same, and the gain of the ammoniacal water are the inducements which are given by the new methods.

The temporary depression in the price of sulphate of ammonia will not last, and even yet at ruling low prices we have not reached two and one-half cents per pound as on the other side.

We do not need to be frightened by wages; it will cost very little more to make coke and gain the bye-products than it now costs, and the slight additional cost will be amply repaid by the tar and ammoniacal water.

The cost of sulphuric acid does hardly come in play, first because we get a higher price for sulphate of ammonia produced, and second, we do not need to turn the ammonia in sulphate.

The ammonia soda industry of this country is in its infancy, and the demand of concentrated ammoniacal waters for the same will be steadily increasing.

The development of these industries is bound to come in spite of all objections, and it will be not so far off either. The right start is the most difficult point.

PROCEEDINGS
OF THE
ELECTRICAL SECTION
OF THE
FRANKLIN INSTITUTE.

[Proceedings of the stated meeting, held Tuesday, October 6, 1891.]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, October 6, 1891.

Prof. EDWIN J. HOUSTON, President, in the chair.

Present, twenty-one members and visitors.

The minutes of the previous meeting were read and approved.

One nomination to membership was referred to the Committee on Admissions. The committee reported six elections since last meeting.

It was moved and carried that the President appoint a committee of three members to secure papers for the meetings.

Mr. H. W. Bartol was unable to present his paper on "The Electric Railway of Buda-Pesth," not having received the expected data with regard to it.

Prof. Edwin J. Houston described the probable production of electricity from light in the leaves of plants, and promised a more formal presentation of the subject later. In the discussion that followed, the analogous action in the selenium cell and applications of it were described.

The Question-box contained queries on the advantages and disadvantages of slow speed in motors, the practical working of the Evans frictional method of driving, the latest theory with regard to the earth's magnetism, and the practicability of dispensing with earth connection for lightning rods—all of which were discussed at some length.

The Chair appointed on the Committee to secure Papers, Dr. Wahl (Chairman), Messrs. Carl Hering and Pike.

The meeting then adjourned.

L. F. RONDINELLA, *Secretary*.