Summary.

An ammoniacal solution of nickel cyanide prepared according to the directions given in this article will quantitatively absorb benzene from mixtures containing benzene and air, and from ordinary coal gas. It will not absorb measurable quantities of ethylene or of the other constituents of ordinary coal gas, with the exception of those absorbable in potassium hydroxide solution.

The method proposed by Morton for absorbing benzene by means of sulphuric acid (Sp. Gr. 1.84) does not give constant results even when the conditions are the same, and yields widely varying results when the conditions are changed. Moreover, it absorbs both ethylene and benzene, and from mixtures containing both of these gases it does not quantitatively remove the benzene but does remove an indeterminate amount of ethylene. Moreover, in the manipulation suggested by Morton, the reagent foams to such an extent as to make the accurate reading of the gas volumes well nigh impossible.

CORNELL UNIVERSITY,
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THE EFFECT OF COAL GAS ON THE CORROSION OF WROUGHT IRON PIPE, BURIED IN THE EARTH.[1]

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This investigation was undertaken in connection with a study of the conditions causing the corrosion of pipe laid under the streets in the City of Nashville.

Five samples of earth were collected as representative of the various types in which the pipes are laid.

Sample No. 1 was taken from a street at the depth of the gas pipes. It was an old fill. Sample No. 2 was taken from about 4 feet from the surface on private property in the heart of the city, 50 feet from the sidewalk, and was a yellow clay. Sample No. 3 was taken from between the car tracks just under the street metal. It was a loamy clay. Sample No. 4 was a clay taken from a vacant lot in the northern part of the city. Sample No. 5 was taken from under the car tracks in the southern part of the city, and was a mixture of clay and loam.

The analyses of the samples gave the following results in percentages:

Sample.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Moisture (sample air-dried)...	15.37	15.82	14.41	13.95	14.98
Chlorine....................	0.04204	0.01501	0.0018	0.0006	0.0024
Nitrogen, as nitrates.........	0.01501	0.22523	0.006	0.003	0.0015
Nitrogen, as nitrites.........	0.00008	0.000002	trace	none	trace
Nitrogen, as ammonia.......	0.000306	0.000165	0.000011	0.000039	0.000042

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[1] Read before the New York Section of the American Chemical Society.

Sample.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Albuminoid ammonia	0.00128	0.000052	0.00002	0.000021	0.000021
Alkali equivalent (Na_2CO_3)	0.0382	0.0478	0.0324	0.0057	0.0318
Sulphuric anhydride (SO_3)	0.0134	0.019	0.0448	0.0073	0.0424
Humus	2.04	3.40	2.05	1.4	2.7

Wrought iron pipes, one inch inside diameter and ten and a half inches long, were carefully cleaned and freed from all oxide by immersing in a warm ammoniacal solution of ammonium citrate for twenty minutes (or longer if necessary), brushing with a stiff brush, rinsing with distilled water, and drying rapidly.

The ammonium citrate solution is made by dissolving 40 grams of citric acid in water and neutralizing with the requisite amount of ammonium hydroxide of sp. gr. 0.896, required by the equation:

$$C_6H_8O_7.H_2O + 3NH_4OH = \text{Etc.}$$

The solution is then diluted to 460 cc. and contains approximately 10 per cent. of ammonium citrate. The citrate solution acts more rapidly on the iron oxide when warmed and has very little effect on metallic iron. A clean and bright piece of iron, having a surface of about 15 square inches, was allowed to remain in the solution for 24 hours, and no effect on the surface was observed nor was any appreciable loss of weight noted.

The pipes were weighed and plugged at one end with corks driven in about one-eighth of an inch beyond the edge, and this space was filled with melted paraffin to keep the moisture in the earth from getting inside.

The samples of earth were each put in a wooden box of one cubic foot capacity, painted inside with asphalt paint to prevent the soluble constituents of the wood from permeating the earth. The pipes were placed in an upright position in the boxes (with the closed ends down) and the samples of earth were carefully tamped around them to within one inch of the top.

The earth in each box was to have been sprinkled daily with 50 cc. of water, so as to maintain natural underground conditions as far as possible, but the person in charge of this series of experiments neglected this precaution during a large part of the time. However, as each received the same treatment, the results are comparable, although they are all too low, except in the case of sample No. 5, which will be referred to later.

At the end of twelve months the pipes were removed, cleaned with the citrate solution, as previously described, and weighed.

The results are as follows:

Sample of earth.	Original weight of pipe. Grams.	Final weight of pipe. Grams.	Loss of weight. Grams.
No. 1	624.49	603.93	20.56
" 2	652.45	638.92	13.53
" 3	665.76	663.20	2.56
" 4	680.81	678.30	2.51
" 5	618.90	606.50	12.40

The results, except that for sample No. 5, show that the amount of corrosion is determined practically by the chlorine content in the earth. There is some error in the result obtained from sample No. 5 which I am not able to discover, but that the result is entirely abnormal will be shown clearly later on.

The series of experiments designed to show the effects of coal gas on the corrosion of the pipe was conducted under the specified conditions in every detail. Into each box was placed an L, made of one-half inch gas pipe, one limb passing vertically down one corner of the box and the other along the bottom to the diagonal corner. The limb along the bottom was perforated on the under side with numerous one-eighth inch holes uniformly distributed and the end was plugged. The gas was admitted to this pipe through a standard meter reading to one-hundredth of a cubic foot.

One-half of a cubic foot of coal gas was admitted into each box daily, except Sundays, and at the same time the earth was moistened by sprinkling with 50 cc. of water. The boxes were covered with canvas so as to prevent the moisture from evaporating too rapidly.

