ECONOMIC QUESTIONS CONNECTED WITH RETORT COKE OVENS WITH THE RESULTING BI-PRODUCTS.

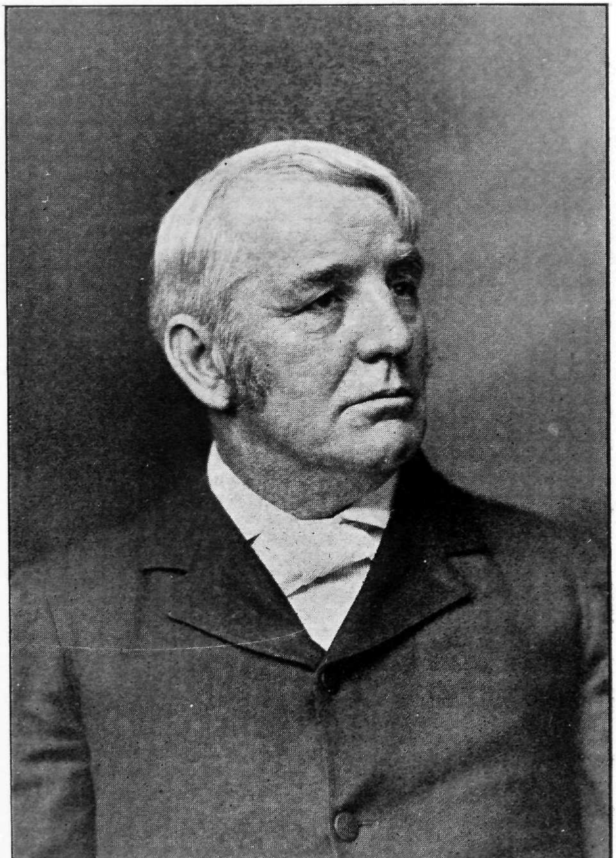
BY R. M. ATWATER.

In appearing before you, I must at the outset ask your friendly indulgence in attempting to speak to you on subjects of which I am comparatively ignorant, and you are experts.

The Solvay Process Company, who represent the Semet-Solvay retort coke ovens in America, are chemical manufacturers, with whom the making of coke is very much of a side issue, and whose direct interest in the matter is chiefly with the ammonia, one of the by-products, which has the least interest to you.

I would further disclaim, in appearing before you, the position of a lecturer or teacher, but rather to ask you to take part in a friendly discussion, in which we have more to learn from you than you from us. I shall therefore make my presentment briefly, and hope that our meeting may result in a sort of symposium, wherein all parties may contribute the best information which each can give.

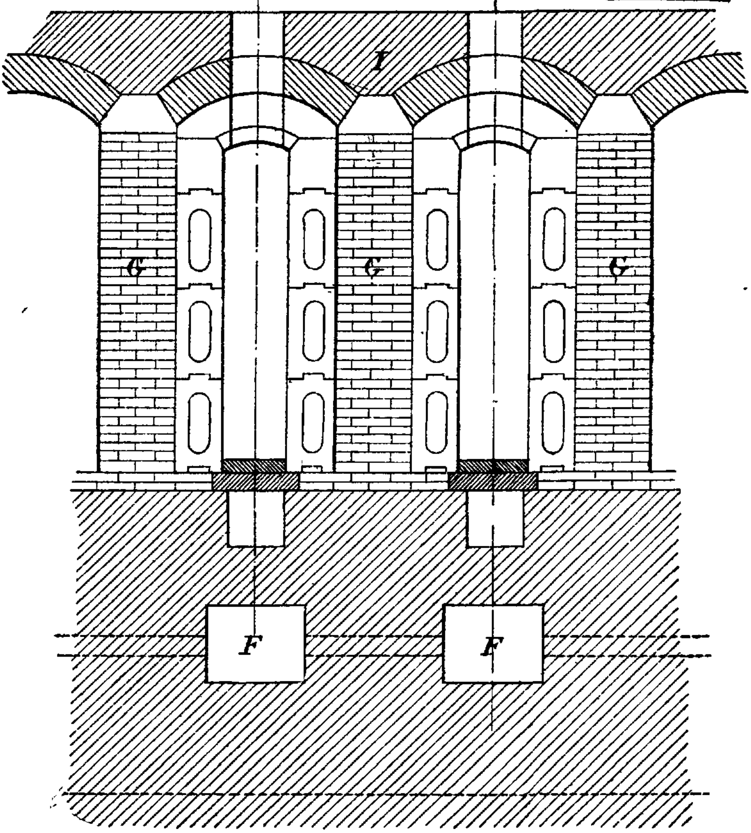
A traveller from distant lands, passing through the Connellsville region at night, and looking out on the thousands of torches dotting the hill-sides in every direction, would at first ask in surprise whether he was passing through a wild country, in which the approach of a stranger was signalled from hill-top to hill-top by these strange fires, or he might ask if he was in the midst of an armed camp, and liable at any time to be seized as a hostage by some enemy, either of the country or of mankind, or whether it were the outburst of some subterranean region, and that the whole land was in danger of destruction and overthrow. When he learns that these fires are the products of a great industry, wherein millions of tons of the most valuable fuel in the world are being consumed, his conclusions may be more easily imagined than described. Well might he ask if this is a great temple of Moloc, where, instead of the dim light of perpetual adoration from a few candles in the great cathedrals,