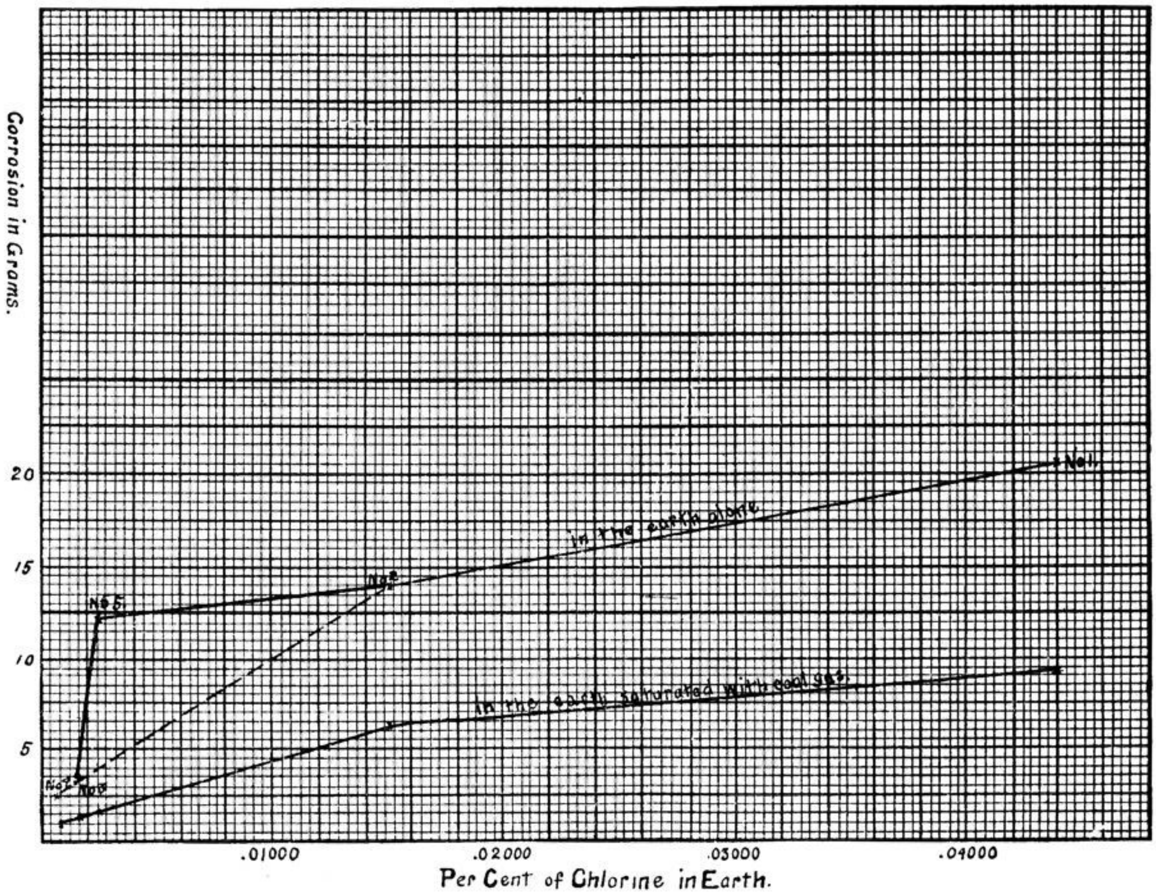
In the samples of earth Nos. 2, 3, 4 and 5, two pipes were placed and the amount of corrosion of each pair shows very good agreement. The results, after twelve months, are as follows:

Sample. of earth.	Original weight of pipe. Grams.	Final weight of pipe. Grams.	Loss of weight. Grams.	Average loss of weight. Grams.
No. 1	661.53	652.36	9.17	9.17
" 2	658.30	651.77	6.53	6.34
	654.07	647.92	6.15	
" 3	663.60	662.45	1.25	1.54
	668.71	666.88	1.83	
" 4	665.62	664.37	1.25	1.17
	671.45	670.36	1.09	
" 5	653.58	651.78	1.80	1.96
	663.14	661.02	2.12	

The following table shows the comparative amount of corrosion of the pipe in the earth alone and in the earth saturated with coal gas:

Sample of earth.	Loss of weight in earth alone. Grams.	Loss of weight in earth saturated with gas. Grams.
No. 1	20.56	9.17
" 2	13.53	6.34
" 3	2.56	1.54
" 4	2.51	1.17
" 5	(12.40)	1.96

The effect of the gas in retarding corrosion of wrought iron pipe is very marked, especially when we consider that the results showing the corrosion in the earth alone are all low (except No. 5, which is manifestly wrong) because of the failure to maintain the proper amount of moisture in the earths throughout the whole period of the test.



The accompanying chart shows the curves, indicating the relationship *between the amount of corrosion and the chlorine content; also the* error in No. 5. In the series of experiments with the coal gas, Sample No. 5 shows the normal amount of corrosion. In the series with the earth alone, No. 5 should have shown about 3 instead of 12.40 grams of corrosion. My opinion is that No. 5 was inadvertently subjected to electrolysis, as the appearance of the pipe indicated it and electrolytic experiments were being carried on at the same time.

No. 2 shows a rather high corrosive power in both series of experiments, which is doubtless due to the abnormally high content of nitrogen as nitrates in this sample of earth. It is said that the location from which Sample No. 2 was taken was formerly the site of a livery stable, which would account for the high percentage of nitrates.

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