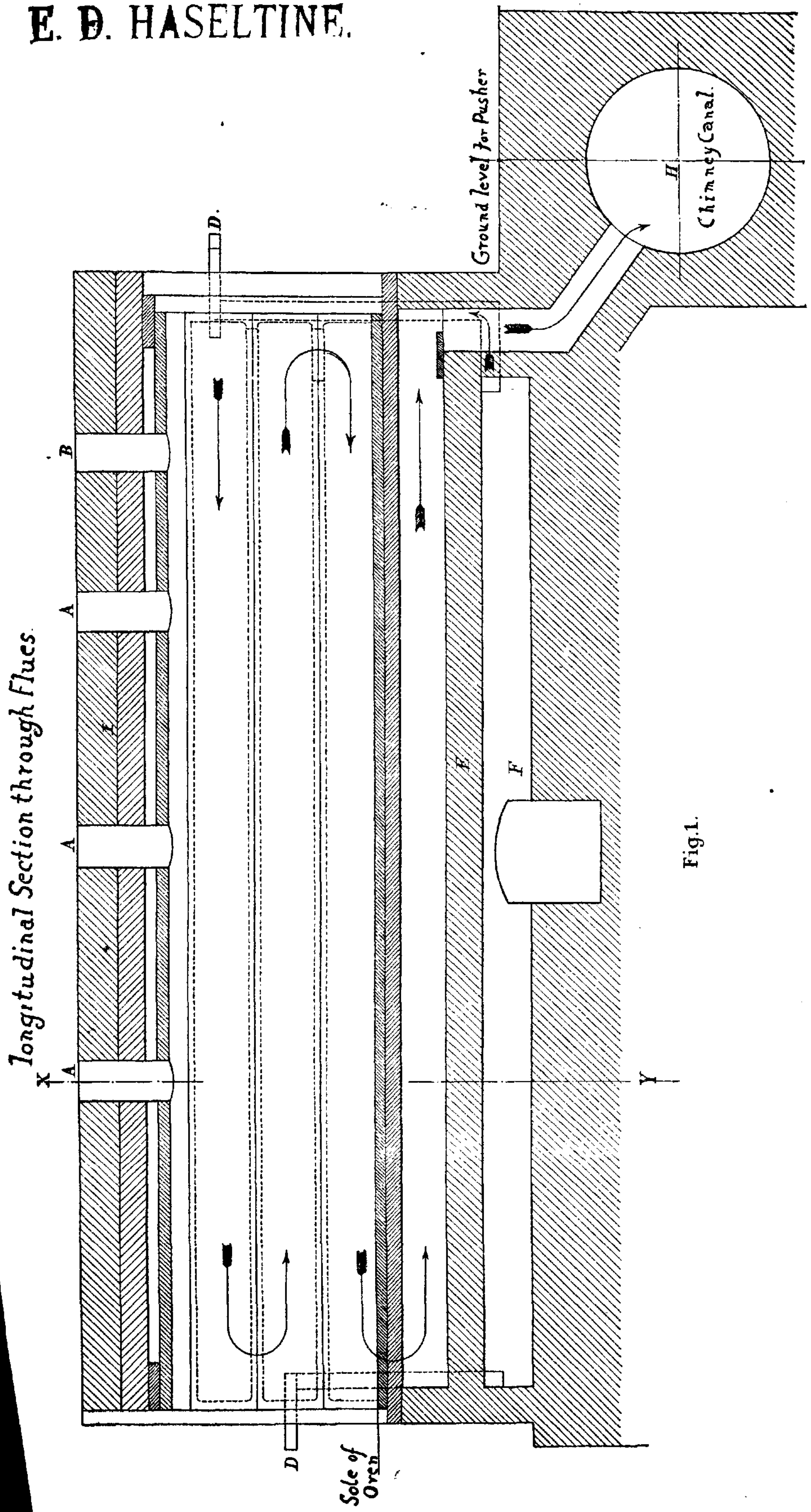
R. M ATWATER.

Fig. 3.

Transverse Section on XY. Fig. 1.



E. D. HASELTINE.



Longitudinal Section through Flues

Fig.1.

representing the aspiration of the human mind for divine recognition, he finds tribute of untold wealth offered up as sacrifices to that more powerful ambition, the greed for riches in this world. Considering the question further, he might ask whether it was worth while to destroy all the unseen values in these rich coal fields, for the sake of that which is gained, and on learning that the wasted value in burning was much greater than the resulted product, he might remark that in China the great delicacy of that country, roast pig, was prepared in much the same manner, as the Chinamen considered it necessary to burn a house down in order to roast a pig properly. His inference would certainly be that, in this case the ways of the "Heathen Chinee" were not peculiar. Naturally, proceeding one step further, he would ask why better methods were not adopted, as has been almost universally done in the old world, and the reply would have to be made, that the American is as wasteful as he dares to be; that the well-known Arkansas Traveler, who could not repair his roof when it was raining, and did not need to when it was not raining, has a close analogy in this industry. Gathering his friends and acquaintances together, he might be conceived of as speaking somewhat after the following fashion: The primary products of bituminous coal are coke, fuel gas, tar and ammonia: the secondary products are illuminating gas, pitch, benzol, toluol, xylol, phenol, naphthalene, anthracene, creosote and pyridine. By the present practice, coke alone is obtained from this long list of valuable products. By means of retort ovens, all of the others, which are of far greater value, are available for the development of American industry and the use of the people of our country.

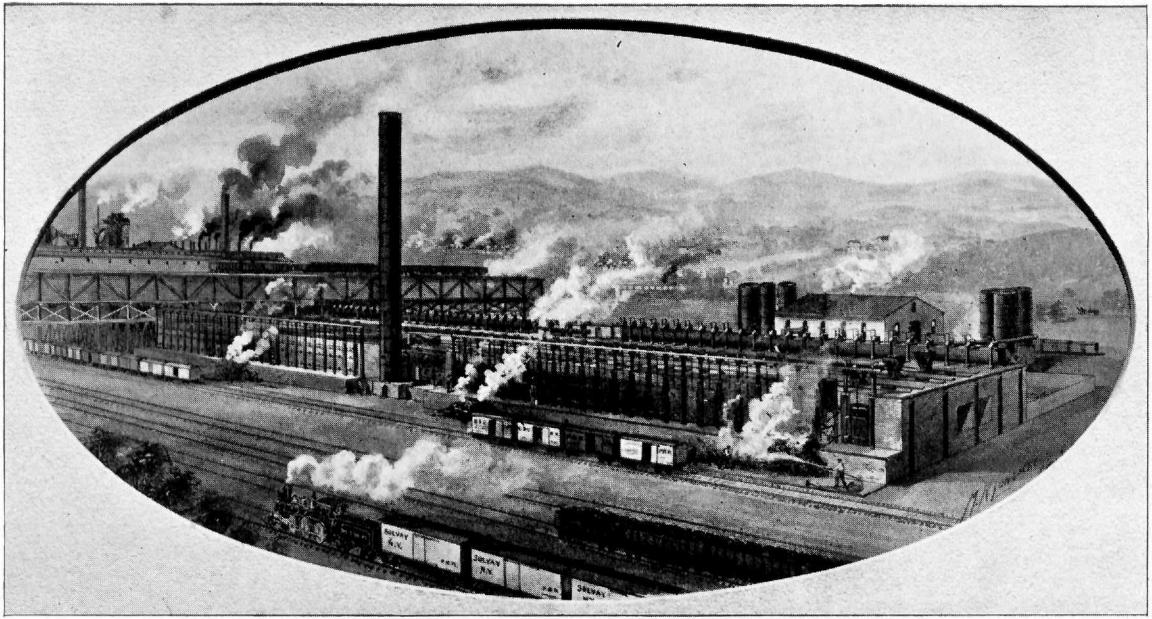
Two general types of retort ovens are prominently before the public, those with vertical flues and those with horizontal flues. Vertical flue ovens are either without regeneration, as in the Coppee type, or with regeneration, as in the Otto-Hoffman ovens. Horizontal flue ovens are either with thick walls of brick, as in the Carve type, or with thin walls of tile, as in the Semet-Solvay oven. These four classes of ovens represent to-day the development of the retort coke oven.

Comparing these ovens with each other, it may be fairly claimed that the system with horizontal flues is better than with vertical. The operation in the coke oven does not require the high heat of the regenerative furnace, but rather the moderate heat of direct firing. This is easily demonstrated by the operation of the beehive oven. Retort ovens are not over six feet in height. With vertical flues, the heat of distillation must do its work in the short space of six feet, and in a direction where the natural flow of the gases is most rapid. The effect of this method of firing is that the higher heats will be at the top of the vertical flues, where they are baffled and turned away from the oven, but the heat of distillation should more properly be adjusted so that the greatest heat will be at the base of the retort oven. With horizontal flues, making three turns along the sides of the oven and a fourth underneath the sole of the oven, the gases pass through a circuit of one hundred and twenty feet, and the opportunity of imparting heat to the interior of the furnace is easier, more economical and better adapted to the work required. The greatest heat is easily regulated at the lower part of the oven, and the available heat of the fuel is more thoroughly exhausted.

By the same reasoning it may easily be seen that recuperation is better than regeneration, for the moderate heat required in the coke ovens. At high temperatures, firebrick become good conductors of heat, and the heat may be transmitted through these thin walls with but little loss. When it is considered that the so-called regeneration of heat is not regeneration, but depends on the heat absorbed by the fire-brick checker-work and given out again during the periods of reversal of the regenerator valves, it is not difficult to see that the two processes are identical in principle. To regenerate, however, involves duplications of the flues and checkerwork, and the complicated reversing machinery, while the recuperation is much simpler and cheaper. Therefore, we may agree with Mr. Darby, of the Brymbo Steel Works, when he says that after large experience with regenerative furnaces, he has no hesitation in saying, that, "if it is possible to do without them, an enormous amount of trouble and expense will be saved."

As to the question with horizontal flues with thick brick walls, or thin tile walls, it may be said that the thick flues require from thirty-six to forty-eight hours to do the work that the thin flues do in eighteen to twenty-four hours, and that, even then, the resulting coke is softer. Mr. Darby states that the loss from the addition of one-half inch to the thickness of the flue wall is thirty per cent. of the heat. The use of tile twenty-four inches long makes fewer joints, and, consequently, less danger of leakage, than where the flues are constructed of firebrick.

Considering the advantage of the retort oven over the beehive, it may be said that the first effort to use retort ovens was not to get the by-products, but to coke coals that would either not coke at all, or would only make inferior coke in beehive ovens.



SEMET-SOLVAY PROCESS, DUNBAR OVENS.

As the continent of Europe is now practically made over to the retort oven, it may be claimed as demonstrated that the retort oven is better than the beehive.

The grafting of the retort oven upon the American coking industry has had its infantile vicissitudes. All of the early efforts were abortive, or still-born, or lived only to demonstrate their inability to cope with the rigor of the American climate. Their little lights went out, and left only a cairn of broken shards to tell their history. The Solvay Process Company built in 1892 a block of twelve Semet-Solvay coke ovens, and have run them without stopping ever since, and have now doubled the number and are erecting plants in Dunbar and Sharon, Pennsylvania, and Detroit. As this company uses the coke for burning limestone at Syracuse, their practice is not conclusive for blast furnace use. But during this period, the company has made tests on a great variety of coaking coals. These tests have demonstrated that the Connellsville and Pocahontas cokes from the Semet-Solvay ovens were equal in the blast furnace with the cokes from the beehive ovens. Both of the parties for whose benefit these tests were made on a large scale, have decided to erect retort coke ovens. In every case, the coke has proved equal with, if not better, than the same coke from beehive ovens. In several cases, coals that cannot be successfully coked in beehive ovens, have produced a marketable coke in the Semet-Solvay oven.

The most important test was made in the interest of the Johnson Company, of Lorain, Ohio, and was conducted by the well-known expert, Mr. John Fulton, of Johnstown, as their representative. I will extract from his recently published work on coke several items covering the essential points in this test. The Semet-Solvay coke from Connellsville coal was to be compared on a working scale in the blast furnace with the best coke in the world. The conditions of the test were severe for the retort ovens. The ovens were not accustomed to the Connellsville coal, and the furnace was not accustomed to the retort coke, but was perfectly familiar with the beehive Connellsville coke. It will be granted that the odds were against the retort oven.

To make the tests in a fairly comprehensive plan, two thousand and fifty-eight and thirteen-twentieths tons of Connellsville coal were shipped from the Valley Mines of the H. C. Frick Company to Syracuse, for the initial coking test in the small experimental plant of twelve Semet-Solvay ovens at this place. These coking tests, as well as the subsequent blast furnace ones, were made with great care, as the importance of such determinations evidently demanded. It was the first time in the industrial records that beehive and retort oven coke, from Connellsville coal, were compared as to economy in cost of coking and relative value in blast furnace work, on fairly equated conditions.

The coking in these ovens was conducted mainly to determine the minimum time required with maximum heat to produce good blast furnace coke. The tests covered the several times for coking, from eighteen to twenty-six hours. It appeared that with well sustained oven heat, good blast furnace coke could be made in twenty hours. This was the standard minimum time used in producing the coke for furnace test. Some coke was made by continuing it in oven twenty-six hours. This produced a bright hard coke evidently equal in hardness of body to the Beehive coke of seventy-two hours.

From subsequent experience in the furnace test, it is quite probable that twenty-three to twenty-four hours would secure a firmer coke, that would bear faster furnace driving.

It will be noted that the Connellsville coke, used at the Buffalo furnace during the test, was from the Adelaide Works of the H. C. Frick Coke Company.

The coal used in making coke in the Semet-Solvay ovens at Syracuse, N. Y., was shipped from the Valley Mines of the H. C. Frick Company.

The physical determinations of the Adelaide coke exhibit a most excellent structure, equalling the standard coke of this region.

The analysis shows its superior chemical purity, excelling in this respect the standard coke.

The physical tests of the Semet-Solvay coke exhibit the increase in density in the retort coke, as compared with the Beehive. These are typical examples, and indicate in a clear and definite manner the condition of coke made in these two principal types of coke ovens. The increase in cell space will be noticed in the Solvay coke, from the walls of the coking chamber to the middle of the ovens.

The coke used at the Buffalo furnace was supplied by the H. C. Frick Coke Company. It was especially noticed as the very best quality of furnace coke; evidently it had been carefully selected, as no "black ends" were visible in the supply examined. It was, therefore, quite manifest that the best Connellsville beehive coke would be used in the competitive test with the Semet-Solvay coke.

Further, it will be noted that the beehive coke has been made from much cleaner coal than that from which the Solvay was made.

RECORD OF CONDITION OF FURNACE DURING TESTS OF CONNELLSVILLE BEEHIVE COKE.

First day. Furnace working irregularly.
Second day. Furnace working irregularly.
Third day. Improved working.
Fourth day. Becoming more regular.
Fifth day. Furnace cool.

CONNELLSVILLE SEMET-SOLVAY RETORT COKE.

Sixth day. Slipping, not down to regular work.
Seventh day. Two slips to-day, cooling furnace.
Eighth day. Furnace gaining heat.
Ninth day. Improved working.
Tenth day. Working steadily.

The tables show that there was little waste from soft coke, as the relations of the two gases $CO:CO_2$, were found to be as 1:2.47 in the Beehive coke, and as 1:2.27 in the Semet-Solvay product. Sir. I. Lowthian Bell found the relations of these gases in a large test of Durham Beehive coke, as 1:2.28, and in Simon Carve's retort coke, as 1:3.32.

The analysis of the gases at top of furnace show that there is no loss in the Solvay coke from dissolution in its passage down the furnace from carbon dioxide, but on the other hand it resists this gas with more firmness than the Adelaide coke.

The five days' run with the Beehive coke left the blast furnace cool and in bad condition. During the run on retort coke, the condition of the furnace steadily improved, and at the close the furnace was working well (page 338).

Perhaps the most important result of this test was in the demonstration of Sir Lowthian Bell's error, in condemning all retort oven coke because of its greater absorption of carbonic acid in the upper region of the furnace. No greater obstacle has hindered the adoption of the retort oven in America. Mr. Fulton's statement is as follows (page 339b):

Stating the final results of the test, Mr. Fulton says (pages 340, 341, 342):

The following condensed statement will show the stock used and pig iron produced from Beehive and Semet-Solvay cokes, during these tests:

	Beehive Coke Test.	Semet-Solvay Coke Test.
Iron ore used..........	4,260,080 lbs.	4,711,190 lbs.
Limestone used........	729,400 "	870,700 "
Coke used............	2,403,060 "	2,775,613 "
Pig metal made.........	1,122 tons	1,205 tons (2,300 lbs)
Coke per pound of iron.	.956 lbs.	1.028 lbs.

Equating the conditions of these cokes, and eliminating excess of moisture, the coke per pound of iron will be for Beehive .938 pound and for the Semet-Solvay .972 pound.

When the further fact is taken into consideration, that the Semet-Solvay coke contained an average of 10.17 per cent. of ash, while the Beehive had only 9.62 per cent. of this impurity, the quantity of each kind of coke to smelt one ton of foundry metal is substantially equal, and the amount of coal used in Semet-Solvay coke is proportionately reduced.

Introducing the factor of relative proportions of coke made from a yound of coal in the two types of ovens, the comparison becomes as follows: Coal per pound of iron, Beehive 1.421; Semet-Solvay 1.389.

The different grades of foundry metal made during the five days' test by each kind of coke is as follows:

	No. 1.	No. 2.	No. 2 Plain.	No. 3.	Ragged.	Total.
Beehive	20	357	480	237	28	1122 tons.
Solvay...	73	487	461	156	28	1205 "

It will be noted that the Solvay coke's products in pig iron Nos. 1 and 2 give five hundred and sixty tons, and the Beehive three hundred and seventy-seven tons. The lower products of Solvay coke in No. 2 plain, No. 3 and ragged, give six hundred and forty-five tons against seven hundred and forty-five tons from the Beehive coke.

The difference, therefore, in the heats afforded in the metal made by Beehive and Solvay coke, is fairly in favor of the latter

The Semet-Solvay coke oven has been designed under correct principles, as regards wearing properties and output.

Its most distinguishing property is in its rapid work in coking, which is thirty per cent. shorter in time than its chief competitors.

The condition of the iron industry in Ohio seems particularly favorable to the retort ovens. Furnaces located on the lake shore have a manifest advantage in lower freights than the inland furnaces, while furnaces near the coke fields have an advantage on coke, but furnaces located between the mines and the deep sea must take up every available improvement that will offset these disadvantages. When their safety is still further threatened by an attempt to monopolize the only available coke supply, it becomes necessary to fight for your hearthstones. The rational and logical solution of this difficulty is the retort coke oven. As a weapon of defense, I offer you this oven, in the confident belief that it will render coal fields ten times as large as the Connellsville field available for good blast furnace coke, and, in addition to this desirable condition, will afford a handsome profit on the by-products, now entirely wasted.

Considering first the advantages of the retort over Beehive coke, we may enumerate them as follows:

(1) The yield of coke will be increased by converting a portion of the hydro-carbons into coke. The Syracuse record, with Morris Run coal, with twenty per cent. volatile, is eighty-three per cent. of good coke, against sixty per cent. obtained in the Beehive oven. From Pocahontas coal, with eighteen per cent. volatile, eighty-five per cent. of good coke was obtained, against sixty-two per cent. in the Beehive oven, and from Connellsville coal, with thirty-two per cent. volatile, seventy-two per cent. to seventy-five per cent. of good coke, against sixty-four per cent. to sixty-six per cent. in the Beehive oven. No such gain is possible with internally fired ovens of the Beehive type.

Note.—Many of the current reports of the yield of coke from coal are misleading, because the unit for the coal is the long ton, or even the mine ton, still further increased by the custom of giving full measures at the mines, while the unit for the coke is the short ton on the scales.

The yield of coke from the retort oven is also increased by more rapid coking, and consequently, larger output. The output of a Beehive oven, is stated as from four hundred to six hundred tons per year. The average of the twelve Semet-Solvay ovens at Syracuse for the year 1895 was one thousand five hundred and forty-three tons per oven. The coking of the coal by the narrow oven with thin flue walls, varies from eighteen to twenty-four hours according to the volatile in the coal. I have no hesitation in saying that two thousand tons of blast furnace coke can be produced in one oven in one year from Pocahontas coal.

(2) The form of the coke is better for blast furnace use, as one dimension is constant. A pile of Semet-Solvay coke has much the appearance of a pile of Belgian paving blocks. This constant dimension corresponds with half of the width of the oven. It is caused by the natural flow of the gases in escaping, and making a natural cleavage through the middle of the coke. The flow of these gases in the beehive oven is vertical, but in the retort oven is first horizontal, until they reach this middle line of cleavage, and then vertical to the outlet of the oven.

(3) The density and hardness of the retort coke is greater than the beehive coke. When the coke begins to fuse and swell in the retort oven it is compressed against the narrow walls. This increased hardness is likely to bring the coals of the Pittsburg district outside of Connellsville into profit, as they seem to lack

only this element of hardness to make them equal with Connellsville coke.

(4) Retort ovens can be placed at the blast furnace, instead of at the mines, with gain both in economy and efficiency. The rate of freight on coal is about sixty per cent. of the rate on coke, representing their approximate relative values under beehive practice, but with the increased yield in the retort oven, from seventy-five per cent. to eighty-five per cent. of coke, it is manifest that there is a direct economy in freights by bringing the coal to the blast furnace and coking it there.

By locating the ovens at the blast furnace, the use of coking coals from different localities is made possible, and the mixing of different coking coals for special purposes.

(5) By locating the coke ovens where the coke is used, the grade of coke produced is easily controlled. The quality of the coal used and the time of coking, may be varied to suit changing conditions. In this manner, blast furnace, foundry, or domestic coke may be turned out of the same oven at will.

(6) With the greater yield of coke, and the equal value, ton for ton, with beehive coke in the blast furnace, the proportion of sulphur and phosphorus added to the iron through the coke is decreased in proportion to the greater yield of coke. The ash in the coke will also be less in proportion to the same increased yield, since all the impurities start from the coal.

We will now consider the somewhat less well known field of the by-products.

TAR.

The product of tar in the retort oven varies with different coals, generally increasing with the volatile, and running usually between forty and one hundred pounds per ton of coal.

(1) This tar has a fuel value equivalent to about $5.00 per ton, or from 10 to 20 cents per ton of coal.

(2) This tar is also largely used by the roofing and paving companies. For these purposes, it has a market value of about $8.00 per ton.

(3) In Europe, a simple distillation of the crude tar is made into light oil, which is sold to the makers of aniline colors, and pitch, which is sold to the paving contractors.

(4) From the tar and gas together, may be distilled benzol, which, as an enricher of illuminating gas, is considered better and cheaper in Europe than naphtha. In this country, owing to the lack of an assured sufficient supply, benzol has not come into use. The large amounts capable of being obtained from retort coke ovens might make this practicable, and so establish a new industry.

(5) Coke oven tar is the only material yet discovered for the economical making of fuel briquettes. No field of American enterprise has stimulated more earnest efforts than the utilization of anthracite culm, now accumulating at the mines in enormous qualities. In this connection, I recall the name of Mr. Loiseau, who exhibited at the Philadelphia Exposition of 1876, his eggettes of compressed culm; also the plan of the late Colonel Price, of Scranton, to generate gas to be piped through the manufacturing regions of the East from the same source.

None of these efforts have succeeded yet in Europe, these fuel briquettes, as they are called, in the form of a brick with rounded ends, are a standard, economical and favorite fuel, and the industry of making them has assumed large proportions. The reason for this is that the enormous production of tar at the coke ovens in Europe, has made a practicable binding material for this waste fuel. I think that we may reasonably expect that with the development of the retort coke oven, this great question will be settled for America as it has been for Europe.

AMMONIA.

The only source for ammonia in America heretofore has been the illuminating gas plants, but, through the development of electricity and water gas, the supply of ammonia from coal gas has been nearly stationary. While on the other hand, the uses for ammonia have largely increased. It is now an essential material in refrigerating plants, in electro-plating, in the charging of batteries, in many large chemical works, and in smokeless powder. In the form of household ammonia, it has won its entrance into the grocery trade, and enormous quantities are now sold throughout the country as a domestic detergent; but the largest use is in the manufacturing of fertilizers, as a substitute for nitrate of soda, imported from the Pacific coast. The importation for the last fiscal year was over one hundred thousand tons of Chilian nitrate, most of which is absorbed by the fertilizer trade. At a price approaching \$50 per ton, sulphate of ammonia is cheaper than nitrate of soda. It may therefore be fairly claimed that a profitable market for all the ammonia which can be produced in this country will be maintained at a price not far from \$50 per ton, and as the cost of making this ammonia from the retort coke oven liquors is from \$20 to \$30 per ton, and the yield of ammonia from twelve to twenty-four pounds of sulphate per ton of coal consumed, it becomes a source of assured profit to the retort coke oven.

It is not necessary that the ammonia from the coke oven gases shall be converted into sulphate. It is practicable to make other salts, but the market price is usually rated on the basis of sulphate.

GAS.

After coking the coal, the remaining gas is available for use or sale. It takes about twelve parts of volatile to do the coking, so in estimating the amount of gas available for other purposes, we deduct this amount and determine the amount of gas. This gas may be considered as, first, fuel gas, for manufacturing purposes; second, illuminating gas. For both these purposes it is in constant use at Syracuse, where the works are lighted by the coke oven gas. Third, domestic fuel gas, replacing natural gas as it gradually takes its flight.

The quality of this gas makes it the best substitute for natural gas yet found. Reckoning the heat basis of natural gas as one hundred, illuminating gas is seventy-five, coke oven gas seventy, producer gas seventeen. It will therefore be seen that coke oven gas is more than four times as rich in heat power as producer gas. While it is not equal in heat power to natural gas, yet on account of its lighter specific gravity, the same pipes will deliver equal amounts in heat of either coke oven gas or natural gas, so that locations which are piped for natural gas can be supplied with fuel of equal effectiveness from the coke ovens.

In general, it may be said that a retort coke oven plant is simply an illuminating gas plant on a large scale.

COKE OVENS FOR ILLUMINATING GAS.

We have heretofore considered the retort coke oven with coke as its prime object, but it is well to consider it with gas as its prime object, replacing plants for illuminating and fuel gas.

This involves a change in the operation of the retort oven, so that ordinary producer gas, with recuperation of both gas and air, may be burned in the flues, instead of the rich coke oven gas now devoted to that purpose. When the requisite temperature is attained by these means, the coke will be in every respect equal to that produced in the present way, and the whole of the gas in the coal—9-10,000 cubic feet per ton—will be available for use or sale. But as the gas will command a high price for illuminating or domestic fuel purposes, a high volatile coal will be used, and the yield of coke proportionately decreased. Many cities are now furnishing domestic fuel gas at a reduced price. In Milwaukee, the domestic gas is furnished at 75 cents per thousand, while $1.00 is charged for illuminating gas, through the same pipes, but with a different meter. It is easily capable of demonstration that fourteen to sixteen candle power gas can be furnished at 25 cents per thousand cubic feet, and pay a larger profit than is now realized by many gas companies. One ton of coal would thus produce

10,000 cubic feet of gas, at 25 cents	$2 50
1,500 pounds of coke	2 00
Ammonia and tar	50
	$5 00

In this manner the inestimable convenience of natural gas may be extended to every city in the country.

Drawing another lesson from European practice, we may note that the fuel most used there by the middle classes is a mixture of equal parts of coke and coft coal. While the briquettes above referred to are somewhat of a luxury, costing about $5.00 per ton, the mixture of coke and soft coal costs about $3.00 per ton, and makes a stronger fire. There will, therefore, be a good market for all the coke produced in such a plant, if the European practice can be made popular in our country.

MOND PRODUCER.

Returning again to the use of producer gas in the flues of the retort coke oven, we must consider that ordinary producer gas would be likely to cause trouble from soot and tar accumulating in the flues and interfering with the regular work of the ovens. In this connection, Mr. Ludwig Mond, of Northwich, England, has patented a new gas producer, which by a scientific method of regulating the combustion, and pre-heating the incoming air and vapor, allows the recovery of from ninety to one hundred pounds of ammonia as sulphate, from every ton of bituminous slack consumed. All of the gas produced by this destructive distillation in the producer, about one hundred and fifty thousand cubic feet per ton of coal, is washed and the tar and ammonia recovered. It is then in good condition to use in the flues of the coke ovens.

The Solvay Process Company have, by practical experiment, satisfied themselves that this is a practicable method of running coke ovens, and are now erecting a plant of Mond producers at Syracuse, which will gasify one hundred and seventy-five tons of coal per day, replacing the coal in their steam plant, and the rich coke oven gas in their retort ovens.

GAS ENGINE.

The claim is made for the lately developed gas engine, that it will produce power at three-fourths pounds of coal per horse-power hour. At twenty-four hours for three hundred and sixty-five days, this will amount to three and one-fourth tons of cola per horse-power per pear. Comparing this with the lowest rates evef attained by the steam engine, or by water power, as offered at Niagara, it is evident that no power yet developed can equal it by one hundred per cent. Therefore, the elimination of the steam boiler, and the substitution of the gas engine for the steam engine seems to be the outcome of this newly developed gas engine, which will convert coal directly into power.

The development of the gas engine has heretofore been hindered, first, by its small capacity, rarely exceeding one hundred horse-power, and, second, by its inability to use ordinary producer gas on account of the tar and soot. The first of these difficulties is claimed to be solved by engineers in Europe, who are already using five hundred horse-power gas engines, and by our own American chief engineer, Mr. George Westinghouse, Jr. The second difficulty is entirely overcome by either coke oven gas, or Mond producer gas. As the net cost of producing these two kinds of gas, owing to their treatment for the recovery of the tar and ammonia, is reduced to less than their equivalent value in coal, it would seem that the time is ripe for pushing these radical improvements to their full development.

SUMMARY.

We may say, in conclusion, that by using retort ovens, either at the mines or at the selling depots, the miners of coal can deliver a better coke at a greater profit, and can use all their slack, which is now often of little value, to good advantage.

BLAST FURNACES.

By placing the coke ovens at the furnace, the blast furnace owners can defy any coke monopoly or combine. They can take advantage of local coal deposits, either using them entirely, or mixing them so as to suit their needs from time to time. They can, by using the surplus gas, and with favorable markets for tar and ammonia, reduce the cost of their iron by $1.00 per ton.

CHEMICAL AND FERTILIZER TRADE.

These large trades, which require large quantities of ammonia in various forms, will find that the retort coke oven and the Mond producer will enable them to obtain a home supply instead of depending on foreign countries.

DOMESTIC FUEL GAS.

There is no reason why the benefits of natural gas should not be extended to every city in the country. To lighten the burden of the American housewife, that overworked woman who does her own work, makes a home for her husband, bears and trains his children, is perhaps to-day the one relief most needed in our civilization. I believe it may be safely claimed, that domestic fuel gas, for warming, cooking and lighting, is available for this the most desirable and beneficent application of the retort coke oven.

PRESIDENT ORTON: We are under great obligations for this very admirable and complete paper on the subject, and before I place it before you for discussion I desire to say that the Institute wishes to open its doors to-night to everybody here who may be interested in the discussion of this topic, whether members of the Institute or not. For my own part, I was intensely interested by what Professor Atwater said. The drift of his paper is all towards economy. My paper had the same general bent, though we had not previously compared papers. This is one of the great problems of the age which no mine engineer can afford to pass lightly.

I am sorry I have never been able to inspect this oven. The only connection I ever had with anything of the kind was when I was called to inspect a plant which is now decaying and falling to pieces. I was called in as a witness in reference to the quality of brick employed in building the famous Hawk's Nest plant in Virginia, and found there was most lamentable failure in accomplishing the desired object; not because it could not be made a success, but because they had not the pluck to stay with it and build it right from the ground up, along the lines we have heard described to-night.

I will place the subject with you for discussion.

MR. JOHN KANE: I would like to ask a question. I don't want to discuss the matter, for it is beyond my depth. I was very much interested in the gentleman's paper and think it is one of the best I have ever heard read before this Institute, for which we should all feel very grateful to Professor Atwater. It has opened out a vista to me that I had never thought of before, and I presume it is much the same with every member of the Institute.

The question which I want to ask is this — and I think Mine Inspector Haseltine can better answer it than anybody, probably — is not that oven a similar oven to the one lying idle at Shawnee, this state?

SECRETARY HASELTINE: I am not familiar with the technicalities of these ovens, and whether it is conducted on the same lines as this, I am not able to say.

MR. KANE: My impression is that the plan is very similar, and when I was there I noticed that for some reason the ovens were not in operation. I do not desire to intimate that it was on account of any lack on the part of the oven, but I thought it would be interesting to know that such an oven as that exists in this state, if such is the case, and the fact might bring out some discussion.

MR. DAUGHERTY: The oven at Shawnee is, I believe, what is called the Belgium oven and is very similar to that. It was built for working Ohio coal, generally conceded to be non-coking coal. I have a sample made from that field and it is good, strong coke, but there is too much soot in it; and it was shut down before some of the ovens were fired. I don't think the plant was ever finished. As I remember they never finished all of the ovens. But in Pittsburg, I understand, the Southside Gas Company built some Solvay ovens and I believe are making a thorough success of them. The main product is gas and not coke, and the supply comes from coke ovens instead of the ordinary gas furnace. Perhaps Mr. Atwater can tell us something about that oven?

PROFESSOR ATWATER: I do not know of any Semet-Solvay ovens at South Pittsburg. There are none built there yet. There are some in contemplation, but none have been built.

MR. KANE: Mr. Lord can perhaps tell about those down at Shawnee.

PROFESSOR LORD: I know nothing of the Shawnee oven, as to what type it was; but my impression is that those are what are called vertical flue ovens of the Coppee type. I did not examine them.

MR. KANE: I think they are horizontal. That is my recollection, though it has been a good while since I have seen them.

PROFESSOR LORD: My impression is that they are vertical flues, though I may be wrong about that.

MR. LOGAN: I would like to say that I am indebted to Professor Atwater, through the Institute, for the greatest treat I ever received. I had a number of questions to ask this evening, as I am quite interested in this subject at present, but the treatment of the subject was so complete that there are none, you may say, left unanswered. There is one, however, I would like to ask in regard to the splitting of the coke as it comes out of the oven. I would like to state that I had the pleasure this summer, during vacation, of visiting at Johnstown a plant of the Otto Hoffman ovens lately erected at that place. I noticed as the coke was forced out by the large ram, it did not seem to split as described this evening. I cannot see why it did not do it, for the flues are the same as these except the sides are built of brick, instead of tile. I cannot see why the coke did not also split in the center as explained here. I will ask the Professor to answer that question.

PROFESSOR ATWATER: Mr. President, the Otto Hoffman plant at Johnstown was put into operation the last of the year and has been going a couple of months. The flues in the Otto Hoffman oven are vertical, not horizontal. I have never seen an Otto Hoffman discharged; but it is difficult to conceive that the gases can escape in any other way than that by which I have indicated. Since the gentleman says that he saw the oven last summer, there must be some mistake, because there was no Otto Hoffman oven in America until last November.

Mr. Brown: I would like to ask about the efficiency of the Mond gas producer. The ordinary blast furnace will yield in sulphate of ammonia what is the equivalent of sixteen per cent. of the nitrogen of coal. Mr. Augustus Henning, of Springfield, Ill., invented a producer, which it is claimed will yield fifty and even eighty per cent. of nitrogen in the form of sulphate of ammonia. What is the work of the Mond producer? How much of the nitrogen in the coal is recovered?

Mr. Blauvelt: I have some knowledge of the Mond Producer and of Mr. Henning's patent. Mr. Henning told me his aim was first to get good gas; second, to get ammonia. Mr. Mond's aim is first to get ammonia and, second, to get gas. According to the analyses, Mr. Henning gets richer gas, but not so much ammonia. Mr. Mond gets ninety to one hundred pounds of ammonia to a ton of coal; Mr. Henning gets sixty to seventy pounds of ammonia — sulphate — to a ton of coal, but his gas is somewhat better.

Mr. Logan: I would like to make a correction. I think perhaps I made a mistake in stating the time I visited the ovens at Johnstown. It was not in the summer, but was in the winter vacation when I was there, and they had just completed them. I was under the impression, but would not say positively, that the flues there were horizontal and not vertical. That is the reason, then, for the coke not being divided.

Mr. Daugherty: I would like to ask the Professor if he knows any way to increase the yield of ammonia and tar in those ovens. I notice he reports forty to one hundred pounds of tar to a ton of coal. I think some gas works run eighteen gallons to a ton. I wondered why this was not capable of producing more ammonia and tar, but both are below the average.

Mr. Blauvelt: The answer to Mr. Daugherty's question is about the same as that given to Mr. Brown. The object of the retort coke oven is to make good coke. Everything else is second. If he wished to increase the ammonia he could do it and in place of fifteen to twenty-five, he could get ninety to one hundred pounds to a ton of coal, as in the Mond Producer, but no good coke. Keeping in view the principal object of making coke, you get what ammonia you can and are so much the better off for it. As soon as you attempt to increase the ammonia and tar beyond a certain point, you have the results of the gas plants and make the coke almost worthless.

MR. DAUGHERTY: If you would reduce the tar, would it help to make better coke?

MR. BLAUVELT: That is what the retort oven does all the time. The tar or hydro carbons are turned into coke, causing the formation of graphitic carbon on the surface of the coke and making it better adapted to the use of blast furnaces. The beehive does it to a certain extent; the retort oven does it still more. It is less in the beehive on account of the internal firing.

PROFESSOR ORTON: Why is this splitting up by the hydro-carbon gases?

MR. BLAUVELT: If those samples of coke are passed to Professor Orton, it will show him just what he asked. (Samples are handed to Professor Orton). You will notice the thick rounded ends where it comes against the bricks. Instantly, as the coal comes against the highly heated tile surface, it is brought to a bright straw color, and the volatile begins to flow into it from both sides. That represents the width of the oven. The gas is expelled and takes its course through here. This is the central line of cleavage. There is dense coke here (indicating), even bedded coke here (indicating), and spongy here.

MR. KANE: I would like to ask another question. I inferred from Mr. Logan's question and the Professor's answer that in the vertical flue there is not that line of cleavage the Professor speaks of. That being the case, how does the gas escape from the vertical flue?

MR. BLAUVELT: If Mr. Logan had examined carefully he would have noticed the line of cleavage. It almost always, when it leaves the oven, rolls over in a body together and does not split open that way, and you would not notice the line of cleavage unless it was called to your attention.

PRESIDENT ORTON: I have another question to propound. Are the mechanical difficulties of withdrawing the coke from the ovens totally conquered in this process, or do you still have bulged walls and stripped cogs on the rammer as in the beginning?

MR. COGSWELL: Since the time the ovens have been in operation in Syracuse, we have never had any difficulty of that kind. At some places in Europe where they have been eight years in use, there has been no difficulty of that kind. We have no mechanical difficulties to overcome.

SECRETARY HASELTINE: When I was compiling the last Journal, it seemed to me that two-thirds of the remarks were made by Secretary Haseltine, and I determined the report of this meeting should not make such a showing. However, I am fearful that our friends from New York will think the audience is one of the quiet and unresponsive kind always. But if an old member had prepared and read a paper which did not meet their views, the Chair would have had difficulty in recognizing the members as they would jump to their feet; and I cannot understand their present silence, except on the ground that they are taken out of their channel. As I said to Mr. Atwater to-day, we are not a coking people in Ohio, and for that reason this is a new subject and an intensely interesting one. I was especially anxious to have the matter brought before the people of the Institute in the hope that we might derive some increased revenue from our wasted coals, as they are now thrown in the gob or dumped on the outside. Mr. Atwater did not in his paper touch on this subject, which is to me of so great interest.

The coke ovens of Shawnee, of which Mr. Kane has spoken, were reported as the Belgium oven. I don't know about the flues as compared with the tile flues in this oven; but under these ovens there was a checkerwork of spaces alternating with brick, and the gas passed through that in the line of the sole of the oven, as it has been termed here to-night. I think there was no attempt there made to save the by-products, no attempt at anything but to make coke; and in doing that they used the lower bench of the great vein of the Hocking Valley, the Middle Kittanning coal system of Pennsylvania. It was ground to a pulp and washed and made as pure as possible, and charged seven tons at a time in the oven. The length of the charge has never been determined. One was a failure; the next worse, and so on. I saw one of them rammed — I think it had been in twenty-four hours. It looked like a ton or two and a half of good walking cane coke; and as soon as water was applied, I do not think there was a good wheelbarrowfull out of perhaps a ton that would do for a heating stove. The rest was ashes.

The proposition Professor Atwater made to me was that by mixing the rich coking coal of Connellsville, or New River, or the Pocahontas, with the leaner coals of Ohio, you would get an equal quantity of by-products and at the same time get a commercial coke. That seems to me a great point for the people of Ohio to know and consider. During the Lake shipping season in the Hocking regions, or any region from which the coal goes to the lake regions, when there is an excess of fine coal, which would be a drug on the market, if it could be prepared and mixed with some richer coals to make good coke and by-products at a profit, that would go a long way towards making the mining business profitable, — especially where some dealers are figuring on five cents profit. That is an important feature and I have been listening for it to be brought out. Before I sit down, I would like to urge some of the large operators present to express themselves on this subject in some way.

Professor Atwater: I am sorry, Mr. President, if I fell short of Mr. Haseltine's proper expectations —

Secretary Haseltine: You did not fall short, — the rest was above the standard.

Professor Atwater: We carried on at Syracuse experiments of two or three weeks on the point Mr. Haseltine has mentioned, — the mixing of coals not considered coking with those which were good coking coals. I would say that in each case we made coke, sometimes good, sometimes indifferent, sometimes poor, — but in no case did we make *no coke.* I will give you a list of the mixtures and presume you will recognize the coals, which are from the western part of Indiana or the eastern part of Illinois.

MIXTURES OF OHIO COALS.

Coxville, all.
Coxville and Brazil Block.
Coxville disintegrated, all.
Coxville disintegrated and Brazil Block.
Coxville, three parts, Brazil disintegrated, one part.
Brazil, two parts, Connellsville, one part.
Coxville, three parts, Connellsville, one part.
Coxville, three parts, Pocahontas, one part.
Brazil, three parts, Pocahontas, one part.
Big Muddy, all.
Brazil, three parts, Big Muddy, one part.
Brazil disintegrated, all.
Coxville, two parts, Big Muddy, one part.
Coxville, six parts, Connellsville, four parts.
Coxville, seven parts, Connellsville, one part.
Big Muddy disintegrated, all.
Glenborn Screenings, all.

These coals are from Western Indiana and Eastern Illinois.

It seemed to me that the determinations of the mixtures of Ohio coals with a certain amount of what may be called flux, which will make good coke, is a field which may well engage the best attention of your chemists. And further, while it has been said, I think by Mr. Logan, that you are not a coking people, yet you will not deny that you are a blast furnace people and therefore interested in coke. I have attempted to make it clear that it seems to us to be the desirable thing that cook ovens should be.

PROFESSOR ATWATER: Do you regard the coal as a good coking coal?

PROFESSOR LORD: No, sir.

PROFESSOR ATWATER: We made good domestic coal in our ovens from that coal.

PROFESSOR LORD: It must be better than the Hocking valley coal, then.

PROFESSOR ATWATER: Send us a sample and we will try it.

MR. WILLARD: I would like to ask the Professor how much space a block of twelve ovens would occupy. At most blast furnaces space is valuable and in a great many cases it would be difficult to get the ovens in. This is especially true of blast furnaces located in cities, where they could find a market for the by-products. The blast furnaces located in the country would not find much market for gas, and whether they would for the other by-products, I don't know.

PROFESSOR ATWATER: It is not considered desirable to build less than twenty-five ovens, because the machinery is as expensive for twenty-five as for twelve, and the operating expenses for charging, discharging and so on. A block of twenty-five ovens would occupy about one hundred and fifty feet in length — about six feet to the oven — and about one hundred and thirty feet in width; so that, a space one hundred and thirty by one hundred and fifty feet would accommodate twenty-five ovens, with perhaps twenty-five feet square anywhere about for a by-product house, not including coke or coal storage.

MR. WILLARD: That would produce how much coke?

PROFESSOR ATWATER: It would produce one hundred tons a day.

MR. WILLARD: How many reserve ovens would be necessary to produce one hundred tons a day? Suppose you have a furnace to use one hundred tons a day, it would be necessary to have twenty-five per cent. reserve for emergencies and repairs, would you not?

PROFESSOR ATWATER: We have never needed such a reserve at Syracuse. It is possible to run the ovens a little less than full capacity, if the demand is not equal to the supply. But in our plant for three years every oven has discharged at least every day its quota of coke.

MR. LOGAN: I would like to ask the Professor how he loads the coke into the flats. The reason I ask it is the fact that they seem to have a great deal of difficulty there in loading the coke, from the fact that they rammed the coke on a large iron box and there pour the water upon it and immediately run the box over the flats and drop it in. This necessitates an extra supply of water in order to cool it so they can drop it into the flat with safety. After they drop it into the flat, they often have to play the hose upon it. I do not understand that this extra amount of water destroys the quality of the coke, but it does destroy the silvery lustre of it.

MR. BUELL: I came here to-night to hear this paper because I was interested in the process, as one of our competitors has introduced it into his line of business. There is a phase of the question which has not been touched upon to-night, and I would like to draw out some information on it: that is, as to the eventual financial outcome if introduced into this country successfully. I have watched with interest the introduction of the retort process into this country — it is in its infancy now. I saw in an English paper a statement which bears on the financial question of the process. It was to the effect that the retort process is being abandoned to some extent for the reason that they had so many of the retort ovens that the by-products had been cheapened so as to render the business unprofitable; and the recent plants were put up without a view to the recovery of by-products. I will not vouch for the authority, but I saw it in an English paper. Probably the author of this paper, as he is eminent authority, can give us some light on the subject.

PROFESSOR ATWATER: Mr. President, I can assure you that new blocks of retort ovens are constantly being built in Belgium, Germany and in England, these being the three coke-producing countries of Europe. I have followed quite closely the statistics which different projectors of coke ovens have published, and I have noticed that the only style of oven built without a view to the recovery of by-products, the Coppe oven, is rarely built. The most of the ovens built are for the recovery of the by-products. I think I can say to the gentleman that the statement he saw in the Eiglish paper is not correct. As to the price of by-products, — the leading by-product is ammonia, the most important one. Anyone at all familiar with the fertilizer question in Europe can realize the almost inexhaustible field for the sale of ammonia as a fertilizer. Now the price is so high that it is hardly used here, almost all being imported. But I am assured by the leading fertilizer authorities that the price cannot go much below forty-two and one half cents a pound. The fertilizer field is almost inexhaustible, especially in Europe, where the soil is exhausted.

PROFESSOR RAY: In regard to the mixing of Ohio coals, I will say that at the time these ovens at Shawnee were being built, there was a great deal of excitement created on account of the alleged experiments supposed to have been made on Number Five coal. Upon the results of the experiments which were made, or on the supposed results of these experiments, they went ahead and invested their money in building this plant of coke ovens, and this naturally aroused a great deal of interest among the coal companies. The Columbus Hocking Coal and Iron Company took it up and made elaborate experiments. They selected coals from all their mines and selected the best coal that they could pick out. In other words, they picked the coal which indicated that if any coal would coke, it certainly would. They sent down two or three different lots, and I was delegated to follow the coal. We had a good deal of trouble to arrange the work so as to be sure that ours and none other was being tested. We did this and selected three alternate ovens with hot ovens on each side, and charged for seventy-two hours in one case, one sixty and some forty-eight, the difference being in the size of the charge. The coking part of it was in charge of the man who did the coking for the Utley Coal Company. The Hocking coal alone made a coke, but very spongy, scarcely any fingers of coke in it and in handling would break up badly. The coal that was mixed with the Pittsburg coal made coke that was fair but high in sulphur and not sufficiently strong for blast furnace use. They made the amount of coal experimented on large in the hope of getting enough coke to make a blast furnace test at the Buchtel furnace. They filled the furnace and I think for about a week or two it suffered with sickness from the use of that coke. It was like a strawstack in the furnace. The result of this experiment was decided to be that it was no use trying to coke a non-coking coal; and that the Shawnee experiment, in which there was an investment of something like a hundred thousand dollars, was a salted experiment, and the results of an attempt to run the furnace proved it.

MR. JONES: I can state in relation to the Shawnee ovens, that they have never been finished to give them a fair test. There seemed to be a difficulty with the ovens to control the heat. Whenever they charged the ovens, it seemed they could not control the heat. There was some difficulty, I believe, about payments and the plans were replevined and the plant never finished. The general opinion is that something was put in so that they could not control the heat, and the plans taken away. I believe if they were finished they could be worked successfully, because coke was made there and sold.

PROFESSOR RAY: I think, if the gentleman remembers, they tried for several weeks to coke the coal mined at Shawnee, and afterwards, if I am not mistaken, they tried a coking coal. The plant was half finished, — half of the ovens finished and the foundation in for the other part. I think the ovens were run for at least a month and you can see the coke lying there on the ground now, and it is exactly similar to the coke we were able to make. The objection to the Shawnee experiments is that there is always quite a per cent. of Ottley coal sticking to the sides of the bin, and the coke they made was from a mixture of Ottley coal and what they took to be experimented upon. I saw that danger and put up a temporary chute and ran it outside on a temporary platform, so as to be sure it was our coal tested instead of a mixture. We also mixed it with the Ottley coal and the coke resulting from the mixture was very similar to the Shawnee experiment. I don't mean to accuse anybody of wilfully sugaring the experiment that the Shawnee people had made, but I offer that as an explanation of how they got better results than the Hocking Coal and Iron Company got. They tested it by at least twenty cars of coal and slack and determined that it was impossible to coke it in the beehive oven, at least.

PROFESSOR ATWATER: If in any way the Semet-Solvay Process Company can assist in determining the character of Ohio coals as to coking properties, we will put the ovens at your disposal and assist you in every way we can to determine the right coals and mixtures, either for domestic or blast furnace use. Further, the ovens are open to inspection and we will be glad to see any member of the Ohio Institute of Mining Engineers, or any gentleman interested in this subject, at Syracuse and show the ovens to them.

DR. EDWARD ORTON: Before Professor Atwater leaves the room, I think it would be comely and proper to express to him our appreciation of his effort for our entertainment and enlightenment. I therefore move, Mr. President, that the thanks of this body be tendered to Professor Atwater for his able exposition of the subject which has been under discussion.

(Motion seconded and unanimously carried.)

PROFESSOR ATWATER: Thank you, Professor Orton and gentlemen.

PRESIDENT ORTON: The Institute will please remain in order for a few moments. If there is any further discussion of the subject, we will have it now; and if there is no further discussion desired, we will close the matter up in a comely way.

(There being no desire for further discussion of the last paper evidenced by the members, and the session having already been extended to a late hour, it was agreed to defer the remaining number of the program for this evening, viz., a paper by John Kane entitled, "The Mine Boss and His Relations to the Operator and Miner," until the following day. The excursion to the steel works of King, Gilbert & Warner, South Columbus, for the morning was announced and arrangements as to time and place of meeting made, after which the Institute adjourned until Wednesday afternoon at 1:30 P. M.)

AFTERNOON SESSION.

Wednesday, January 22, 1896.

After the opening of the session, Mr. John Kane was called upon for his paper, which was deferred from last evening, and read the same as follows: