FUEL VALUES OF IOWA COALS

BY

F. A. WILDER

ANALYSES OF IOWA COALS

BY

JAMES H. LEES AND A. W. HIXSON

FUEL VALUE OF IOWA COALS

BY FRANK A. WILDER

WITH ANALYSES OF IOWA COALS

BY JAMES H. LEES AND A. W. HIXSON

CONTENTS

CHAPTER II

THE FUEL VALUE OF IOWA COALS

The following chapter gives the results of chemical and physical tests, carefully made at large expense to the national government, to show the fuel value of Iowa coals; and to determine how to handle them in order to obtain from them the greatest efficiency.

The state of Iowa, with individuals and companies engaged in coal mining within the state, contributed in various ways to this fund of information with reference to the nature of Iowa coals.

To the engineer who wants to post himself on Iowa coals, the complete presentation of the tests as made in the following tables will be considered natural and necessary, though the casual student of the subject might get along with a more condensed statement.

Care was taken to make the tests typical, and though they actually stand for coals from certain mines, they probably represent rather correctly the coals of the state and their behavior under various conditions, except where note is made to the contrary.

The tests were made under an act of congress approved in 1904, providing for the analysis and testing of the coals and lignites of the United States, in order to determine their fuel value and the methods that should be employed to obtain from them the greatest efficiency.

The testing plant was established at St. Louis in connection with the Louisiana Purchase Exposition, and was under the supervision of the United States Geological Survey.

A very complete plant was established with all desirable apparatus and machinery for making both chemical and physical tests on coal and lignite.

A particularly valuable feature of the tests is found in the fact that coals from all portions of the United States were brought together and tested under identical conditions by disinterested persons.

For the first time, therefore, opportunity was given to compare the coals of America and to determine their relative value.

If the prices of coals are taken into calculation, and the fuel values used which are set forth on the following pages it will be found that there is no excuse for importing expensive eastern coals into the Mississippi Valley, except for domestic and metallurgical purposes.

Moreover the possibility of briquetting Iowa coal and putting it in an especially attractive form for domestic use, is plainly brought out.

The Iowa Geological Survey co-operated effectively with the National Survey in connection with these tests.

The state survey selected the mines from which the coal for testing should be taken, and in doing so, endeavored to select points that might be regarded as typical for the state, and points, moreover, which would long be producers.

It was felt that the tests should represent as large an area as possible, and that the results obtained should have weight for a considerable period of time; in-as-much as the tests were expensive and could not readily be duplicated.

The Iowa Geological Survey selected and secured the donation of five cars of coal from as many important mines; and secured from the railroads the free transportation of four cars of this coal from the mine to the testing plant. The State Survey paid the freight on the fifth car.

The coals that were tested are presented in the table below, and on the following pages they will be referred to by the numbers here shown.

NAME OF SAMPLE	OPERATOR	MINE	LOCATION	GRADE OF COAL	NAME OF BED
Iowa 1....	Anchor Coal Co., Ottumwa, Iowa	No. 2	Laddsdale, Ia.	Over ¼ inch screen.	Middle bed.
Iowa 2....	Mammoth Vein Coal Co., Hamilton, Ia.	No. 5	Liberty Twp., Marion Co., Ia.	Run of mine.	Big vein.
Iowa 3....	Gibson Coal Mining Co., Des Moines, Ia.	No. 4	Near Altoona, Polk Co., Ia.	Over ⅛ inch screen.	Third vein.
Iowa 4....	Centerville Block Coal Co., Centerville, Ia.	No. 3	Centerville, Appanoose Co., Ia.	Over 1⅝ inch screen.	Lower bed.
Iowa 5....	Inland Fuel Co., Chariton, Ia.	No. 1	Chariton, Lucas Co., Ia.	Run of mine.	Lower bed.

Mr. Savage, at that time Assistant State Geologist, in company with Mr. Groves, who represented the United States Geological Survey, secured the mine samples, and supervised the loading of the cars. The report of Mr. Savage, made in Bulletin No. 2, Iowa Geological Survey, is quoted at this point:

From each of the mines from which a car of coal was shipped to be tested, two samples were taken for chemical analysis. These samples were obtained from points in the mine quite widely separated. They were cut from the full section of the working faces of the seam mined at the time the car was loaded, and were immediately sent to the St. Louis laboratory by mail in air-tight cans. The two coal samples that were collected at the mine for chemical analysis are referred to in the tables which follow as "mine sample A" and "mine sample B" respectively.

As each car load of coal, sent to the plant for testing, was unloaded at St. Louis, a third sample was taken for chemical analysis which represented the coal actually contained in the car to be tested. This sample is designated in the following tables as the "car sample".

As the coal was distributed to the testing divisions samples were taken at frequent intervals, quartered down, and analyzed. In this way at least six separate samples from each car of coal were obtained at the plant, and two at the mine.

Quotations are freely made on the following pages from Professional Paper 48, of the United States Geological Survey, in which all the tests of the St. Louis plant are presented, and from which the tables showing results of tests are taken.

DESCRIPTION OF MINES AND SAMPLING METHODS

IOWA NO. 1.

Operator.—Anchor Coal Company, Ottumwa, Iowa.

Mine.—Mine No. 2, located at Laddsdale, Wapello county, Iowa, on Chicago, Rock Island and Pacific Railroad.

Coal bed.—In Wapello county the coal beds lie at no great depth below the surface. The middle bed in this mine is found at a depth of 58 feet, and what is called the third seam at a depth of 70 feet. The coal beds vary greatly in thickness in this region, but in the majority of places in which they are now worked they range from 3 to 5½ feet.

Two sections were measured on each bed and the variations are shown in plate X. The detailed sections are as follows:

Sections of coal bed in mine No. 2, Anchor Coal Company, Laddsdale, Iowa.

MIDDLE BED.				THIRD BED.			
SECTION A.		SECTION C.		SECTION B.		SECTION D.	
	Ft. in.		*Ft. in.*		*Ft. in.*		*Ft. in.*
Coal	2 11	Coal	3 10	Coal	2 3	Coal	4 5

Samples for chemical analysis.—Two samples for chemical analysis were obtained in this mine. Sample A is from the middle seam and sample B is from the third seam. These samples were taken at the points where sections A and B, noted above, were measured. The samples were obtained in the usual manner by making cuts across the face of the coal from roof to floor, so as to obtain coal from all parts of the bed. The samples were then crushed and quartered down until about a quart of crushed coal remained of each sample. The samples were then packed in air-tight galvanized-iron cans and mailed to the laboratory at the testing plant.

Character of car sample.—Two grades of coal were loaded in the car for testing. In one end of the car was placed coal that had been passed over a 1¼-inch screen and in the opposite end of the car was loaded the material that had passed through the same screen. These grades together were in the proper proportion to constitute run-of-mine coal. This coal is all from the middle bed. The lower bed is not developed sufficiently to furnish much coal. The coal was loaded in an open coal car, which was shipped on October 17 and was received at the testing plant November 1, 1904.

Mining methods.—Mining is done on the room-and-pillar system. The coal is shot off the solid and hauled to the foot of the shaft by mules.

IOWA NO. 2.

Operator.—Mammoth Vein Coal Company, Hamilton, Iowa.

Mine.—Mine No. 5, located in Liberty township, Marion county, Iowa, on the Wabash Railroad.

Coal bed.—There are at least six well-defined coal beds in Marion county. These are nearly all well exposed in the bluffs of the Des Moines river. The coal beds of this county are among the most extensive of central Iowa. The seam worked in No. 5 mine is known locally as the Big Vein. The thickness and character of the bed are shown graphically in plate X, and also by detailed sections A and B. Section A was measured in the fifth west entry on the south side of the mine and section B was measured in the third west entry on the south side of the mine. The sections are as follows:

Sections of coal bed in mine No. 5, Mammoth Vein Coal Company, Marion Co., Ia.

SECTION A.			SECTION B.		
	Ft.	*in.*		*Ft.*	*in.*
Coal	2	11	Coal	1	3
Sulphur and shale	0	1	Sulphur	0	2
Coal	1	3	Coal	3	11
Sulphur and shale	0	6			
Coal	2	6			
Total	7	3	Total	5	4

Samples for chemical analysis.—Two samples were cut in this mine for analysis. Sample A was obtained from the place where section A was measured and sample B from the place where section B was measured. These samples were obtained by making cuts from roof to floor, exclusive of the large partings, which are thrown out by the miner in loading the coal. These samples were carefully crushed and quartered down to about quart size and mailed to the chemical laboratory at the testing plant in air-tight galvanized-iron cans.

Character of car sample.—The car for testing purposes was loaded with run-of-mine coal. Many large sulphur balls are found in this coal, but these were mostly picked out in loading the coal. The coal was loaded in a gondola car, which was shipped from the mine October 23 and received at the testing plant November 23, 1904.

IOWA NO. 3.

Operator.—Gibson Coal Mining Company, Des Moines, Iowa.

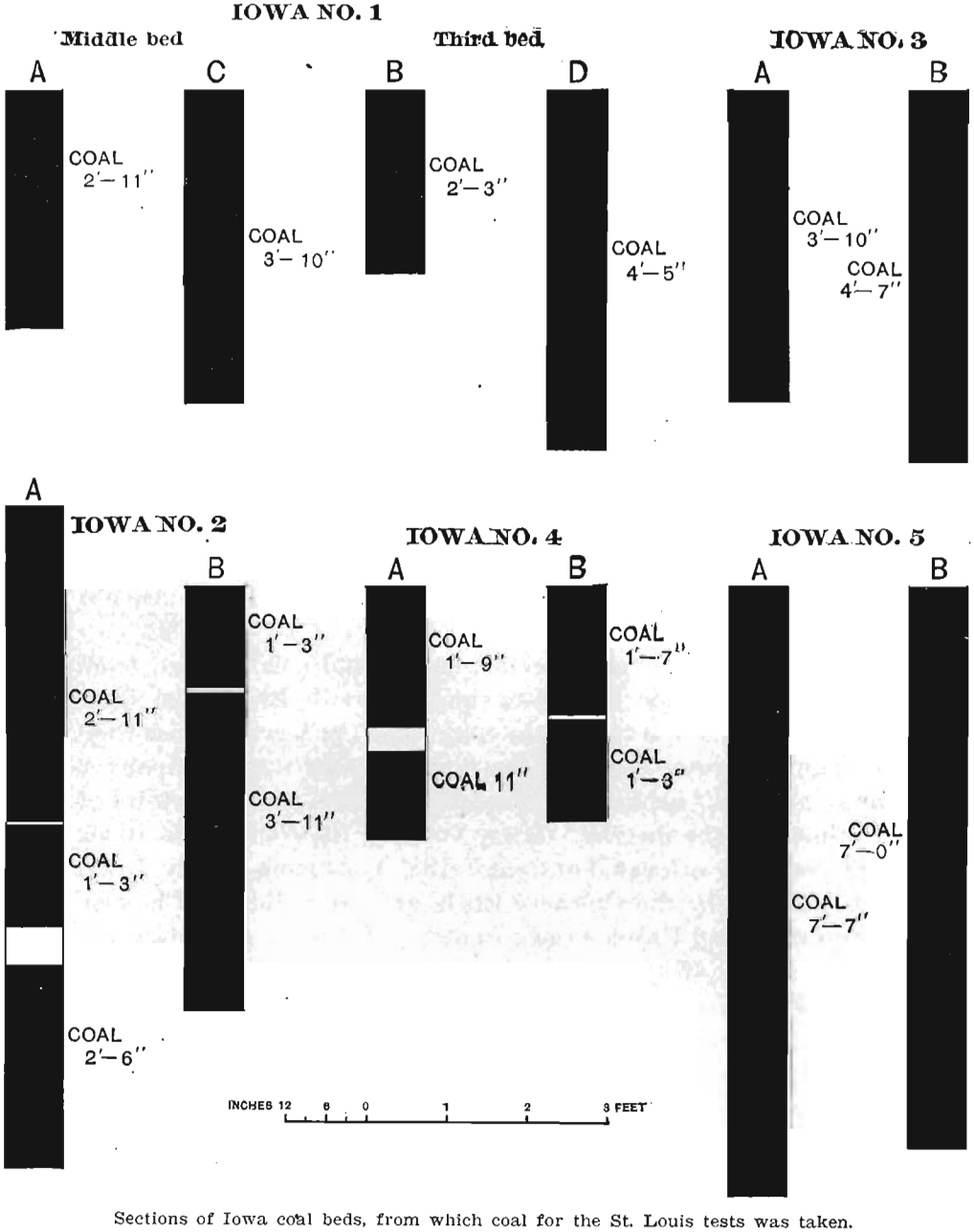
Mine.—Mine No. 4, located near Altoona, Polk county, Iowa, on the Chicago, Rock Island and Pacific Railroad.

Coal bed.—Polk county has long been one of the most important coal-producing counties in the state. In this county three seams of coal are recognized. They are commonly called "first," "second," and "third" seams. These are the workable seams, and they have associated with them other beds that are not of workable thickness. Mine No. 4 is on the third seam. Two sections of this coal are shown graphically in plate X. Section A was measured in the ninth north entry and section B was measured in the main west entry. These sections are as follows:

Sections of coal bed in mine No. 4, Gibson Coal Mining Co., near Altoona, Iowa.

SECTION A.		SECTION B.	
	Ft. in.		*Ft. in.*
Coal	3 10	Coal	4 7

Samples for chemical analysis.—Two samples were cut from working faces of the mine to furnish material for chemical analysis. Sample A was obtained at the place where section A was



Sections of Iowa coal beds, from which coal for the St. Louis tests was taken.

measured and sample B at the place where section B was measured. These samples included all parts of the bed, and were obtained in the usual way, by cutting channels from roof to floor. The original bulk of the samples was reduced by crushing the pieces of coal to a uniform size and quartering down to about one-eighth of the original. These final samples contained about a quart and they were mailed in hermetically sealed galvanized-iron cans to the chemical laboratory.

Character of car sample.—The coal for testing was run into the car over a bar screen with five-eighths inch bars set 1⅜ inches apart. This constitutes lump coal and was selected, as run-of-mine coal is not shipped and the smaller sizes of coal and slack contain an abnormal amount of sulphur. The coal was loaded in an open coal car, which was shipped from the mine October 25 and received at the testing plant November 12, 1904.

IOWA NO. 4.

Operators.—Centerville Block Coal Company, Centerville, Iowa; Scandinavian Coal Company, Centerville, Iowa; Anchor Coal Company, Centerville, Iowa.

Mines.—These operators combined to send a car of coal from their district, and decided upon the Centerville Block Coal Company's mine No. 3 to supply the coal. The Centerville Block Coal Company operates 6 mines, the Scandinavian Coal Company 2 mines, and the Anchor Coal Company 3 mines, making a total of 11 mines for the district. Mine No. 3 of the Centerville Block Coal Company is located at Centerville, Appanoose county, Iowa, and is served by the Chicago, Burlington and Quincy; Chicago, Rock Island and Pacific; Iowa Central; and Chicago, Milwaukee and St. Paul Railways.

Coal bed.—In the Appanoose county district the coal bed which is being mined has a wide geographical extent, covering nearly all of Appanoose county and parts of the adjoining counties of Iowa and Missouri. In the reports of the Iowa Geological Survey this coal bed is called the Mystic coal. At Centerville it is found at a depth of 125 feet, rising gradually to the north and east. At the mine from which the sample was obtained the coal is reached at a depth of 110 feet. Sections of the coal bed are

shown graphically in plate X. Section A was measured in the first room off the sixth east entry, and section B in the first room off the sixth east entry off the main south entry. The sections are as follows:

Sections of coal bed in mine No. 3, Centerville Block Coal Co., Centerville, Iowa.

SECTION A.			SECTION B.		
	Ft.	*in.*		*Ft.*	*in.*
Coal	1	9	Coal	1	7
Fire clay	0	4	Fire clay	0	1
Coal	0	11	Coal	1	3
Total	3	0	Total	2	11

Samples for chemical analysis.—Two samples were obtained in this mine for chemical analysis. Sample A was obtained at the place where section A was measured and sample B at the place where section B was measured. The samples were obtained by making a cut from roof to floor, including everything except the fire-clay parting. These samples were crushed and quartered down to about one-eighth their original bulk and mailed to the chemical laboratory at the testing plant in sealed metal cylinders.

Character of car sample.—The coal shipped for testing consisted of about 35 tons of lump and about 4 tons of fine coal. The lump coal was that which passed over a bar screen with 1⅜-inch spaces, and the fine coal was that which passed through this screen. The slack, which was not included in the carload, was screened off through a five-eighths inch screen. The coal was loaded in a gondola car and shipped from the mine October 28 and was received at the testing plant November 14, 1904.

IOWA NO. 5.

Operator.—Inland Fuel Company, Chariton, Lucas county, Iowa.

Mine.—Inland No. 1, located in secs. 4, 5, 8, and 9, T. 72 N., R. 21 W., fifth principal meridian. At present the mine has no railroad connection.

Coal bed.—Two general coal horizons have been recognized in Lucas county, one near the surface and the other about 250 feet

below. The Inland Fuel Company is working on a coal bed at the lower horizon, and reaches the coal by a shaft 250 feet deep.

The thickness of the coal bed, as determined by four measured sections, is 7 feet 4 inches, 7 feet 9 inches, 7 feet 7 inches, and 7 feet. Two of these sections are shown in plate X. The bed is irregular, being disturbed to some extent by horsebacks. The thick coal lies in local basins or swamps, and therefore does not extend for a great distance. The roof consists of black shale and the floor of about 3 inches of shale overlying sandy fire clay.

Samples for chemical analysis.—Two samples were taken in this mine for chemical analysis. Sample A was obtained in room 33, off the second north entry, and sample B was obtained in room 8, off the first east entry on the south side. They were obtained by making cuts across clean faces of the coal bed, from roof to floor. The coal so obtained was pulverized and quartered down until two quart samples were obtained, which were placed in galvanized-iron cans, sealed air-tight, and mailed to the chemical laboratory for analysis.

Character of car sample.—The carload sample for testing purposes consisted of run-of-mine coal. As the mine has recently been opened it has no railroad connection, and the coal had to be hauled 6 miles in wagons. The rehandling probably produced considerable slack, but since all coal was crushed at the plant before tests were made, this probably had little effect. The coal was loaded in a gondola car which was shipped from the mine October 31 and was received at the testing plant November 10, 1904.

CHEMICAL ANALYSES OF IOWA COALS

Mr. Savage, in the report already referred to, summed up the results of analyses and heat unit tests as follows:

A careful comparison of the above tables shows that the average per cent of sulphur contained in the Iowa coal samples is 4.67, and the same figures represent the per cent of sulphur in the coals of Missouri. The average amount of ash present in the Missouri samples is a little less than that in the Iowa coal samples. The six samples of Illinois coal contained on the average a slightly smaller per cent of sulphur than the coal of Missouri and a somewhat larger percentage of ash. It would seem

that for domestic purposes the coal of these three states should rank about equal in value.

It will be noticed, also, that the calorific value of the Iowa coals compares very favorably with the coals of Missouri and Illinois, yielding on the average 6,144 calories and 11,066 British thermal units.

Results of steam tests show equivalent evaporation from and at 212 degrees as ranging from 7.02 to 7.50 pounds per pound of dry coal.

No thorough experiments were made on washing Iowa coals, but small lots of each sample were washed preparatory to making a test of their coking qualities. In all cases the results showed a notable reduction of ash and of sulphur, and it seemed probable that washing could be done to advantage in many parts of the Iowa field.

Coking tests were made on all samples of Iowa coals, but with indifferent success. In some cases no coke was produced; in others coke of fair quality was made. In all cases the coke was high in sulphur, which, of course, would preclude its use in an iron furnace, but it might be used in other ways.

No gas-producer tests were made during the regular work on Iowa coal, but later a run was made on the coal from Marion county. The test was not entirely satisfactory, as the quality of the gas varied greatly from time to time, but no clinkers formed in the producer, and it is probable that better results could be obtained on a second trial of this coal. Its high percentage of sulphur was a detriment, but it is probable that this can be eliminated with more careful work.

The figures on page 466 show that to produce 1 electrical horsepower hour with this coal in the producer required 1.73 pounds of dry coal, whereas under the steam boiler it required 4.95 pounds to produce the same result, a gain in efficiency for the producer of 186 per cent. As this coal ran nearly 17 per cent of ash in the car sample, the great advantage of using it in the producer plant will be apparent, and these results seem to open the way to the much better utilization of Iowa coals.

CHEMICAL ANALYSES OF IOWA NO. 1 COAL.

(Lump and fine coal from mine No. 2. Received from Anchor Coal Company, Laddsdale, Iowa.)

	Mine sample No. 1	Mine sample No. 2	Car sample	Sample from boiler test*	Sample of coal from coke test, washed coal	Coke sample, washed coal†
Laboratory sample number.....	1270	1271	1347	1357	1356	1371
Loss of moisture on air drying—per cent	7.90	8.00	3.20	2.30	4.30	8.60
Analysis of air-dried sample:						
Proximate—						
Moisture .....per cent..	3.74	4.43	5.21	6.54	8.92	2.11
Volatile matter.....do....	41.96	40.52	31.76	33.86	37.53	1.79
Fixed carbon.....do....	42.89	41.65	46.51	40.83	42.84	77.01
Ash .....do....	11.41	13.40	16.52	18.77	10.71	19.09
	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate—						
Hydrogen .....do....	-------	-------	4.61	-------	-------	-------
Carbon .....do....	-------	-------	61.80	-------	-------	-------
Nitrogen .....do....	-------	-------	.97	-------	-------	-------
Oxygen .....do....	-------	-------	10.90	-------	-------	-------
Sulphur .....do....	5.12	5.42	5.20	6.54	4.82	4.25
Ash .....do....	-------	-------	16.52	-------	-------	-------
			100.00			
Calorific value determined, calories	6,843	-------	6,329	-------	-------	-------
Calorific value determined, B. T. U.	12,317	-------	11,392	-------	-------	-------
Calorific value calculated from ultimate analysis—calories.....	-------	-------	6,230	-------	-------	-------
Calorific value calculated from ultimate analysis—B. T. U.....	-------	-------	11,214	-------	-------	-------
Phosphorus in coke.....	-------	-------	-------	-------	-------	.051
Analysis corrected to sample as received:						
Proximate—						
Moisture .....per cent..	11.35	12.07	8.24	8.69	12.84	10.53
Volatile matter.....do....	38.65	37.28	30.74	33.08	35.91	1.63
Fixed carbon.....do....	39.49	38.32	45.02	39.89	41.00	70.39
Ash .....do....	10.51	12.33	16.00	18.34	10.25	17.45
	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate—						
Hydrogen .....do....	-------	-------	4.81	-------	-------	-------
Carbon .....do....	-------	-------	59.82	-------	-------	-------
Nitrogen .....do....	-------	-------	.94	-------	-------	-------
Oxygen .....do....	-------	-------	13.40	-------	-------	-------
Sulphur .....do....	4.72	4.99	5.03	6.39	4.61	3.89
Ash .....do....	-------	-------	16.00	-------	-------	-------
			100.00			
Calorific value determined, calories	6,303	-------	6,126	‡ 5,805	-------	-------
Calorific value determined, B. T. U.	11,345	-------	11,027	‡10,449	-------	-------

*Refuse from boiler test, laboratory No. 1358: Combustible, 13.12 per cent; ash, 86.88 per cent.

†Specific gravity of the coke substance, 1.87; apparent specific gravity of the coke, 0.93; percentage of porosity, 51 per cent.

‡Derived from the determinations on the carload sample.

CHEMICAL ANALYSES OF IOWA NO. 2 COAL.

(Run-of-mine coal from mine No. 5. Received from Mammoth Vein Coal Company, Hamilton, Iowa.)

	Mine sample No. 1	Mine sample No. 2	Car sample*	Car sample (second portion)†	Sample from boiler test‡	Sample from gas-producer test	Sample of coal from coke test w'sh'd coal
Laboratory sample number	1289	1291	1570	1608	1490	1611	1483
Loss of moisture on air drying, per cent	9.30	9.50	10.40	15.50	10.40	14.90	10.10
Analysis of air-dried sample:							
Proximate—							
Moisture .....per cent..	7.00	6.63	4.25	1.76	5.00	2.10	9.73
Volatile matter.....do....	40.65	40.82	37.02	39.09	39.45	36.92	39.42
Fixed carbon .....do....	39.52	42.40	41.74	42.04	37.65	36.66	39.41
Ash .....do....	12.83	10.15	16.99	17.11	17.90	24.32	11.44
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate—							
Hydrogen .....do....	------	------	4.84	------	------	------	------
Carbon .....do....	------	------	60.36	------	------	------	------
Nitrogen .....do....	------	------	1.46	------	------	------	------
Oxygen .....do....	------	------	11.15	------	------	------	------
Sulphur .....do....	5.49	5.74	5.20	6.09	5.28	6.40	4.37
Ash .....do....	------	------	16.99	------	------	------	------
Calorific value determined, calories	6,302	------	6,212	------	------	------	------
Calorific value determined, B. T. U.	11,344	------	11,182	------	------	------	------
Calorific value calculated from ultimate analysis—calories.....	------	------	6,183	------	------	------	------
Calorific value calculated from ultimate analysis—B. T. U.....	------	------	11,129	------	------	------	------
Analysis corrected to sample as received:							
Proximate—							
Moisture .....per cent..	15.65	15.50	14.21	16.99	14.88	16.69	18.85
Volatile matter.....do....	36.87	36.94	33.17	33.03	35.35	31.42	35.44
Fixed carbon.....do....	35.84	38.37	37.40	35.52	33.73	31.19	35.43
Ash .....do....	11.64	9.19	15.22	14.46	16.04	20.70	10.28
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate—							
Hydrogen .....do....	------	------	5.50	------	------	------	------
Carbon .....do....	------	------	54.08	------	------	------	------
Nitrogen .....do....	------	------	1.31	------	------	------	------
Oxygen .....do....	------	------	19.23	------	------	------	------
Sulphur .....do....	5.10	5.19	4.66	5.15	4.73	5.50	3.93
Ash .....do....	------	------	15.22	------	------	------	------
			100.00				
Calorific value determined, calories	5,716	------	5,566	------	§5,436	------	------
Calorific value determined, B. T. U.	10,289	------	10,019	------	§9,785	------	------

*Represents 10 tons of coal.
†Represents 6 tons of coal.
‡Refuse from boiler test, laboratory No. 1491: Combustible, 18.07 per cent; ash, 81.93 per cent.
§Derived from the determinations on the carload sample.

CHEMICAL ANALYSES OF IOWA NO. 3 COAL.

(Lump coal from mine No. 4. Received from Gibson Coal Mining Co., Altoona, Ia.)

	Mine sample No. 1	Mine sample No. 2	Car sample*	Sample from boiler test†	Sample of coal from coke test, washed coal	Coke sample washed coal‡
Laboratory sample number	1312	1313	1434	1392	1389	1399
Loss of moisture on air drying—per cent	9.60	11.00	9.80	1.50	6.90	4.00
Analysis of air-dried sample:						
Proximate—						
Moisture .....Per cent..	5.33	5.51	4.52	11.11	10.67	1.80
Volatile matter.....do....	41.82	42.04	40.96	36.69	42.18	1.95
Fixed carbon.....do....	40.69	38.55	38.99	36.31	38.53	78.64
Ash .....do....	12.16	13.90	15.53	15.89	8.62	17.61
	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate—						
Hydrogen .....do....	-------	-------	4.93	-------	-------	-------
Carbon .....do....	-------	-------	60.62	-------	-------	-------
Nitrogen .....do....	-------	-------	.93	-------	-------	-------
Oxygen .....do....	-------	-------	11.16	-------	-------	-------
Sulphur .....do....	6.52	7.59	6.83	6.16	4.88	4.76
Ash .....do....	-------	-------	15.53	-------	-------	-------
			100.00			
Calorific value determined, calories	6,539	-------	6,309	-------	-------	-------
Calorific value determined, B. T. U.	11,770	-------	11,356	-------	-------	-------
Calorific value calculated from ultimate analysis—calories	-------	-------	6,271	-------	-------	-------
Calorific value calculated from ultimate analysis—B. T. U	-------	-------	11,288	-------	-------	-------
Phosphorus in coke	-------	-------	-------	-------	-------	.018
Analysis corrected to sample as received:						
Proximate—						
Moisture .....per cent..	14.42	15.90	13.88	12.44	16.83	5.73
Volatile matter.....do....	37.81	37.42	36.94	36.14	39.27	1.87
Fixed carbon.....do....	36.78	34.31	35.17	35.77	35.87	75.49
Ash .....do....	10.99	12.37	14.01	15.65	8.03	16.91
	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate—						
Hydrogen .....do....	-------	-------	5.52	-------	-------	-------
Carbon .....do....	-------	-------	54.68	-------	-------	-------
Nitrogen .....do....	-------	-------	.84	-------	-------	-------
Oxygen .....do....	-------	-------	18.80	-------	-------	-------
Sulphur .....do....	5.89	6.76	6.15	6.07	4.55	4.57
Ash .....do....	-------	-------	14.01	-------	-------	-------
			100.00			
Calorific value determined, calories	5,911	-------	5,691	§ 5,679	-------	-------
Calorific value determined, B. T. U.	10,640	-------	10,244	§10,222	-------	-------

*Represents 12 tons of coal.

†Refuse from boiler test, laboratory No. 1393: Combustible, 27.11 per cent; ash, 72.89 per cent.

‡Specific gravity of the coke substance, 1.88; apparent specific gravity of the coke, 0.81; percentage of porosity, 57.

§Derived from the determinations on the carload sample.

CHEMICAL ANALYSES OF IOWA NO. 4 COAL.

(Lump coal from mine No. 3. Received from Centerville Block Coal Company, Centerville, Iowa.)

	Mine sample No. 1	Mine sample No. 2	Car sample*	Sample from boiler test†	S'mple of coal from coke test w'sh'd coal	Coke sample w'sh'd coal‡	Sample of briquett's from boiler test§
Laboratory sample number	1323	1324	1437	1380	1378	1400	1488
Loss of moisture on air-drying—per cent	9.40	8.60	4.50	2.00	3.60	11.00	3.90
Analysis of air-dried sample:							
Proximate—							
Moisture .....per cent..	8.53	8.25	10.03	11.71	14.81	2.30	9.72
Volatile matter.....do....	39.12	38.23	37.27	34.79	38.99	2.60	37.98
Fixed carbon.....do....	44.55	41.40	41.22	38.04	38.79	82.14	39.38
Ash .....do....	7.80	12.12	11.48	15.46	7.41	12.96	12.92
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate—							
Hydrogen .....do....	------	------	5.31	------	------	------	5.42
Carbon .....do....	------	------	61.25	------	------	------	62.52
Nitrogen .....do....	------	------	.94	------	------	------	.78
Oxygen .....do....	------	------	16.56	------	------	------	14.31
Sulphur .....do....	4.42	5.21	4.46	5.14	3.70	3.33	4.05
Ash .....do....	------	------	11.48	------	------	------	12.92
			100.00				100.00
Calorific value determined—calories	6,703	------	6,237	------	------	------	6,292
Calorific value determined—B. T. U.	12,065	------	11,227	------	------	------	11,326
Calorific value calculated from ultimate analysis—calories	------	------	6,165	------	------	------	6,394
Calorific value calculated from ultimate analysis—B. T. U.	------	------	11,097	------	------	------	11,509
Phosphorus in coke	------	------	------	------	------	.013	------
Analysis corrected to sample as received:							
Proximate—							
Moisture .....per cent..	17.13	16.14	14.08	13.48	17.88	13.05	13.24
Volatile matter.....do....	35.44	34.94	35.59	34.09	37.59	2.32	36.50
Fixed carbon.....do....	40.36	37.84	39.37	37.28	37.39	73.10	37.85
Ash .....do....	7.07	11.08	10.96	15.15	7.14	11.53	12.41
	100.00	100.00	100.00	100.00	100.06	100.00	100.00
Ultimate—							
Hydrogen .....do....	------	------	5.57	------	------	------	5.64
Carbon .....do....	------	------	58.49	------	------	------	60.08
Nitrogen .....do....	------	------	.90	------	------	------	.75
Oxygen .....do....	------	------	19.82	------	------	------	17.22
Sulphur .....do....	4.00	4.76	4.26	5.04	3.57	2.97	3.90
Ash .....do....	------	------	10.96	------	------	------	12.41
			100.00				100.00
Calorific value determined—calories	6,073	------	5,957	** 5,613	------	------	6,047
Calorific value determined—B. T. U.	10,931	------	10,723	**10,103	------	------	10,885

*Represents 31 tons of coal.

†Refuse from the boiler test, laboratory No. 1381: Combustible, 19.25 per cent; ash, 80.75 per cent.

‡Specific gravity of the coke substance, 1.82; apparent specific gravity of the coke, 0.81; percentage of porosity, 55.

§Refuse from the boiler test of the briquettes, laboratory No. 1486: Combustible, 23.82 per cent; ash, 76.18 per cent.

**Derived from the determinations on the carload sample.

CHEMICAL ANALYSES OF IOWA NO. 5 COAL.
(Run-of-mine coal from mine No. 1. Received from Inland Fuel Company, Chariton, Iowa.)

	Mine sample No. 1	Mine sample No. 2	Car Sample*	Sample from boiler test†	Sample of coal from coke test washed coal
Laboratory sample number	1332	1333	1433	1423	1419
Loss of moisture on air drying—per cent	9.40	7.10	6.80	3.80	6.70
Analysis of air-dried sample:					
Proximate—					
Moisture.....per cent..	10.25	12.37	9.22	12.69	13.45
Volatile matter.....do....	35.10	36.98	32.71	33.01	33.30
Fixed carbon.....do....	46.12	42.95	44.52	40.37	44.75
Ash .....do....	8.53	7.70	13.55	13.93	8.50
	100.00	100.00	100.00	100.00	100.00
Ultimate—					
Hydrogen .....do....			5.35		
Carbon .....do....			59.89		
Nitrogen .....do....			1.22		
Oxygen .....do....			16.57		
Sulphur .....do....	2.64	3.34	3.42	3.21	2.44
Ash .....do....			13.55		
			100.00		
Calorific value determined—calories.	6,442		6,105		
Calorific value determined—B. T. U..	11,596		10,989		
Calorific value calculated from ultimate analysis—calories			6,045		
Calorific value calculated from ultimate analysis—B. T. U			10,881		
Analysis corrected to sample as received:					
Proximate—					
Moisture .....per cent..	18.69	18.59	15.39	16.01	19.25
Volatile matter .....do....	31.80	34.36	30.49	31.76	31.07
Fixed carbon .....do....	41.78	39.90	41.49	38.83	41.75
Ash .....do....	7.73	7.15	12.63	13.40	7.93
	100.00	100.00	100.00	100.00	100.00
Ultimate—					
Hydrogen .....do....			5.74		
Carbon .....do....			55.81		
Nitrogen .....do....			1.14		
Oxygen .....do....			21.49		
Sulphur .....do....	2.39	3.10	3.19	3.09	2.28
Ash .....do....			12.63		
			100.00		
Calorific value determined—calories.	5,836		5,690‡	5,583	
Calorific value determined—B. T. U..	10,505		10,242‡	10,049	

*Represents 7 tons of coal.
†Refuse from the boiler test, laboratory No. 1422: Combustible, 15.28 per cent; ash, 84.72 per cent.
‡Derived from the determinations on the carload sample.

BOILER TESTS ON IOWA COALS

Regular and special observations on test of Iowa No. 1 coal, November 3, 1904.

REGULAR.

(Duration of trial, 10.017 hours.)

Time	Steam pressure gage	Temperatures			Calorimeter		Draft pres'res		Flue gases		
		Outside	Boiler room	Flue gases, base of stack	Steam discharge	Water separated in 10 minutes	In hood, in inches of water	In furnace, in inches of water	CO_2.	O_2.	CO.
	Lbs.	*°F.*	*°F.*	*°F.*	*Lbs.*	*Lbs.*			*Per ct*	*Per ct.*	*Per ct.*
7.43	81			525			0.45	0.09			
8	90	45	52	475	4.48	0.029	.22	.07			
8.20	100	49	54	517			.33	.09			
8.40	90	50	56	517			.34	.09	9.4	9.5	0.0
9	100	52	58	483	4.78	.027	.29	.11			
9.20	92	55	60	500			.31	.11			
9.40	96	58	63	514			.29	.09	9.8	8.2	.3
10	97	59	66	506	4.60	.027	.36	.15			
10.20	89	60	66	514			.36	.13			
10.40	83	60	67	507			.39	.15	9.8	9.2	.4
11	81	60	67	507	3.69	.02	.52	.27			
11.20	62	62	68	480							
11.40	82	62	69	532			.53	.18	7.4	12.5	.0
12	78	62	71	556	4.12	.035	.53	.17			
12.20	84	63	70	524			.36	.10			
12.40	83	64	70	557			.51	.17	8.9	9.8	.2
1	79	64	71	553	4.00	.029	.52	.20			
1.20	85	64	70	562			.54	.22			
1.40	71	65	71	562			.52	.14	8.7	10.8	.0
2	86	65	72	580	3.86	.026	.61	.20			
2.20	64	65	73	552			.68	.12			
2.40	77	65	73	600			.70	.18	8.0	11.6	.0
3	90	66	74	528	4.16	.02	.18	.06			
3.20	83	65	73	537			.44	.17			
3.40	82	65	72	539			.44	.19	9.1	10.1	.3
4	80	65	72	573	3.95	.022	.54	.19			
4.20	80	63	71	557			.56	.25			
4.40	90	62	70	577			.61	.22	8.8	10.8	.0
5	79	61	69	575	4.16	.039	.66	.23			
5.20	79	60	68	502							
5.44	83			537			.66	.10	6.8	13.8	.0
Total	2,596	1,756	1,956	16,548	41.80	.274	13.45	4.44	86.7	106.3	1.2
Av.	83.7	60.5	67.4	534	4.18	.0274	.464	.153	8.67	10.63	.12

Regular and special observations on test of Iowa No. 1 coal, November 3, 1904. (Continued.)

SPECIAL.

Time	Height of water		Weight of coal burned		Weight of water fed to boiler	
	In tank	In gage glass	During period	Total	During period	Total
	Inches	*Inches*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Start, 7.43	40.00	2.50				
8.08	31.50	4.75	700	700	1,632	1,632
8.42	26.00	5.00	700	1,400	3,409	5,041
9.14	27.25	4.75	700	2,100	3,182	8,223
9.56	36.50	4.50	700	2,800	3,978	12,201
10.43	24.75	5.50	700	3,500	4,154	16,355
11.38	31.50	3.00	700	4,200	4,898	21,253
12.07	26.50	5.00	700	4,900	2,779	24,032
12.50	35.25	2.50	700	5,600	4,779	28,811
1.29	29.75	2.75	700	6,300	4,042	32,853
2.20	30.50	3.25	700	7,000	4,857	37,710
2.46	33.75	3.75	700	7,700	2,172	39,882
3.16	32.00	3.50	700	8,400	3,359	43,241
4	24.50	4.00	700	9,100	4,710	47,951
4.42	27.50	4.50	700	9,800	4,089	52,040
Close, 5.44	40.00	3.00	531	10,331	5,333	57,373

RECORD OF FURNACE CONDITIONS.

Time	Observation	Time	Observation
	Boiler under a load during night.	1.06	Fire raked, 8 inches thick.
		1.40	Fire sliced, 10 inches thick.
7	Cleaned fire.	2	Fire raked, 10 inches thick.
7.43	Test started, fire 2 inches thick.	2.03	Cleaning fire.
		2.18	Fire cleaned, 4 inches thick.
9.01	Fire raked, 7 inches thick.	2.44	Fire raked, 6 inches thick.
9.33	Fire sliced, 9 inches thick.	3.10	Fire raked, 8 inches thick.
9.49	Fire raked, 10 inches thick.	3.35	Do.
10.14	Do.	3.57	Do.
10.53	Do.	4.30	Fire sliced, 9 inches thick.
11.10	Cleaning fire.	5.05	Fire raked.
11.23	Fire cleaned, 3 inches thick.	5.08	Cleaning fire.
11.49	Fire raked, 6 inches thick.	5.20	Fire cleaned, 3 inches thick.
12.27	Fire raked, 8 inches thick.	5.44	Test closed, fire 2 inches thick.
12.47	Fire raked, 7 inches thick.		

Refuse dark and heavy. Coal burned freely with long flame. 99 firings during test.

Steam Test of Iowa No. 1 Coal

CONDITIONS OF BOILER TRIAL.

Made by boiler division, United States Geological Survey.
At fuel-testing plant, Louisiana Purchase Exposition, St. Louis, Mo.
Kind of boiler, Heine safety.
To determine the economy of coal as a fuel.
Steam jets not operated. Hughes apparatus operated.
Kind of fuel, Iowa No. 1.
Kind of furnace, hand fired.
State of the weather, cloudy.
Method of starting and stopping the test, alternate.
Number of boiler (plant number), 2.
Type of boiler, water tube.

1.	Date of trial, November 3, 1904.		
2.	Duration of trial	hours..	10.017

DIMENSIONS AND PROPORTIONS.

3.	Grate surface	square feet..	40.55
3.1	Width of grate	feet..	6.16
3.2	Length of grate	do..	6.58
4.	Height of furnace	inches..	26.
5.	Approximate width of air spaces in grate	do...	.5
6.	Proportion of air space to whole grate surface	per cent..	44
6.1	Area of chimney	square feet..	7.67
6.2	Height of chimney above grate	feet..	113.25
6.3	Length of flue connecting to chimney	do..	None
6.4	Kind of draft		Natural
7.	Water-heating surface	square feet..	2,031
7.1	Outside diameter of shell	inches..	42.94
7.2	Length of shell (outside to outside of heads)	feet..	21.58
7.3	Number of tubes		116
7.4	Diameter of tubes (outside—inside)	inches..	3.5
		..do....	3.26
7.5	Length of tubes exposed	feet..	17.87
8.	Superheating surface	Square feet..	None
9.	Ratio of water-heating surface to grate surface		50.1:1
10.	Ratio of minimum draft area to grate surface		1:9.1

AVERAGE PRESSURES.

11.	Barometer	inches of mercury..	29.61
		pounds..	14.53
11.1	Steam pressure by gage per square inch	..do....	83.70
		..do....	*98.23
12.	Force of draft between damper and boiler	inches of water..	.46
13.	Force of draft in furnace	..do....	.15
14.	Force of draft or blast in ash pit	do....	0

*Absolute.

AVERAGE TEMPERATURES.

15.	Of external air	degrees..	60.5
16.	Of fireroom	do....	67.4
17.	Of steam	do....	326.3
18.	Of feed water in tank	do....	57.4
19.	Of feed water entering economizer	do....	.....
20.	Of feed water entering boiler	do....	195
21.	Of escaping gases from boiler	do....	534
22.	Of escaping gases from economizer	do....	.....
22.1	Of furnace	do....	.....

FUEL.

23.	Size and condition: Nut—small, 80 per cent; slack, 20 per cent; dull.		
24.	Weight of wood used in lighting fire	pounds..	None
25.	Weight of coal as fired	do....	10,331
26.	Percentage of moisture in coal		8.69
27.	Total weight of dry coal consumed	pounds..	9,433
28.	Total ash and refuse	do....	1,875
29.	Quality of ash and refuse: Clinker	per cent..	63
30.	Total combustible consumed	pounds..	7,558
		do....	*7,292
31.	Percentage of ash and refuse in dry coal		19.88

PROXIMATE ANALYSIS OF COAL.

		Per cent of coal	Per cent of combustible
32.	Fixed carbon	39.89	54.66
33.	Volatile matter	33.08	45.34
34.	Moisture	8.69	.....
35.	Ash	18.34	.....
		100.00	100.00
36.	Sulphur, separately determined	6.39	.....

ULTIMATE ANALYSIS OF DRY COAL.

37.	Carbon (C)	61.67	77.17
38.	Hydrogen (H)	4.01	5.02
39.	Oxygen (O)	6.26	7.83
40.	Nitrogen (N)	.97	1.21
41.	Sulphur (S)	7.00	8.77
42.	Ash	20.09	.....
		100.00	100.00
43.	Moisture in sample of coal as received	8.69	.....

ANALYSIS OF ASH AND REFUSE.

44.	Carbon	per cent..	13.12
45.	Earthy matter	do....	86.88

*Calculated from chemistry of ash.

FUEL PER HOUR.

46.	Dry coal consumed per hour	pounds..	942
47.	Combustible consumed per hour	..do....	755
		..do....	*728
48.	Dry coal per square foot of grate surface per hour	do....	23.23
49.	Combustible per square foot of water-heating surface per hour	..do....	.372
		..do..!.	*.358

CALORIFIC VALUE OF FUEL.

50.	Calorific value by oxygen calorimeter per pound of dry coal, B. T. U.		11,443
51.	Calorific value by oxygen calorimeter per pound of combustible, B. T. U.		14,320
52.	Calorific value by analysis, per pound of dry coal, B. T. U.		11,257
53.	Calorific value by analysis, per pound of combustible, B. T. U.		14,087

QUALITY OF STEAM.

54.	Percentage of moisture in steam		.651
55.	Number of degrees of superheating		.....
56.	Quality of steam (dry steam=unity)	per cent..	99.5

WATER.

57.	Total weight of water fed to boiler	pounds..	57,373
58.	Equivalent water fed to boiler from and at 212°	do....	68,675
59.	Water actually evaporated, corrected for quality of steam	do....	57,086
60.	Factor of evaporation		1.197
61.	Equivalent water evaporated into dry steam from and at 212°	pounds..	68,332

WATER PER HOUR.

62.	Water evaporated per hour, corrected for quality of steam	pounds..	5,690
63.	Equivalent evaporation per hour from and at 212°	do....	6,822
64.	Equivalent evaporation per hour from and at 212° per square foot of water-heating surface	pounds..	3.36

HORSEPOWER.

65.	Horsepower developed (34½ pounds of water evaporated per hour into dry steam from and at 212°=1 horsepower)		197.7
66.	Builders' rated horsepower		210
67.	Percentage of builders' rated horsepower developed		94.16

ECONOMIC RESULTS.

68.	Water apparently evaporated under actual conditions per pound of coal as fired. (Item 57÷item 25)	pounds..	5.55
69.	Equivalent evaporation from and at 212° per pound of coal as fired. (Item 61÷item 25)	pounds..	6.61
70.	Equivalent evaporation from and at 212° per pound of dry coal. (Item 61÷item 27)	pounds..	7.24

*Calculated from chemistry of ash.

71.	Equivalent evaporation from and at 212° per pound of combustible (Item 61÷item 30)	do....	9.04
		do....	*9.37

EFFICIENCY.

72.	Efficiency of the boiler (heat absorbed by the boiler per pound of combustible divided by the heat value of 1 pound of combustible	per cent..	60.96
		do....	*63.19
73.	Efficiency of boiler, including the grate (heat absorbed by the boiler per pound of dry coal divided by the heat value of 1 pound of dry coal)	per cent..	61.10

COST OF EVAPORATION.

74.	Cost of coal per ton of 2,000 pounds delivered in boiler room (assumed)		$1.00
75.	Cost of fuel for evaporating 1,000 pounds of water under observed conditions		$0.09
76.	Cost of fuel used for evaporating 1,000 pounds of water from and at 212°		$0.0756

SMOKE OBSERVATIONS.

77.	Percentage of smoke as observed		50.4
78.	Weight of soot per hour obtained from smoke meter	ounces..	.....
79.	Volume of soot per hour obtained from smoke meter	cubic inches..	.....

METHOD OF FIRING.

80.	Kind of firing (spreading, alternate or coking)		Alternate
81.	Average thickness of fire	inches..	8
82.	Average intervals between firing for each furnace during time when fires are in normal condition	minutes..	6
83.	Average intervals between times of leveling or breaking up	minutes..	30

ANALYSIS OF THE DRY GASES.

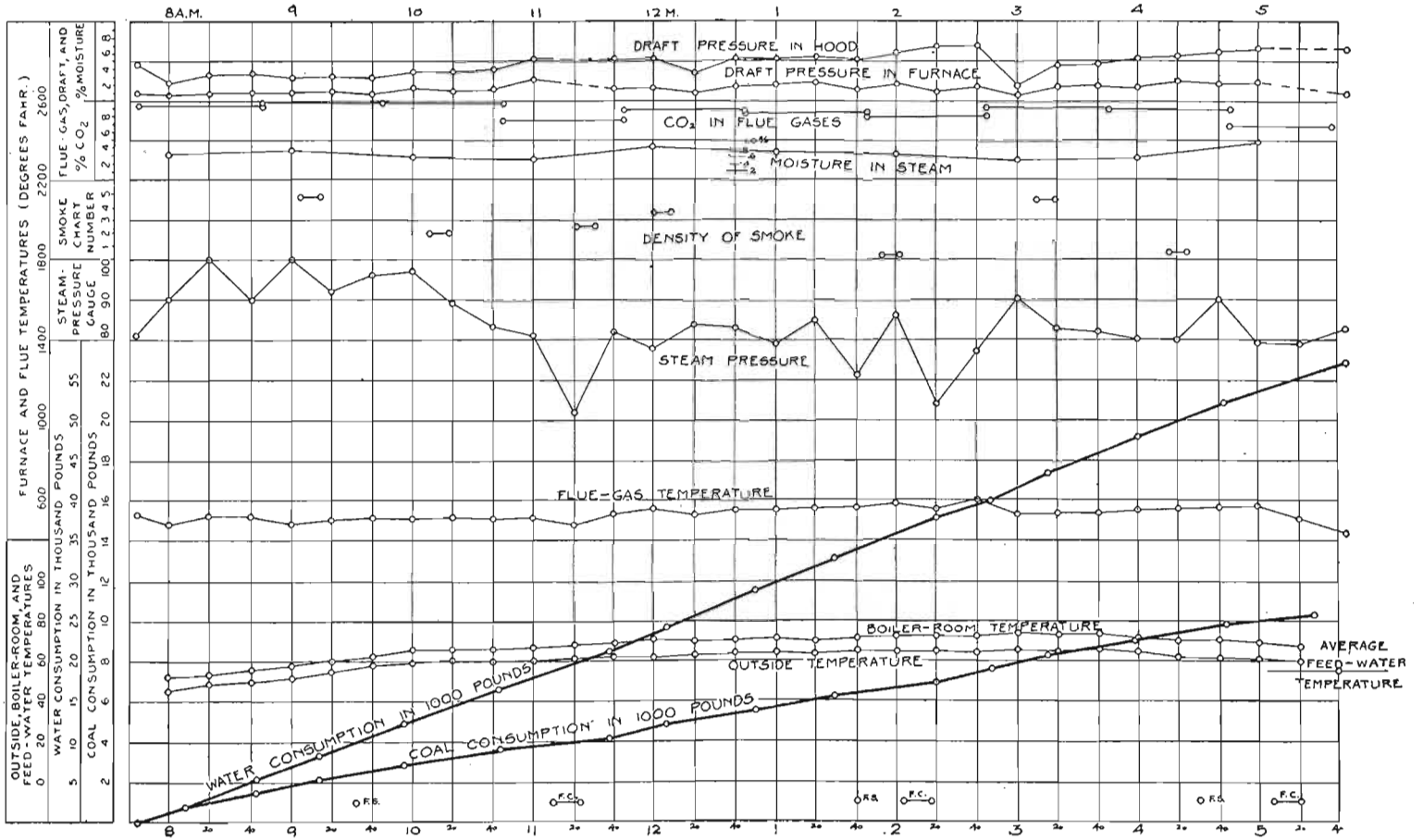
84.	Carbon dioxide (CO_2)	per cent..	8.67
85.	Oxygen (O)	do....	10.63
86.	Carbon monoxide (CO)	do....	.12
87.	Hydrogen and hydrocarbons	do....	.....
88.	Nitrogen (by difference) (N)	do....	80.58

HEAT BALANCE, OR DISTRIBUTION OF THE HEATING VALUE OF THE COMBUSTIBLE.

Total heat value of 1 pound of combustible, B. T. U. 14,320

		B. T. U.	Per cent.
1.	Heat absorbed by the boiler=evaporation from and at 212° per pound of combustible×965.7	9,049	*63.19
2.	Loss due to moisture in coal=per cent of moisture referred to combustible÷100×[(212−t)+966+0.48 (T−212)] (t=temperature of air in the boiler room; T=that of the flue gases)	151	1.05

*Calculated from chemistry of ash.



Graphic log sheet, Iowa No. 1 coal (nut, dull).

3. Loss due to moisture formed by the burning of hydrogen= per cent of hydrogen to combustible÷100×9×[(212−t)+ 966+0.48 (T−212)]	572	3.99
4. Loss due to heat carried away in the dry chimney gases= weight of gas per pound of combustible×0.24×(T−t)	2,442	17.05
5. Loss due to incomplete combustion of carbon= $\frac{CO}{CO_2+CO}\times\frac{\text{per cent C in combustible}}{100}\times 10{,}150$	107	.75
6. Loss due to unconsumed hydrogen and hydrocarbons, to heating the moisture in the air, to radiation, and unaccounted for. (Some of these losses may be separately itemized if data are obtained from which they may be calculated)	1,999	13.97
		100.00

REMARKS.

Dry coal per indicated horsepower hour = 3.91 pounds.
Dry coal per electrical horsepower hour = 4.82 pounds.

*Calculated from chemistry of ash.

Regular and special observation on test of Iowa No. 2 coal, November 28, 1904.

REGULAR.

(Duration of trial, 9.917 hours.)

Time	Steam pressure gage	Temperatures			Calorimeter		Draft pres'res		Flue gases		
		Outside	Boiler room	Flue gases, base of stack	Steam discharge	Water separated in 10 minutes	In hood, in inches of water	In furnace, in inches of water	CO_2.	O_2.	CO.
	Lbs.	*°F.*	*°F.*	*°F.*	*Lbs.*	*Lbs.*			*Per ct.*	*Per ct.*	*Per ct.*
7.29	85			615			0.58	0.14			
7.40	97	30	50	625			.59	.13			
8	92	32	50	650	4.51	0.033	.62	.16			
8.20	91	34	51	640			.61	.18	7.2	12.2	0.0
8.40	89	35	51	610			.57	.18			
9	81	36	52	615	4.07	.04	.61	.26			
9.20	84	38	53	635			.53	.16	8.9	10.6	.0
9.40	81	39	54	605			.59	.19			
10	80	40	56	605	3.98	.037	.61	.20			
10.20	78	41	57	615			.59	.22	8.0	11.7	.0
10.40	79	43	58	615			.57	.24			
11	80	45	59	615	3.86	.04					
11.20	81	48	63	630			.56	.17	7.6	11.8	.0
11.40	77	50	63	625			.57	.15			
12	79	51	64	635	3.93	.045	.62	.24			
12.20	85	52	64	655			.68	.20	8.8	10.2	.3
12.40	78	52	64	620			.59	.20			
1	83	54	65	630	4.05	.034	.60	.22			
1.20	83	54	66	600			.69	.22	8.2	11.8	.0
1.40	82	55	66	645			.68	.24			
2	80	56	67	570	3.81	.04					
2.20	81	56	70	630			.61	.12	7.5	12.3	.0
2.40	82	57	69	650			.66	.26			
3	83	57	70	655	4.05	.02	.63	.15			
3.20	82	57	70	655			.70	.25	8.6	10.7	.2
3.40	75	57	70	650			.68	.30			
4	81	57	70	650	4.10	.04	.68	.30			
4.20	82	57	70	645			.66	.27	8.3	11.5	.4
4.40	81	57	68	635			.68	.22			
5	81	56	68	560	4.21	.045					
5.24	84			645			.59		7.9	12.0	.0
Total	2,557	1,396	1,798	19,430	40.57	.374	17.35	5.57	81.0	114.8	.9
Av.	82.5	48	62	627	4.057	.0374	.62	.21	8.1	11.48	.09

Regular and special observations on test of Iowa No. 2 coal, November 28, 1904—Continued.

SPECIAL.

Time	Height of water		Weight of coal burned		Weight of water fed to boiler	
	In tank	In gage glass	During period	Total	During period	Total
	Inches	*Inches*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Start, 7.29	40.00	3.75				
7.57	31.00	4.50	700	700	2,177	2.177
8.27	24.50	3.00	700	1,400	3,435	5,612
8.56	30.00	3.25	700	2,100	2,760	8,372
9.46	26.50	3.50	700	2,800	4,562	12,934
10.22	29.50	5.25	700	3,500	3,046	15,980
11.16	25.00	2.00	700	4,200	4,533	20,513
11.47	30.00	2.00	700	4,900	3,510	24,023
12.16	28.00	4.25	700	5,600	2,518	26,541
1.04	27.50	4.75	700	6,300	4,298	30,839
1.38	28.50	2.75	700	7,000	3,798	34,637
2.23	24.00	2.75	700	7,700	3,438	38,075
2.54	24.00	2.00	700	8,400	2,794	40,869
3.25	20.00	2.75	700	9,100	3,149	44,018
3.57	30.00	4.75	700	9,800	3,164	47,182
4.33	30.50	4.50	700	10,500	3,228	50,410
Close, 5.24	40.00	3.25	486	10,986	4,620	55,030

RECORD OF FURNACE CONDITIONS.

Time	Observation	Time	Observation
		1.16	Fire sliced, 8 inches thick.
	Boiler under light load during night.	1.29	Fire raked, 8 inches thick.
		1.55	Cleaning fire.
7	Fire cleaned.	2.05	Fire cleaned, 3 inches thick.
7.29	Test started, fire 2 inches thick.	2.37	Fire raked, 7 inches thick.
		3.03	Fire raked, 8 inches thick.
8.50	Fire raked, 7 inches thick.	3.32	Do.
9.10	Fire sliced, 8 inches thick.	3.50	Do.
9.43	Fire raked, 8 inches thick.	4.12	Do.
10.05	Do.	4.16	Fire sliced, 8 inches thick.
10.16	Fire sliced, 9 inches thick.	4.46	Fire raked, 9 inches thick.
10.36	Fire raked, 10 inches thick.	4.56	Cleaning fire.
10.55	Fire raked, 8 inches thick.	5.05	Fire cleaned, 3 inches thick.
11.02	Cleaning fire.	5.20	Fire raked, 2 inches thick.
11.12	Fire cleaned, 3 inches thick.	5.24	Test closed, fire 2 inches thick.
11.50	Fire raked, 6 inches thick.		
12.14	Fire raked, 8 inches thick.		
12.44	Do.		
1.09	Do.		

Clinker dark and heavy. Firing deadened the fire. Coal did not burn freely. 106 firings during test.

Steam Test of Iowa No. 2 Coal

CONDITIONS OF BOILER TRIAL.

Made by boiler division, United States Geological Survey.
At fuel-testing plant, Louisiana Purchase Exposition, St. Louis, Mo.
Kind of boiler (commercial name), Heine Safety.
To determine the economy of coal as a fuel.
Steam jets not operated. Hughes apparatus operated.
Kind of fuel, Iowa No. 2.
Kind of furnace, hand fired.
State of the weather, cloudy.
Method of starting and stopping the test, alternate.
Number of boiler (plant number), 2.
Type of boiler, water tube.

1.	Date of trial, November 28, 1904.		
2.	Duration of trial	hours..	9.917
3-10	Dimensions and proportions of boiler same as given in test of coal No. 1.		

AVERAGE PRESSURES.

11.	Barometer	inches of mercury..	29.23
		pounds..	14.35
11.1	Steam pressure by gage per square inch	do....	82.5
		do....	*96.85
12.	Force of draft between damper and boiler	inches of water..	.62
13.	Force of draft in furnace	do....	.21
14.	Force of draft or blast in ash pit	do....	0

AVERAGE TEMPERATURES.

15.	Of external air	degrees..	48
16.	Of fireroom	do....	62
17.	Of steam	do....	325.3
18.	Of feed water in tank	do....	48
19.	Of feed water entering economizer	do....	.....
20.	Of feed water entering boiler	do....	169
21.	Of escaping gases from boiler	do....	627
22.	Of escaping gases from economizer	do....	.....
22.1	Of furnace	do....	.....

FUEL.

23.	Size and condition: Nut—small, 50 per cent; slack, 50 per cent; very dirty.		
24.	Weight of wood used in lighting fire	pounds..	None
25.	Weight of coal as fired	do....	10,986
26.	Percentage of moisture in coal		14.88
27.	Total weight of dry coal consumed	pounds..	9,351
28.	Total ash and refuse	do....	1,629
29.	Quality of ash and refuse, clinker	per cent..	58
30.	Total combustible consumed	pounds..	7,722
		do....	†7,294
31.	Percentage of ash and refuse in dry coal		17.44

*Absolute.
†Calculated from chemistry of ash.

PROXIMATE ANALYSIS OF COAL.

		Per cent of coal	Per cent of combustible
32.	Fixed carbon	33.73	48.83
33.	Volatile matter	35.35	51.17
34.	Moisture	14.88	.....
35.	Ash	16.04	.....
		100.00	100.00
36.	Sulphur, separately determined	4.73	.....

ULTIMATE ANALYSIS OF DRY COAL.

37.	Carbon (C)	62.04	76.42
38.	Hydrogen (H)	4.49	5.53
39.	Oxygen (O)	7.59	9.35
40.	Nitrogen (N)	1.50	1.85
41.	Sulphur (S)	5.56	6.85
42.	Ash	18.82	.....
		100.00	100.00
43.	Moisture in sample of coal as received	14.88	.....

ANALYSIS OF ASH AND REFUSE.

44.	Carbon	per cent.	18.07
45.	Earthy matter	do.	81.93

FUEL PER HOUR.

46.	Dry coal consumed per hour	pounds.	944
47.	Combustible consumed per hour	do.	779
		do.	*736
48.	Dry coal per square foot of grate surface per hour	do.	23.28
49.	Combustible per square foot of water-heating surface per hour	do.	.383
		do.	*.363

CALORIFIC VALUE OF FUEL.

50.	Calorific value by oxygen calorimeter per pound of dry coal, B. T. U.	11,497
51.	Calorific value by oxygen calorimeter per pound of combustible, B. T. U.	14,162
52.	Calorific value by analysis per pound of dry coal, B. T. U.	11,444
53.	Calorific value by analysis per pound of combustible, B. T. U.	14,097

QUALITY OF STEAM.

54.	Percentage of moisture in steam		.913
55.	Number of degrees of superheating		None
56.	Quality of steam (dry steam=unity)	per cent.	99.3

*Calculated from chemistry of ash.

WATER.

57.	Total weight of water fed to boiler	pounds..	55,030
58.	Equivalent water fed to boiler from and at 212°	do....	66,394
59.	Water actually evaporated, corrected for quality of steam	do....	54,645
60.	Factor of evaporation		1.2065
61.	Equivalent water evaporated into dry steam from and at 212°	pounds..	65,929

WATER PER HOUR.

62.	Water evaporated per hour, corrected for quality of steam	pounds..	5,510
63.	Equivalent evaporation per hour from and at 212°	do....	6,648
64.	Equivalent evaporation per hour from and at 212° per square foot of water-heating surface	pounds..	3.27

HORSEPOWER.

65.	Horsepower developed (34½ pounds of water evaporated per hour into dry steam from and at 212°=1 horsepower)		192.7
66.	Builders' rated horsepower		210
67.	Percentage of builder's rated horsepower developed		91.76

ECONOMIC RESULTS.

68.	Water apparently evaporated under actual conditions per pound of coal as fired. (Item 57÷item 25)	pounds..	5.01
69.	Equivalent evaporation from and at 212° per pound of coal as fired. (Item 61÷item 25)	pounds..	6
70.	Equivalent evaporation from and at 212° per pound of dry coal. (Item 61÷item 27)	pounds..	7.05
71.	Equivalent evaporation from and at 212° per pound of combustible. (Item 61÷item 30)	do....	8.54 *9.04

EFFICIENCY.

72.	Efficiency of the boiler (heat absorbed by the boiler per pound of combustible divided by the heat value of 1 pound of combustible)	per cent.. do....	58.23 *61.64
73.	Efficiency of boiler, including the grate (heat absorbed by the boiler per pound of dry coal divided by the heat value of 1 pound of dry coal)	per cent..	59.22

COST OF EVAPORATION.

74.	Cost of coal per ton of 2,000 pounds delivered in boiler room (assumed)	$1.00
75.	Cost of fuel for evaporating 1,000 pounds of water under observed conditions	$0.0998
76.	Cost of fuel used for evaporating 1,000 pounds of water from and at 212°	$0.0833

*Calculated from chemistry of ash.

SMOKE OBSERVATIONS.

77.	Percentage of smoke as observed	46.8
78.	Weight of soot per hour obtained from smoke meter....ounces..	.....
79.	Volume of soot per hour obtained from smoke meter .....cubic inches..	.....

METHOD OF FIRING.

80.	Kind of firing (spreading, alternate or coking)	Alternate
81.	Average thickness of fire.....inches..	8
82.	Average intervals between firing for each furnace during time when fires are in normal condition.....minutes..	5.6
83.	Average intervals between times of leveling or breaking up .....minutes	25

ANALYSIS OF THE DRY GASES.

84.	Carbon dioxide (CO_2).....per cent..	8.1
85.	Oxygen (O) .....do....	11.48
86.	Carbon monoxide (CO).....do....	.09
87.	Hydrogen and hydrocarbons.....do....	.....
88.	Nitrogen (by difference) (N).....do....	80.33

HEAT BALANCE, OR DISTRIBUTION OF THE HEATING VALUE OF THE COMBUSTIBLE.

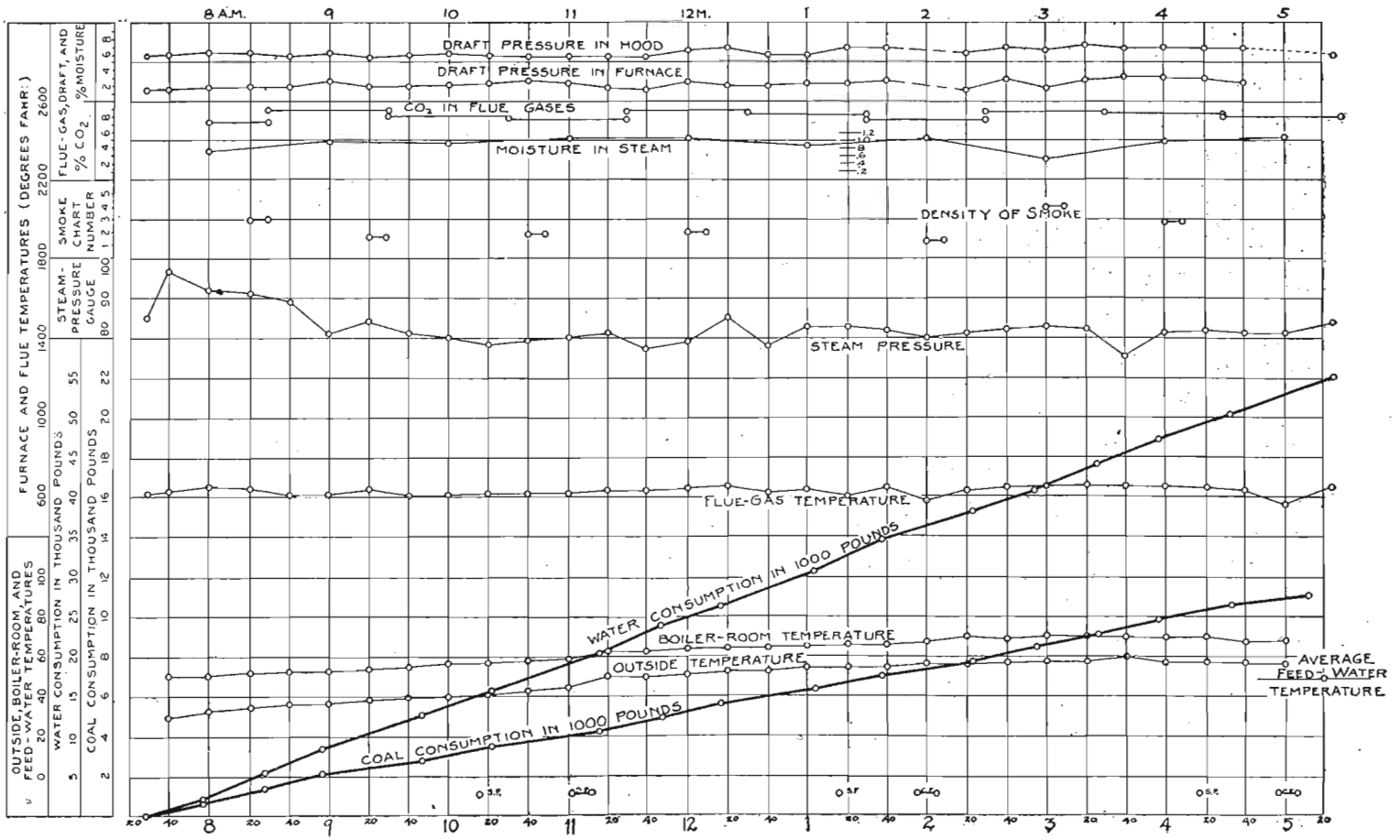
Total heat value of 1 pound of combustible, B. T. U..... 14,162

		B. T. U.	Per cent.
1.	Heat absorbed by the boiler=evaporation from and at 212° per pound of combustible×965.7.....	8,730	*61.64
2.	Loss due to moisture in coal=per cent of moisture referred to combustible÷100×[(212−t)+966+0.48 (T−212)] (t=temperature of air in the boiler room; T=that of the flue gases	279	1.97
3.	Loss due to moisture formed by the burning of hydrogen=per cent of hydrogen to combustible÷100×9×[(212−t)+966+0.48 (T−212)]	650	4.59
4.	Loss due to heat carried away in the dry chimney gases=weight of gas per pound of combustible×0.24×(T−t)....	3,137	22.15
5.	Loss due to incomplete combustion of carbon= $\frac{CO}{CO^2+CO}\times\frac{\text{per cent C in combustible}}{100}\times 10{,}150$.....	85	.62
6.	Loss due to unconsumed hydrogen and hydrocarbons, to heating the moisture in the air, to radiation, and unaccounted for. (Some of these losses may be separately itemized if data are obtained from which they may be calculated)	1,281	9.03
			100.00

REMARKS.

Dry coal per indicated horsepower hour=4.01 pounds.
Dry coal per electrical horsepower hour=4.95 pounds.

*Calculated from chemistry of ash.



Graphic log sheet, Iowa No. 2 coal (nut, dirty),

Regular and special observations on test of Iowa No. 3 coal, November 8, 1904.

REGULAR.

(Duration of trial, 10.033 hours.)

Time	Steam-pressure gage	Temperatures			Calorimeter		Draft pres're		Flue gases		
		Outside	Boiler room	Flue gases, base of stack	Steam discharge	Water separated in 10 minutes	In hood, in inches of water	In furnace, in inches of water	CO_2.	O_2.	CO.
	Lbs.	*°F.*	*°F.*	*°F.*	*Lbs.*	*Lbs.*			*Per ct.*	*Per ct.*	*Per ct.*
7.46	82	47	50	------	------	------	0.12	0.06	------	------	------
8	78	47	50	580	------	------	.69	.18	------	------	------
8.20	84	47	50	625	------	------	.73	.24	------	------	------
8.40	84	47	48	555	4.10	0.043	.47	.21	7.2	12.0	0.0
9	82	48	49	550	------	------	.47	.15	------	------	------
9.20	83	50	51	556	------	------	.47	.19	------	------	------
9.40	83	51	51	560	4.08	.038	.55	.30	8.7	11.6	.3
10	83	52	56	560	------	------	.51	.18	------	------	------
10.20	86	53	58	555	------	------	.54	.26	------	------	------
10.40	78	54	60	549	4.08	.059	.53	.22	8.6	11.1	.1
11	75	55	64	525	------	------	.55	.10	------	------	------
11.20	82	56	64	590	------	------	.58	.19	------	------	------
11.40	89	57	66	600	4.10	.023	.66	.18	7.8	13.0	.0
12	85	57	65	610	------	------	.59	.19	------	------	------
12.20	82	58	66	595	------	------	.61	.23	------	------	------
12.40	78	57	66	590	3.91	.047	.62	.25	7.6	13.8	.0
1	83	57	66	580	------	------	.59	.26	------	------	------
1.20	84	56	67	575	------	------	.67	.29	------	------	------
1.40	80	56	68	570	4.02	.05	.60	.32	6.7	13.4	.0
2	83	56	67	554	------	------	.60	.31	------	------	------
2.20	94	56	68	565	------	------	.57	.16	------	------	------
2.40	80	56	68	610	3.81	.021	.60	.16	6.0	14.4	.0
3	79	56	68	620	------	------	.60	.19	------	------	------
3.20	90	56	67	616	------	------	.67	.20	------	------	------
3.40	89	55	67	603	4.44	.037	.61	.23	6.6	13.6	.0
4	95	55	66	595	------	------	.60	.22	------	------	------
4.20	75	54	65	574	------	------	.59	.31	------	------	------
4.40	93	53	64	565	4.44	.047	.64	.35	6.8	13.6	.0
5	78	52	63	550	------	------	.70	.36	------	------	------
5.20	90	51	64	560	------	------	.60	.18	------	------	------
5.48	80	49	63	600	------	------	------	------	5.8	14.7	.0
Total	2,587	1,656	1,905	17,337	36.98	.365	17.33	6.67	71.8	131.2	.4
Av.	83.5	53.4	61.5	578	4.11	.0406	.578	.222	7.18	13.12	.04

Regular and special observations on test of Iowa No. 3 coal, November 8, 1904—Continued.

SPECIAL.

Time	Height of water		Weight of coal burned		Weight of water fed to boiler	
	In tank	In gage glass	During period	Total	During period	Total
	Inches	*Inches*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Start, 7.46	40.00	3.00				
8.08	42.25	4.25	700	700	1,340	1,340
8.38	38.50	3.00	700	1,400	3,187	4,527
9.13	43.50	5.00	700	2,100	2,823	7,350
9.40	42.75	4.00	700	2,800	2,922	10,272
10.17	39.00	2.75	700	3,500	3,821	14,093
11.11	35.00	3.25	700	4,200	4,502	18,595
11.42	33.00	3.50	700	4,900	3,203	21,798
12.25	35.00	3.75	700	5,600	4,234	26,032
1.08	38.50	4.50	700	6,300	3,975	30,007
1.55	37.50	3.00	700	7,000	4,377	34,384
2.43	42.00	3.75	700	7,700	3,281	37,665
3.24	42.50	3.00	700	8,400	4,046	41,711
4.01	44.50	5.00	700	9,100	2,985	44,696
4.29	41.00	2.50	700	9,800	3,600	48,296
5.28	35.00	4.00	700	10,500	4,278	52,574
Close, 5.48	40.00	3.00	168	10,668	2,533	55,107

RECORD OF FURNACE CONDITIONS.

Time	Observation	Time	Observation
	Boiler under a load during night.	12.55	Fire raked, 9 inches thick.
	Fire cleaned.	1.30	Fire raked.
7.46	Test started, fire 1½ inches thick.	1.41	Fire raked, 10 inches thick.
8.32	Fire raked, 5 inches thick.	2.01	Fire raked.
9.05	Fire raked, 7 inches thick.	2.05	Cleaning fire.
9.27	Fire raked, 8 inches thick.	2.14	Fire cleaned, 4 inches thick.
9.58	Fire sliced, 9 inches thick.	2.40	Fire raked, 6 inches thick.
10.05	Fire raked, 10 inches thick.	3.12	Fire raked, 8 inches thick.
10.44	Do.	3.35	Fire raked, 7 inches thick.
10.50	Cleaning fire.	3.58	Fire raked, 8 inches thick.
11.01	Fire cleaned, 4 inches thick.	4.20	Do.
12.16	Fire raked, 6 inches thick.	5.07	Cleaning fire.
12.40	Fire raked, 8 inches thick.	5.17	Fire cleaned, 4 inches thick.
		5.48	Test closed, fire 1½ inches thick.

Ash dark and heavy. Coal burned rapidly, with long flame. 88 firings during test.

Steam Test of Iowa No. 3 Coal

CONDITIONS OF BOILER TRIAL.

Made by boiler division, United States Geological Survey.
At fuel-testing plant, Louisiana Purchase Exposition, St. Louis, Mo.
Kind of boiler, Heine safety.
To determine the economy of coal as a fuel.
Steam jets not operated. Hughes apparatus operated.
Kind of fuel, Iowa No. 3.
Kind of furnace, hand fired.
State of weather, clear.
Method of starting and stopping the test, alternate.
Number of boiler (plant number), 2.
Type of boiler, water tube.

1.	Date of trial, November 8, 1904.		
2.	Duration of trial	hours..	10.033
3-10	Dimensions and proportions of boiler same as given in test of coal No. 1.		

AVERAGE PRESSURES.

11.	Barometer	inches of mercury..	29.45
		pounds..	14.46
11.1	Steam pressure by gage per square inch	..do....	83.5
		..do....	*97.96
12.	Force of draft between damper and boiler	inches of water..	.58
13.	Force of draft in furnace	do....	.22
14.	Force of draft or blast in ash pit	do....	0

AVERAGE TEMPERATURES.

15.	Of external air	degrees..	53.4
16.	of fireroom	do....	61.5
17.	Of steam	do....	326.1
18.	Of feed water in tank	do....	56.1
19.	Of feed water entering economizer	do....	.....
20.	Of feed water entering boiler	do....	190
21.	Of escaping gases from boiler	do....	578
22.	Of escaping gases from economizer	do....	.....
22.1	Of furnace	do....	.....

FUEL.

23.	Size and condition: Nut—small, 70 per cent; slack, 30 per cent; dull.		
24.	Weight of wood used in lighting fire	pounds..	None
25.	Weight of coal as fired	do....	10,668
26.	Percentage of moisture in coal		12.44
27.	Total weight of dry coal consumed	pounds..	9,341
28.	Total ash and refuse	do....	1,431
29.	Quality of ash and refuse: Clinker	per cent..	57
30.	Total combustible consumed	pounds..	7,910
		.. do....	†7,283
31.	Percentage of ash and refuse in dry coal		15.32

*Absolute.
†Calculated from chemistry of ash.

PROXIMATE ANALYSIS OF COAL.

		Per cent of coal.	Per cent of combustible
32.	Fixed carbon	35.77	49.74
33.	Volatile matter	36.14	50.26
34.	Moisture	12.44	.....
35.	Ash	15.65	.....
		100.00	100.00
36.	Sulphur, separately determined	6.07	.....

ULTIMATE ANALYSIS OF DRY COAL.

37.	Carbon (C)	62.34	75.9
38.	Hydrogen (H)	4.56	5.55
39.	Oxygen (O)	7.34	8.94
40.	Nitrogen (N)	.96	1.17
41.	Sulphur (S)	6.93	8.44
42.	Ash	17.87	.....
		100.00	100.00
43.	Moisture in sample of coal as received	12.44	.....

ANALYSIS OF ASH AND REFUSE.

44.	Carbon	per cent.	27.11
45.	Earthy matter	do.	72.89

FUEL PER HOUR.

46.	Dry coal consumed per hour	pounds.	931
47.	Combustible consumed per hour	do.	788
		do.	*726
48.	Dry coal per square foot of grate surface per hour	do.	22.96
49.	Combustible per square foot of water-heating surface per hour	do.	.388
		do.	*.357

CALORIFIC VALUE OF FUEL.

50.	Calorific value by oxygen calorimeter per pound of dry coal, B. T. U.	11,671
51.	Calorific value by oxygen calorimeter per pound of combustible, B. T. U.	14,210
52.	Calorific value by analysis per pound of dry coal, B. T. U.	11,605
53.	Calorific value by analysis per pound of combustible, B. T. U.	14,130

QUALITY OF STEAM.

54.	Percentage of moisture in steam		.978
55.	Number of degrees of superheating		None
56.	Quality of steam (dry steam=unity)	per cent.	99.25

*Calculated from chemistry of ash.

WATER.

57.	Total weight of water fed to boiler	pounds..	55,107
58.	Equivalent water fed to boiler from and at 212°	do....	66,035
59.	Water actually evaporated, corrected for quality of steam	do....	54,694
60.	Factor of evaporation		1.1983
61.	Equivalent water evaporated into dry steam from and at 212°	pounds..	65,540

WATER PER HOUR.

62.	Water evaporated per hour, corrected for quality of steam	pounds..	5,451
63.	Equivalent evaporation per hour from and at 212°	do....	6,532
64.	Equivalent evaporation per hour from and at 212° per square foot of water-heating surface	pounds..	3.22

HORSEPOWER.

65.	Horsepower developed (34½ pounds of water evaporated per hour into dry steam from and at 212°=1 horsepower)		189.3
66.	Builders' rated horsepower		210
67.	Percentage of builders' rated horsepower developed		90.15

ECONOMIC RESULTS.

68.	Water apparently evaporated under actual conditions per pound of coal as fired. (Item 57÷item 25)	pounds..	5.17
69.	Equivalent evaporation from and at 212° per pound of coal as fired. (Item 61÷item 25)	pounds..	6.14
70.	Equivalent evaporation from and at 212° per pound of dry coal. (Item 61÷item 27)	pounds..	7.02
71.	Equivalent evaporation from and at 212° per pound of combustible. (Item 61÷item 30)	..do....	8.29
		..do....	*9.00

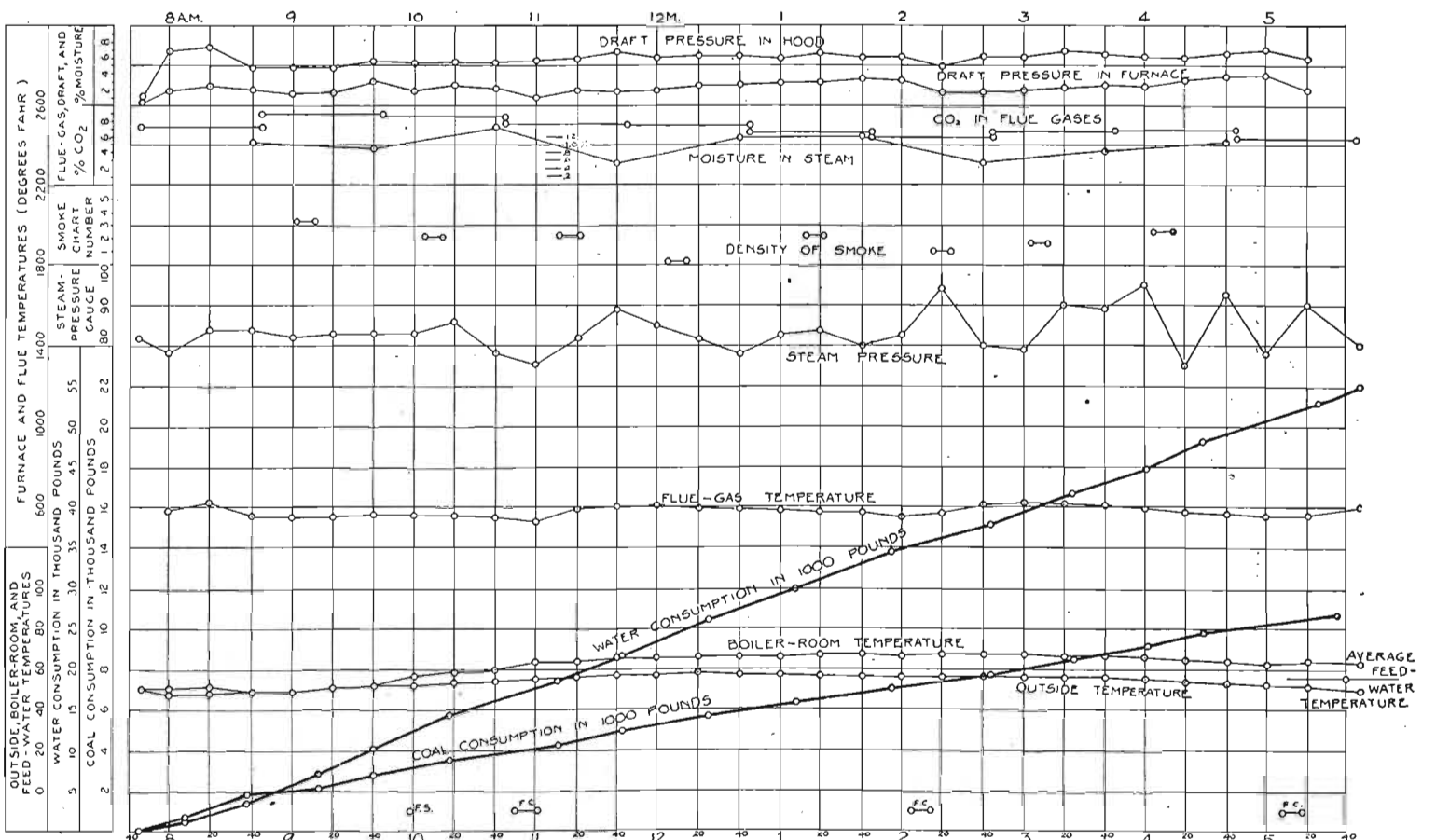
EFFICIENCY.

72.	Efficiency of the boiler (heat absorbed by the boiler per pound of combustible divided by the heat value of 1 pound of combustible)	per cent..	56.34
		....do....	*61.16
73.	Efficiency of boiler, including the grate (heat absorbed by the boiler per pound of dry coal divided by the heat value of 1 pound of dry coal)	per cent..	58.09

COST OF EVAPORATION.

74.	Cost of coal per ton of 2,000 pounds delivered in boiler room (assumed)	$1.00
75.	Cost of fuel for evaporating 1,000 pounds of water under observed conditions	$0.0967
76.	Cost of fuel used for evaporating 1,000 pounds of water from and at 212°	$0.0814

*Calculated from chemistry of ash.



Graphic log sheet, Iowa No. 3 coal (nut, dull).

SMOKE OBSERVATIONS.

77.	Percentage of smoke as observed	34.8
78.	Weight of soot per hour obtained from smoke meter..ounces..	.....
79.	Volume of soot per hour obtained from smoke meter .....cubic inches..	.....

METHOD OF FIRING.

80.	Kind of firing (spreading, alternate or coking)	Spreading
81.	Average thickness of fire.....inches..	8
82.	Average intervals between firing for each furnace during time when fires are in normal condition.....minutes..	6.8
83.	Average intervals between times of leveling or breaking up .....minutes..	30

ANALYSIS OF THE DRY GASES.

84.	Carbon dioxide (CO_2).....per cent..	7.18
85.	Oxygen (O) .....do....	13.12
86.	Carbon monoxide (CO) .....do....	.04
87.	Hydrogen and hydrocarbons.....do....	.....
88.	Nitrogen (by difference) (N).....do....	79.66

HEAT BALANCE, OR DISTRIBUTION OF THE HEATING VALUE OF THE COMBUSTIBLE.

Total heat value of 1 pound of combustible, B. T. U..... 14,210

		B. T. U.	Per cent.
1.	Heat absorbed by the boiler=evaporation from and at 212° per pound of combustible×965.7.....	8,691	*61.16
2.	Loss due to moisture in coal=per cent of moisture referred to combustible÷100×[(212−t)+966+0.48 (T−212)] (t=temperature of air in the boiler room; T=that of the flue gases)	223	1.57
3.	Loss due to moisture formed by the burning of hydrogen=per cent of hydrogen to combustible÷100×9×[(212−t)+966+0.48 (T−212)]	645	4.54
4.	Loss due to heat carried away in the dry chimney gases=weight of gas per pound of combustible×0.24×(T−t)....	3,222	22.67
5.	Loss due to incomplete combustion of carbon= $\frac{CO}{CO_2+CO}\times\frac{\text{per cent C in combustible}}{100}\times 10{,}150$.....	43	.30
6.	Loss due to unconsumed hydrogen and hydrocarbons, to heating the moisture in the air, to radiation, and unaccounted for. (Some of these losses may be separately itemized if data are obtained from which they may be calculated)	1,386	9.76
			100.00

REMARKS.

Dry coal per indicated horsepower hour=4.03 pounds.
Dry coal per electrical horsepower hour=4.97 pounds.

*Calculated from chemistry of ash.

Regular and special observations on test of Iowa No. 4 coal, November 7, 1904.

REGULAR.

(Duration of trial, 10 hours.)

Time	Steam-pressure gage	Temperatures			Calorimeter		Draft pres'res		Flue gases		
		Outside	Boiler room	Flue gases, base of stack	Steam discharge	Water separated in 10 minutes	In hood in inches of water	In furnace, in inches of water	CO_2.	O_2.	CO.
	Lbs.	*°F.*	*°F.*	*°F.*	*Lbs.*	*Lbs.*			*Per ct.*	*Per ct.*	*Per et.*
8	80		50								
8.10	95		50	570			0.50	0.09			
8.20	90		50	560	4.55	0.065	.45	.19			
8.40	95	49	50	575			.47	.14			
9	92	52	52	565			.48	.16	7.8	11.2	0.2
9.20	89	48	54	535			.49	.27			
9.40	97	49	56	547	4.69	.07	.45	.19			
10	87	50	58	553			.49	.26	8.4	11.0	.0
10.20	83	52	60	537	4.29	.06	.51	.28			
10.40	87	55	62	532			.49	.20			
11	86	60	64	510							
11.20	94	62	66	545	4.40	.05	.46	.12	7.8	11.9	.0
11.40	88	63	67	573			.47	.15			
12	88	65	68	560			.47	.19			
12.20	91	66	70	560	4.03	.039	.50	.21	8.4	11.0	.2
12.40	83	66	70	540			.51	.22			
1	105	67	71	527			.50	.27			
1.20	83	66	71	530	4.42	.06	.49	.26			
1.40	81	66	71	523			.49	.30			
2	92	66	71	515			.50	.31			
2.20	86	65	71	510	4.21	.05	.40	.09			
2.40	90	66	72	525			.40	.06			
3	88	65	72	567			.45	.10	6.4	14.0	.0
3.20	86	65	71	597	4.36	.06	.57	.16			
3.40	93	66	71	600			.56	.18			
4	80	63	70	610			.60	.19			
4.20	92	61	70	603	4.44	.04	.59	.22			
4.40	82	60	68	590			.59	.24			
5	93	59	67	578			.60	.27	7.8	12.3	.3
5.20	83	58	67	557	4.40	.07	.50	.07			
5.40	78	56	66	590			.52	.21			
6	78			540					6.8	14.8	.0
Total	2,815	1,685	1,996	17,224	43.79	.564	14.5	5.6	53.4	86.2	.7
Av.	88	60	64.4	556	4.379	.0564	.50	.193	7.63	12.31	.1

Regular and special observations on test of Iowa No. 4 Coal, November 7, 1904—Continued.

SPECIAL.

Time	Height of water		Weight of coal burned		Weight of water fed to boiler	
	In tank	In gage glass	During period	Total	During period	Total
	Inches	*Inches*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Start, 8	40.00	5.25				
8.21	31.25	3.00	700	700	1,923	1,923
9	38.50	4.50	700	1,400	2,861	4,784
9.37	35.50	4.00	700	2,100	3,519	8,303
10.28	44.50	2.50	700	2,800	4,420	12,723
11.24	40.00	2.50	700	3,500	3,436	16,159
12	34.00	4.00	700	4,200	3,012	19,171
12.40	35.50	2.50	700	4,900	4,228	23,399
1.19	40.25	3.00	700	5,600	3,352	26,751
2.46	41.25	3.00	700	6,300	5,013	31,764
3.23	35.00	2.50	700	7,000	3,076	34,840
3.55	38.50	3.00	700	7,700	2,793	37,633
4.33	42.25	4.50	700	8,400	3,701	41,334
5.28	39.00	3.00	700	9,100	5,779	47,113
Close, 6	40.00	5.25	285	9,385	1,652	48,765

RECORD OF FURNACE CONDITIONS.

Time	Observation	Time	Observation
	Boiler under a load during night.	1.08	Fire raked, 8 inches thick.
7	Fire cleaned.	1.37	Fire raked, 9 inches thick.
8	Test started, fire 3 inches thick.	2.02	Do.
8.50	Fire raked, 6 inches thick.	2.08	Cleaning fire, difficult to remove clinker.
9.35	Fire sliced.	2.43	Fire cleaned, 4 inches thick.
9.59	Fire raked, 8 inches thick.	5	Fire raked, 8 inches thick.
10.25	Do.	5.18	Cleaning fire.
10.39	Fire sliced.	5.27	Fire cleaned, 4 inches thick.
10.57	Cleaning fire.	5.53	Fire raked.
11.08	Fire cleaned, 4 inches thick.	6	Test closed, fire 3 inches thick.
11.57	Fire raked, 6 inches thick.		

Ash dark and heavy. Coal burned freely with long flame. 83 firings during test.

Steam Test of Iowa No. 4 Coal

CONDITIONS OF BOILER TRIAL.

Made by boiler division, United State Geological Survey.
At fuel-testing plant, Louisiana Purchase Exposition, St. Louis, Mo.
Kind of boiler, Heine safety.
To determine the economy of coal as a fuel.
Steam jets not operated. Hughes apparatus operated.
Kind of fuel, Iowa No. 4.
Kind of furnace, hand fired.
State of weather, clear.
Method of starting and stopping the test, alternate.
Number of boiler (plant number), 2.
Type of boiler, water tube.

1.	Date of trial November 7, 1904.		
2.	Duration of trial	hours..	10
3-10	Dimensions and proportions of boiler same as given in test of coal No. 1.		

AVERAGE PRESSURES.

11.	Barometer	inches of mercury..	29.45
		pounds..	14.45
11.1	Steam pressure by gage per square inch	..do....	88
		..do....	*102.5
12.	Force of draft between damper and boiler	inches of water..	.5
13.	Force of draft in furnace	do....	.193
14.	Force of draft or blast in ash pit	do....	0

AVERAGE TEMPERATURES.

15.	Of external air	degrees..	60
16.	Of fireroom	do....	64.4
17.	Of steam	do....	329.3
18.	Of feed water in tank	do....	60
19.	Of feed water entering economizer	do....	.....
20.	Of feed water entering boiler	do....	181
21.	Of escaping gases from boiler	do....	556
22.	Of escaping gases from economizer	do....	.....
22.1	Of furnace	do....	.....

FUEL.

23.	Size and condition: Mine run—lump, 30 per cent; small, 50 per cent; slack, 20 per cent; dull.		
24.	Weight of wood used in lighting fire	pounds..	None
25.	Weight of coal as fired	do....	9,385
26.	Percentage of moisture in coal		13.48
27.	Total weight of dry coal consumed	pounds..	8,120
28.	Total ash and refuse	do....	1,302
29.	Quality of ash and refuse: Clinker	per cent..	59
30.	Total combustible consumed	pounds..	6,818
		.. do....	†6,447
31.	Percentage of ash and refuse in dry coal		16.03

*Absolute.
†Calculated from chemistry of ash.

PROXIMATE ANALYSIS OF COAL.

		Per cent of coal	Per cent of combustible
32.	Fixed carbon	37.28	52.23
33.	Volatile matter	34.09	47.77
34.	Moisture	13.48	.....
35.	Ash	15.15	.....
		100.00	100.00
36.	Sulphur separately determined	5.04	.....

ULTIMATE ANALYSIS OF DRY COAL.

37.	Carbon (C)	63.43	76.89
38.	Hydrogen (H)	4.35	5.27
39.	Oxygen (O)	7.92	9.6
40.	Nitrogen (N)	.97	1.18
41.	Sulphur (S)	5.82	7.06
42.	Ash	17.51	.....
		100.00	100.00
43.	Moisture in sample of coal as received	13.48	.....

ANALYSIS OF ASH AND REFUSE.

44.	Carbon	per cent..	19.25
45.	Earthy matter	do....	80.75

FUEL PER HOUR.

46.	Dry coal consumed per hour	pounds..	812
47.	Combustible consumed per hour	do....	682
		do....	*645
48.	Dry coal per square foot of grate surface per hour	do....	20.02
49.	Combustible per square foot of water-heating surface per hour	do....	.336
		do....	*.318

CALORIFIC VALUE OF FUEL.

50.	Calorific value by oxygen calorimeter per pound of dry coal, B. T. U.	11,678
51.	Calorific value by oxygen calorimeter per pound of combustible, B. T. U.	14,157
52.	Calorific value by analysis per pound of dry coal, B. T. U.	11,545
53.	Calorific value by analysis per pound of combustible, B. T. U.	13,996

QUALITY OF STEAM.

54.	Percentage of moisture in steam		1.27
55.	Number of degrees of superheating		None
56.	Quality of steam (dry steam=unity)	per cent..	99.03

*Calculated from chemistry of ash.

WATER.

57.	Total weight of water fed to boiler	pounds..	48,765
58.	Equivalent water fed to boiler from and at 212°	do....	58,289
59.	Water actually evaporated, corrected for quality of steam	do....	48,292
60.	Factor of evaporation		1.1953
61.	Equivalent water evaporated into dry steam from and at 212°	pounds..	57,723

WATER PER HOUR.

62.	Water evaporated per hour, corrected for quality of steam	pounds..	4,829
63.	Equivalent evaporation per hour from and at 212°	do....	5,772
64.	Equivalent evaporation per hour from and at 212° per square foot of water-heating surface	pounds..	2.84

HORSEPOWER.

65.	Horsepower developed (34½ pounds of water evaporated per hour into dry steam from and at 212°=1 horsepower)		167.3
66.	Builders' rated horsepower		210
67.	Percentage of builders' rated horsepower developed		79.7

ECONOMIC RESULTS.

68.	Water apparently evaporated under actual conditions per pound of coal as fired. (Item 57÷item 25)	pounds..	5.196
69.	Equivalent evaporation from and at 212° per pound of coal as fired. (Item 61÷item 25	pounds..	6.15
70.	Equivalent evaporation from and at 212° per pound of dry coal. (Item 61÷item 27)	pounds..	7.11
71.	Equivalent evaporation from and at 212° per pound of combustible. (Item 61÷item 30)	..do....	8.47
		..do....	*8.95

EFFICIENCY.

72.	Efficiency of the boiler (heat absorbed by the boiler per pound of combustible divided by the heat value of 1 pound of combustible)	per cent..	57.78
		....do....	*61.05
73.	Efficiency of boiler, including the grate (heat absorbed by the boiler per pound of dry coal divided by the heat value of 1 pound of dry coal)	per cent..	58.79

COST OF EVAPORATION.

74.	Cost of coal per ton of 2,000 pounds delivered in boiler room (assumed)	$1.00
75.	Cost of fuel for evaporating 1,000 pounds of water nnder observed conditions	$0.0962
76.	Cost of fuel used for evaporating 1,000 pounds of water from and at 212°	$0.0813

*Calculated from chemistry of ash.

SMOKE OBSERVATIONS.

77.	Percentage of smoke as observed	41
78.	Weight of soot per hour obtained from smoke meter....ounces..	.....
79.	Volume of soot per hour obtained from smoke meter .....cubic inches..	.....

METHOD OF FIRING.

80.	Kind of firing (spreading, alternate or coking)	Spreading
81.	Average thickness of fire.....inches..	8
82.	Average intervals between firing for each furnace during time when fires are in normal condition.....minutes..	7.2
83.	Average intervals between times of leveling or breaking up .....minutes..	46

ANALYSIS OF THE DRY GASES.

84.	Carbon dioxide (CO_2).....per cent..	7.63
85.	Oxygen (O) .....do....	12.31
86.	Carbon monoxide (CO).....do....	.10
87.	Hydrogen and hydrocarbons.....do....	.....
88.	Nitrogen (by difference) (N).....do....	79.96

HEAT BALANCE, OR DISTRIBUTION OF THE HEATING VALUE OF THE COMBUSTIBLE.

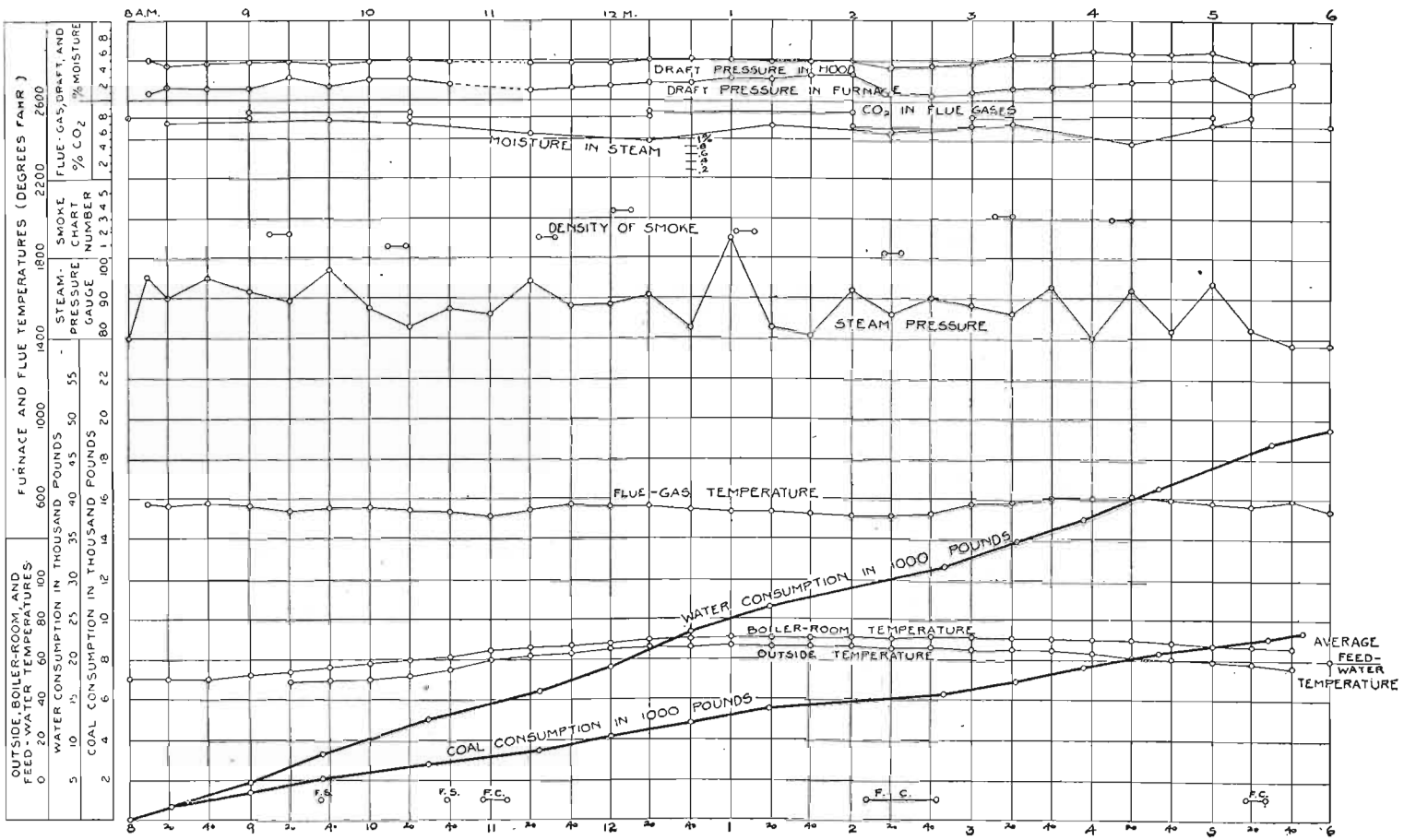
Total heat value of 1 pound of combustible, B. T. U..... 14,157

	B. T. U.	Per cent.
1. Heat absorbed by the boiler=evaporation from and at 212° per pound of combustible×965.7.....	8,643	*61.05
2. Loss due to moisture in coal=per cent of moisture referred to combustible÷100×[(212−t)+966+0.48 (T−212)] (t=temperature of air in the boiler room; T=that of the flue gases)	242	1.71
3. Loss due to moisture formed by the burning of hydogen=per cent of hydrogen to combustible÷100×9×[(212−t)+966+0.48 (T−212)].....	606	4.28
4. Loss due to heat carried away in the dry chimney gases=weight of gas per pound of combustible×0.24×(T−t)....	2,906	20.53
5. Loss due to incomplete combustion of carbon= $\frac{CO}{CO_2+CO}\times\frac{\text{per cent C in combustible}}{100}\times 10{,}150$.....	101	.71
6. Loss due to unconsumed hydrogen and hydrocarbons, to heating the moisture in the air, to radiation, and unaccounted for. (Some of these losses may be separately itemized if data are obtained from which they may be calculated)	1,659	11.72
		100.00

REMARKS.

Dry coal per indicated horsepower hour=3.98 pounds.
Dry coal per electrical horsepower hour=4.91 pounds.

*Calculated from chemistry of ash.



Graphic log sheet, Iowa No. 4 coal (run-of-mine, dull).

Regular and special observations on test of Iowa No. 4 coal (large briquettes), November 26, 1904.

REGULAR.

(Duration of trial, 10.033 hours.)

Time	Steam pressure gage	Temperatures			Calorimeter		Draft pres're		Flue gases		
		Outside	Boiler room	Flue gases, base of stack	Manometer, pressure per square inch	Temperature of steam	In hood, in inches of water	In furnace in inches of water	CO_2.	O_2.	CO.
	Lbs.	*°F.*	*°F.*	*°F.*	*Lbs.*	*°F.*			*Per ct.*	*Per ct.*	*Per ct.*
7.44	84			515							
8	100		49.0	660			0.75	0.22			
8.20	104		49.0	660			.56	.15			
8.40	102	31.0	49.0	665			.65	.19	6.5	13.1	0.1
9	100	32.0	49.0	645			.60	.21			
9.20	103	32.0	49.5	615			.55	.23			
9.40	102	34.0	50.0	603			.50	.10	8.7	11.0	.0
10	102	36.0	51.0	590	0.4	282	.55	.28			
10.20	98	36.0	52.0	600	.4	268	.60	.32			
10.40	100	36.0	53.0	585	.5	277	.70	.40	7.5	12.1	.0
11	102	37.0	54.0	665			.66	.11			
11.20	97	38.5	60.0	670	.6	269	.60	.14			
11.40	104	38.0	60.0	655	.5	283	.60	.20	7.0	12.5	
12	99	39.0	62.0	630	.2	266	.60	.25			
12.20	100	40.0	59.0	600	.2	274	.60	.30			
12.40	103	40.0	61.0	595	.0	260	.65	.34	6.8	13.2	.0
1	97	41.0	63.0	600	.2	265	.70	.35			
1.20	97	42.0	63.0	615	.3	283	.60	.29			
1.40	104	42.0	63.0	615	.5	278	.65	.33	6.2	14.1	.0
2	101	42.0	64.0	575	.5	278					
2.20	99.5	42.0	64.0	660	.4	282	.55	.13			
2.40	98	42.0	63.0	670	.5	281	.60	.16	7.0	13.5	
3	97	42.0	62.0	650	.6	278	.50	.16			
3.20	100	43.0	61.0	650	.5	278	.50	.16			
3.40	103	42.0	62.0	650	.5	280	.55	.19	8.6	10.8	.5
4	98	42.0	62.0	650	.5	283	.60	.23			
4.20	95	41.0	60.0	645	.5	279	.55	.22			
4.40	100	40.0	60.0	650	.5	278	.55	.18	8.4	11.4	.0
5	89	39.0	61.0	635	.5	278					
5.20	82.5	38.0	60.0	630	.4	267	.45	.07			
5.46	83.5								8.2	11.0	.0
Total	3044.5	1047.5	1675.5	18,848	9.2	6,067	15.97	5.91	74.9	122.7	.6
Av.	98.2	38.8	57.7	628	.42	276	.59	.22	7.49	12.27	.06

Regular and special observations on test of Iowa No. 4 coal (large briquettes), November 26, 1904—Continued.

SPECIAL.

Time	Height of water		Weight of coal burned		Weight of water fed to boiler	
	In tank	In gage glass	During period	Total	During period	Total
	Inches	*Inches*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Start, 7.44	40.00	3.50				
7.58	39.00	2.50	600	600		
8.21	33.50	4.75	600	1,200	1,847	1,847
8.49	31.50	4.50	600	1,800	3,377	5,224
9.25	34.50	4.50	600	2,400	3,629	8,853
10.02	43.75	4.25	600	3,000	3,346	12,199
11	34.75	12.00	600	3,600	2,244	14,443
11.26	24.50	6.00	600	4,200	3,985	18,428
12.02	27.00	5.00	600	4,800	4,010	22,438
12.42	29.50	2.50	600	5,400	3,270	25,708
1.24	27.25	2.00	600	6,000	3,480	29,188
2.15	33.50	4.50	600	6,600	3,191	32,379
2.44	28.00	3.50	600	7,200	3,213	35,592
3.16	38.00	4.00	600	7,800	3,039	38,631
3.54	44.00	4.00	600	8,400	4,086	42,717
4.30	23.00	5.50	600	9,000	3,882	46,599
5.15	35.00	4.00	600	9,600	4,260	50,859
Close, 5.46	40.00	2.25	300	9,900	2,699	53,558

RECORD OF FURNACE CONDITIONS.

Time	Observation	Time	Observation
.....	Fire banked under boiler during night.	12.30	Fire raked, 11 incehs thick.
		12.48	Fire sliced.
7.15	Fire cleaned.	1.15	Do.
7.44	Test started, fire 3 inches thick.	1.45	Fire raked, 11 inches thick.
		1.55	Cleaning fire.
8.04	Fire raked, 6 inches thick.	2.07	Fire cleaned.
8.15	Fire raked, 9 inches thick.	2.08	Fire raked, 3 inches thick.
8.26	Fire raked.	2.27	Fire raked, 8 inches thick.
8.55	Fire raked, 10 inches thick.	2.35	Fire raked, 9 inches thick.
9.37	Fire raked, 12 inches thick.	3.15	Fire raked, 12 inches thick.
9.43	Fire sliced.	4.07	Do.
10.06	Fire raked, 10 inches thick.	4.26	Fire sliced and raked, 10 inches thick.
10.20	Do.		
10.21	Fire sliced.	4.47	Fire raked, 10 inches thick.
10.40	Fire raked, 8 inches thick.	4.50	Fire raked, 7 inches thick.
10.44	Cleaning fire.	5.02	Cleaning fire.
10.53	Fire cleaned.	5.10	Fire cleaned, 2½ inches thick.
11.22	Fire raked, 8 inches thick.	5.35	Fire raked, 4 inches thick.
11.30	Fire raked, 10 inches thick.	5.46	Test closed, fire 3 inches thick.
11.49	Do.		
12.21	Fire raked, 12 inches thick.		

Refuse dark and heavy. Briquettes fell apart in fire; burned with long flame.

Steam Test of Iowa No. 4 Coal (Briquettes)

CONDITIONS OF BOILER TRIAL.

Made by boiler division, United States Geological Survey.
At fuel-testing plant, Louisiana Purchase Exposition, St. Louis, Mo.
Kind of boiler, Heine safety.
To determine the economy of coal as a fuel.
Steam jets not operated. Hughes apparatus operated.
Kind of fuel, Iowa No. 4 (briquettes).
Kind of furnace, hand fired.
State of the weather, clear.
Method of starting and stopping the test, alternate.
Number of boiler (plant number), 1.
Type of boiler, water tube.

1.	Date of trial, November 26, 1904.		
2.	Duration of trial	hours..	10.033
3-10	Dimensions and proportions of boiler same as given in test of coal No. 1.		

AVERAGE PRESSURES.

11.	Barometer	inches of mercury..	29.97
		pounds..	14.71
11.1	Steam pressure by gage per square inch	..do....	98.2
		..do....	*112.91
12.	Force of draft between damper and boiler	inches of water..	.59
13.	Force of draft in furnace	do....	.22
14.	Force of draft or blast in ash pit	do....	0

AVERAGE TEMPERATURES.

15.	Of external air	degrees..	38.8
16.	Of fireroom	do....	57.7
17.	Of steam	do....	336.5
18.	Of feed water in tank	do....	57.6
19.	Of feed water entering economizer	do....	.....
20.	Of feed water entering boiler	do....	.....
21.	Of escaping gases from boiler	do....	628
22.	Of escaping gases from economizer	do....	.....
22.1	Of furnace	do....	.....

FUEL.

23.	Size and condition: Large briquettes.		
24.	Weight of wood used in lighting fire	pounds..	None
25.	Weight of coal as fired	do....	9,900
26.	Percentage of moisture in coal		13.24
27.	Total weight of dry coal consumed	pounds..	8,589
28.	Total ash and refuse	do....	1,186
29.	Quality of ash and refuse: Clinker	per cent..	58
30.	Total combustible consumed	pounds..	7,403
		.. do....	*7,078
31.	Percentage of ash and refuse in dry coal		13.82

*Absolute.
*Calculated from chemistry of ash.

PROXIMATE ANALYSIS OF COAL.

		Per cent of coal	Per cent of combustible
32.	Fixed carbon	37.85	50.9
33.	Volatile matter	36.50	49.1
34.	Moisture	13.24	.....
35.	Ash	12.41	.....
		100.00	100.00
36.	Sulphur, separately determined	3.9	.....

ULTIMATE ANALYSIS OF DRY COAL.

37.	Carbon (C)	69.25	80.82
38.	Hydrogen (H)	4.81	5.61
39.	Oxygen (O)	6.28	7.33
40.	Nitrogen (N)	.86	1.00
41.	Sulphur (S)	4.49	5.24
42.	Ash	14.31	.....
		100.00	100.00
43.	Moisture in sample of coal as received	13.24	.....

ANALYSIS OF ASH AND REFUSE.

44.	Carbon	per cent..	23.82
45.	Earthy matter	do....	76.18

FUEL PER HOUR.

46.	Dry coal consumed per hour	pounds..	856
47.	Combustible consumed per hour	..do....	738
		..do....	*705
48.	Dry coal per square foot of grate surface per hour	do....	21.11
49.	Combustible per square foot of water-heating surface per hour	..do....	.364
		..do....	*.348

CALORIFIC VALUE OF FUEL.

50.	Calorific value by oxygen calorimeter per pound of dry coal, B. T. U.	12,546
51.	Calorific value by oxygen calorimeter per pound of combustible, B. T. U.	14,641
52.	Calorific value by analysis per pound of dry coal, B. T. U.	12,749
53.	Calorific value by analysis per pound of combustible, B. T. U.	14,878

QUALITY OF STEAM.

54.	Percentage of moisture in steam		.84
55.	Number of degrees of superheating		None
56.	Quality of steam (dry steam=unity)	per cent..	99.36

*Calculated from chemistry of ash.

WATER.

57.	Total weight of water fed to boiler	pounds..	53,558
58.	Equivalent water fed to boiler from and at 212°	do....	64,270
59.	Water actually evaporated, corrected for quality of steam	do....	53,215
60.	Factor of evaporation		1.2
61.	Equivalent water evaporated into dry steam from and at 212°	pounds..	63,858

WATER PER HOUR.

62.	Water evaporated per hour, corrected for quality of steam	pounds..	5,304
63.	Equivalent evaporation per hour from and at 212°	do....	6,385
64.	Equivalent evaporation per hour from and at 212° per square foot of water-heating surface	pounds..	3.13

HORSEPOWER.

65.	Horsepower developed (34½ pounds of water evaporated per hour into dry steam from and at 212°=1 horsepower)		184.5
66.	Builders' rated horsepower		210
67.	Percentage of builders' rated horsepower developed		87.86

ECONOMIC RESULTS.

68.	Water apparently evaporated under actual conditions per pound of coal as fired. (Item 57÷item 25)	pounds..	5.41
69.	Equivalent evaporation from and at 212° per pound of coal as fired. (Item 61÷item 25)	pounds..	6.43
70.	Equivalent evaporation from and at 212° per pound of dry coal. (Item 61÷item 27)	pounds..	7.43
71.	Equivalent evaporation from and at 212° per pound of combustible. Item 61÷item 30)	do....	8.62
		do....	*9.02

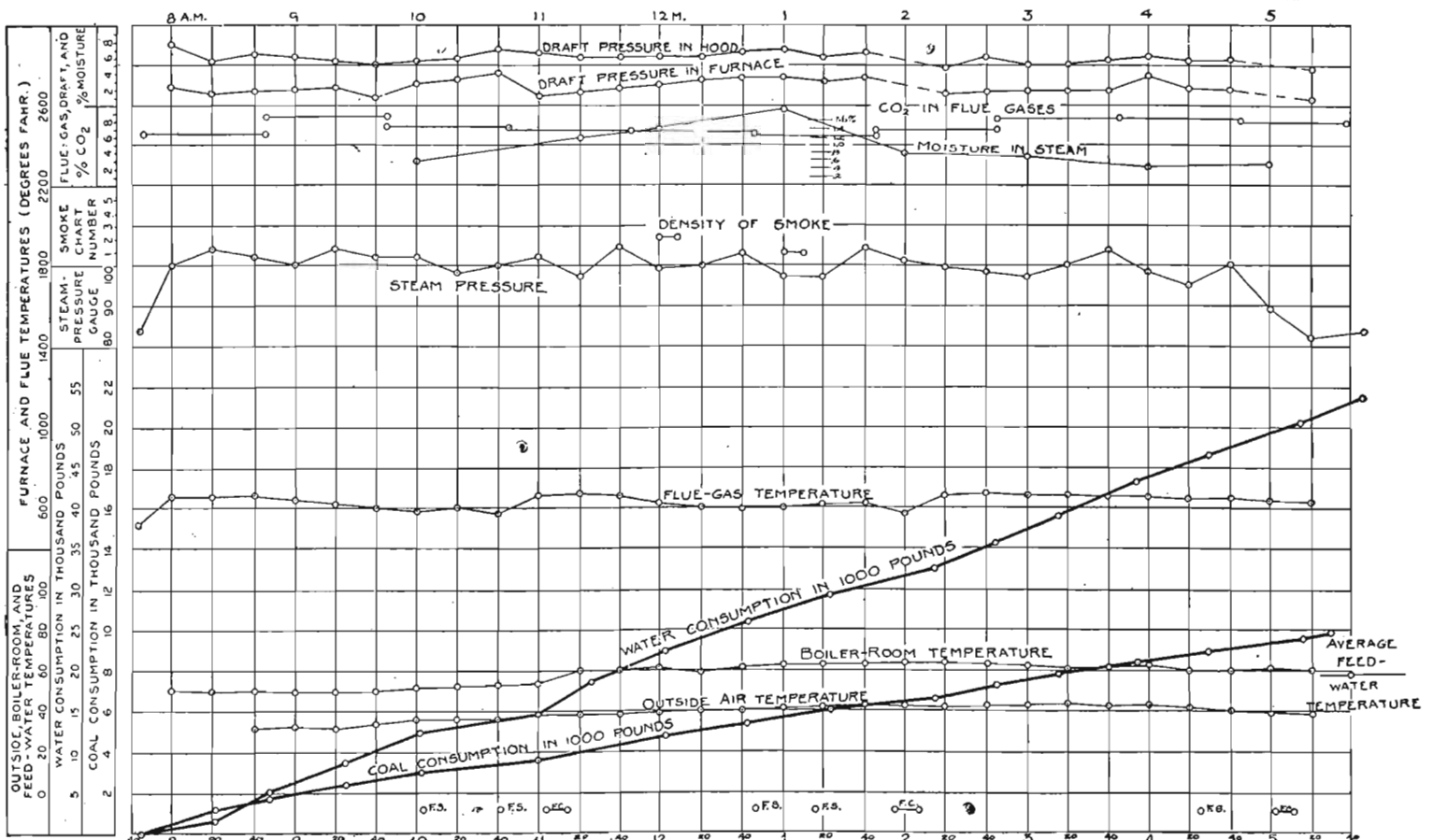
EFFICIENCY.

72.	Efficiency of the boiler (heat absorbed by the boiler per pound of combustible divided by the heat value of 1 pound of combustible)	per cent..	56.85
		do....	*59.49
73.	Efficiency of boiler, including the grate (heat absorbed by the boiler per pound of dry coal divided by the heat value of 1 pound of dry coal)	per cent..	57.18

COST OF EVAPORATION.

74.	Cost of coal per ton of 2,000 pounds delivered in boiler room (assumed)	$1.00
75.	Cost of fuel for evaporating 1,000 pounds of water under observed conditions	$0.0924
76.	Cost of fuel used for evaporating 1,000 pounds of water from and at 212°	$0.0778

*Calculated from chemistry of ash.



Graphic log sheet, Iowa No. 4 coal (large briquettes).

SMOKE OBSERVATIONS.

77.	Percentage of smoke as observed	27.3
78.	Weight of soot per hour obtained from smoke meter..ounces..	.....
79.	Volume of soot per hour obtained from smoke meter .....cubic inches..	.....

METHOD OF FIRING.

80.	Kind of firing (spreading, alternate or coking)	Alternate
81.	Average thickness of fire.....inches..	10
82.	Average intervals between firing for each furnace during the time when fires are in normal condition.....minutes..	.....
83.	Average intervals between times of leveling or breaking up .....minutes..	20

ANALYSIS OF THE DRY GASES.

84.	Carbon dioxide (CO_2).....per cent..	7.49
85.	Oxygen (O) .....do....	12.27
86.	Carbon monoxide (CO).....do....	.06
87.	Hydrogen and hydrocarbons.....do....	.....
88.	Nitrogen (by difference) (N).....do....	80.18

HEAT BALANCE. OR DISTRIBUTION OF THE HEATING VALUE OF THE COMBUSTIBLE.

Total heat value of 1 pound of combustible, B. T. U..... 14,641

		B. T. U.	Per cent.
1.	Heat absorbed by the boiler=evaporation from and at 212° per pound of combustible×965.7.....	8,710	*59.49
2.	Loss due to moisture in coal=per cent of moisture referred to combustible÷100×[(212−t)+966+0.48 (T−212)] (t=temperature of air in the boiler room, T=that of the flue gases)	235	1.61
3.	Loss due to moisture formed by the burning of hydrogen=per cent of hydrogen to combustible÷100×9×[(212−t)+966+0.48 (T−212)].....	666	4.55
4.	Loss due to heat carried away in the dry chimney gases=weight of gas per pound of combustible×0.24×(T−t)....	3,621	24.73
5.	Loss due to incomplete combustion of carbon= $\frac{CO}{CO_2+CO}\times\frac{\text{per cent C in combustible}}{100}\times 10{,}150$.....	65	.45
6.	Loss due to unconsumed hydrogen and hydrocarbons, to heating the moisture in the air, to radiation, and unaccounted for. (Some of these losses may be separately itemized if data are obtained from which they may be calculated)	1,344	9.17
			100.00

REMARKS.

Dry coal per indicated horsepower hour=3.80 pounds.
Dry coal per electrical horsepower hour=4.70 pounds.

*Calculated from chemistry of ash.

Regular and special observations on test of Iowa No. 5 coal, November 14, 1904.

REGULAR.

(Duration of trial 9.983 hours.)

Time	Steam-pressure gage	Temperatures			Calorimeter		Draft pres'res		Flue gases		
		Outside	Boiler room	Flue gases, base of stack	Steam discharge	Water separated in 10 minutes	In hood, in inches of water	In furnace, in inches of water	CO_2.	O_2.	CO
	Lbs.	*°F.*	*°F.*	*°F.*	*Lbs.*	*Lbs.*			*Per ct.*	*Per ct.*	*Per ct.*
7.32	83		43	475			0.40	0.14			
7.40	88	28	43	512			.44	.15			
8	86	30	43	525	4.21	0.033	.48	.18			
8.20	84	33	43	510			.47	.19	7.4	12.0	0.0
8.40	73	35	43	495			.36	.16			
9	81	38	45	530	4.02	.047	.52	.34			
9.20	77	40	47	530			.64	.35	7.8	11.8	.0
9.40	86	41	48	505			.50	.32			
10	80	40	48	535	4.13	.05	.58	.24			
10.20	85	41	50	540			.60	.31	8.7	11.3	.0
10.40	83	42	52	520			.66	.39			
11	78	43	54	520	4.21	.056					
11.20	86	44	56	525			.51	.13	7.6	12.4	.0
11.40	81	45	56	520			.49	.19			
12	84	45	57	515	4.21	.029	.50	.18			
12.20	82	46	57	530			.49	.17	8.3	10.1	.8
12.40	84	46	57	542			.58	.29			
1	79	46	57	515	4.04	.034	.57	.24			
1.20	83	46	57	520			.55	.28	8.2	10.8	.4
1.40	79	47	58	540			.67	.34			
2	78	47	58	555	4.16	.05	.56	.23			
2.20	80	47	59	535					7.9	11.8	.2
2.40	75	47	60	500			.36	.13			
3	79	47	59	525	3.96	.038	.42	.15			
3.20	84	47	59	510			.55	.22	7.3	12.3	.5
3.40	83	46	59	575			.53	.21			
4	86	46	59	570	4.00	.026	.56	.26			
4.20	80	45	59	530			.59	.34	7.9	11.6	.3
4.40	80	45	58	565			.57	.22			
5	81	42	57	560	4.00	.052					
5.20	83	40	55	575			.37	.09	7.2	12.5	.6
5.31	82	39	54	565			.16	.04			
Total	2,613	1,314	1,710	16,969	40.94	.415	14.68	6.48	78.3	116.6	2.8
Av.	81.7	42.4	53.5	530	4.094	.0415	.51	.224	7.83	11.66	.28

Regular and special observations on test of Iowa No. 5 coal, November 14, 1904—Continued.

SPECIAL.

Time	Height of water		Weight of coal burned		Weight of water fed to boiler	
	In tank	In gage glass	During period	Total	During period	Total
	Inches	*Inches*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Start, 7.32	40.00	3.00				
8.03	39.00	3.00	700	700	2,597	2,597
8.29	26.50	3.00	700	1,400	3,276	5,873
9	30.00	3.00	700	2,100	2,965	8,838
9.45	33.00	3.50	700	2,800	3,460	12,298
10.31	33.00	3.25	700	3,500	4,519	16,817
11.16	30.00	4.00	700	4,200	3,726	20,543
11.41	34.00	3.75	700	4,900	3,023	23,566
12.09	27.25	4.00	700	5,600	2,848	26,414
12.45	25.50	3.75	700	6,300	4,629	31,043
1.18	35.00	3.25	700	7,000	2,781	33,824
1.53	29.75	4.25	700	7,700	3,773	37,597
2.47	27.00	3.25	700	8,400	4,944	42,541
3.22	32.00	4.50	700	9,100	3,083	45,624
4.02	37.50	3.00	700	9,800	4,630	50,254
4.28	31.00	3.25	700	10,500	2,834	53,088
5.24	31.50	4.50	700	11,200	5,260	58,348
Close, 5.31	40.00	3.25			735	59,083

RECORD OF FURNACE CONDITIONS.

Time	Observation	Time	Observation
	Boiler under a light load during night.	12.51	Fire sliced, 8 inches thick.
7	Fire cleaned.	1.06	Fire raked, 8 inches thick.
7.32	Test started, fire 3 inches thick.	1.42	Do.
8.18	Fire raked, 5 inches thick.	1.51	Fire sliced, 9 inches thick.
8.41	Fire raked, 7 inches thick.	2.08	Fire raked, 8 inches thick.
8.58	Fire raked, 8 inches thick.	2.10	Cleaning fire.
9.10	Fire raked, 9 inches thick.	2.27	Fire cleaned, 4 inches thick.
9.19	Fire sliced, 10 inches thick.	2.41	Fire raked, 6 inches thick.
9.36	Fire raked, 10 inches thick.	3.11	Fire raked, 7 inches thick.
9.53	Do.	3.38	Fire raked, 8 inches thick.
9.58	Fire sliced, 10 inches thick.	4.13	Fire raked, 7 inches thick.
10.25	Fire raked, 9 inches thick.	4.40	Fire sliced, 8 inches thick.
10.35	Do.	4.50	Fire raked, 9 inches thick.
11	Cleaning fire.	5	Cleaning fire.
11.05	Fire cleaned, 3 inches thick.	5.08	Fire cleaned, 4 inches thick.
12.30	Fire raked, 7 inches thick.	5.31	Test closed, fire 3 inches thick.
12.43	Do.		

Clinker dark and heavy. 94 firings during test.

Steam Test of Iowa No. 5 Coal

CONDITIONS OF BOILER TRIAL.

Made by boiler division, United States Geological Survey.
At fuel-testing plant, Louisiana Purchase Exposition, St. Louis, Mo.
Kind of boiler, Heine safety.
To determine the economy of coal as a fuel.
Steam jets not operated. Hughes apparatus operated.
Kind of fuel, Iowa No. 5.
Kind of furnace, hand fired.
State of weather, clear.
Method of starting and stopping the test, alternate.
Number of boiler (plant number), 2.
Type of boiler, water tube.

1.	Date of trial November 14, 1904.		
2.	Duration of trial	hours..	9.983
3-10	Dimensions and proportions of boiler same as given in test of coal No. 1.		

AVERAGE PRESSURES.

11.	Barometer	inches of mercury..	29.75
		pounds..	14.6
11.1	Steam pressure by gage per square inch	..do....	81.7
		..do....	*96.3
12.	Force of draft between damper and boiler	inches of water..	.51
13.	Force of draft in furnace	do....	.22
14.	Force of draft or blast in ash pit	do....	0

AVERAGE TEMPERATURES.

15.	Of external air	degrees..	42.4
16.	Of fireroom	do....	53.5
17.	Of steam	do....	324.9
18.	Of feed water in tank	do....	51.4
19.	Of feed water entering economizer	do....	.....
20.	Of feed water entering boiler	do....	177
21.	Of escaping gases from boiler	do....	530
22.	Of escaping gases from economizer	do....	.....
22.1	Of furnace	do....	.....

FUEL.

23.	Size and condition: Nut, medium bright—small, 65 per cent; slack 35 per cent.		
24.	Weight of wood used in lighting fire	pounds..	None
25.	Weight of coal as fired	do....	11,200
26.	Percentage of moisture in coal		16.01
27.	Total weight of dry coal consumed	pounds..	9,407
28.	Total ash and refuse	do....	1,328
29.	Quality of ash and refuse, clinker	per cent..	57
30.	Total combustible consumed	pounds..	8,079
		.. do....	*7,700
31.	Percentage of ash and refuse in dry coal		14.12

*Absolute.
*Calculated from chemistry of ash.

PROXIMATE ANALYSIS OF COAL.

		Per cent of coal	Per cent of combustible
32.	Fixed carbon	38.83	55.01
33.	Volatile matter	31.76	44.99
34.	Moisture	16.01	.....
35.	Ash	13.04	.....
		100.00	100.00
36.	Sulphur, separately determined	3.09	

ULTIMATE ANALYSIS OF DRY COAL.

37.	Carbon (C)	65.21	77.59
38.	Hydrogen (H)	4.71	5.6
39.	Oxygen (O)	9.12	10.85
40.	Nitrogen (N)	1.33	1.58
41.	Sulphur (S)	3.68	4.38
42.	Ash	15.95	.....
		100.00	100.00
43.	Moisture in sample of coal as received	16.01	

ANALYSIS OF ASH AND REFUSE.

44.	Carbon	per cent	15.49
45.	Earthy matter	do	84.51

FUEL PER HOUR.

46.	Dry coal consumed per hour	pounds	942
47.	Combustible consumed per hour	do	809
		do	*771
48.	Dry coal per square foot of grate surface per hour	do	23.23
49.	Combustible per square foot of water-heating surface per hour	do	.398
		do	*.38

CALORIFIC VALUE OF FUEL.

50.	Calorific value by oxygen calorimeter per pound of dry coal, B. T. U.	11,963
51.	Calorific value by oxygen calorimeter per pound of combustible, B. T. U.	14,233
52.	Calorific value by analysis per pound of dry coal, B. T. U.	11,848
53.	Calorific value by analysis per pound of combustible, B. T. U.	14,096

QUALITY OF STEAM.

54.	Percentage of moisture in steam		1
55.	Number of degrees of superheating		None
56.	Quality of steam (dry steam=unity)	per cent	99.24

*Calculated from chemistry of ash.

WATER.

57.	Total weight of water fed to boiler	pounds..	59,083
58.	Equivalent water fed to boiler from and at 212°	do....	71,065
59.	Water actually evaporated, corrected for quality of steam	do....	58,632
60.	Factor of evaporation		1.2028
61.	Equivalent water evaporated into dry steam from and at 212°	pounds..	70,523

WATER PER HOUR.

62.	Water evaporated per hour, corrected for quality of steam	pounds..	5,873
63.	Equivalent evaporation per hour from and at 212°	do....	7,064
64.	Equivalent evaporation per hour from and at 212° per square foot of water-heating surface	pounds..	3.48

HORSEPOWER.

65.	Horsepower developed (34½ pounds of water evaporated per hour into dry steam from and at 212°=1 horsepower)		204.75
66.	Builders' rated horsepower		210
67.	Percentage of builders' rated horsepower developed		97.5

ECONOMIC RESULTS.

68.	Water apparently evaporated under actual conditions per pound of coal as fired. (Item 57÷item 25)	pounds..	5.28
69.	Equivalent evaporation from and at 212° per pound of coal as fired. (Item 61÷item 25)	pounds..	6.2
70.	Equivalent evaporation from and at 212° per pound of dry coal. (Item 61÷item 27)	pounds..	7.5
71.	Equivalent evaporation from and at 212° per pound of combustible. (Item 61÷item 30)	do....	8.73
		do....	*9.16

EFFICIENCY.

72.	Efficiency of the boiler (heat absorbed by the boiler per pound of combustible divided by the heat value of 1 pound of combustible)	per cent..	59.23
		do....	*62.10
73.	Efficiency of boiler, including the grate (heat absorbed by the boiler per pound of dry coal divided by the heat value of 1 pound of dry coal)	per cent..	60.54

COST OF EVAPORATION.

74.	Cost of coal per ton of 2,000 pounds delivered in boiler room (assumed)		$1.00
75.	Cost of fuel for evaporating 1,000 pounds of water under observed conditions		$0.0947
76.	Cost of fuel for evaporating 1,000 pounds of water from and at 212°		$0.0793

SMOKE OBSERVATIONS.

77.	Percentage of smoke as observed		49.5
78.	Weight of soot per hour obtained from smoke meter	ounces..	.....
79.	Volume of soot per hour obtained from smoke meter	cubic inches..	.....

*Calculated from chemistry of ash.

METHOD OF FIRING.

80.	Kind of firing (spreading, alternate or coking)	Alternate
81.	Average thickness of fire.....inches..	9
82.	Average intervals between firing for each furnace during time when fires are in normal condition.....minutes..	6.3
83.	Average intervals between times of leveling or breaking up .....do....	22

ANALYSIS OF THE DRY GASES.

84.	Carbon dioxide (CO_2).....per cent..	7.83
85.	Oxygen (O) .....do....	11.66
86.	Carbon monoxide (CO).....do....	.28
87.	Hydrogen and hydrocarbons.....do....	.....
88.	Nitrogen (by difference) (N).....do....	80.23

HEAT BALANCE, OR DISTRIBUTION OF THE HEATING VALUE OF THE COMBUSTIBLE.

Total heat value of 1 pound of combustible, B. T. U..... 14,233

		B. T. U.	Per cent
1.	Heat absorbed by the boiler=evaporation from and at 212° per pound of combustible×965.7.....	8,846	*62.1
2.	Loss due to moisture in coal=per cent of moisture referred to combustible÷100×[(212−t)+966+0.48 (T−212)] (t=temperature of air in the boiler room; T=that of the flue gases)	290	•2.03
3.	Loss due to moisture formed by the burning of hydrogen=per cent of hydrogen to combustible÷100×9×[(212−t)+966+0.48 (T−212)]	644	4.52
4.	Loss due to heat carried away in the dry chimney gases=weight of gas per pound of combustible×0.24×(T−t)....	2,709	19.03
5.	Loss due to incomplete combustion of carbon= $\frac{CO}{CO_2+CO}\times\frac{\text{per cent C in combustible}}{100}\times 10{,}150$.....	272	1.91
6.	Loss due to unconsumed hydrogen and hydrocarbons, to heating the moisture in the air, to radiation, and unaccounted for. (Some of these losses may be separately itemized if data are obtained from which they may be calculated)	1,472	10.41
			100.00

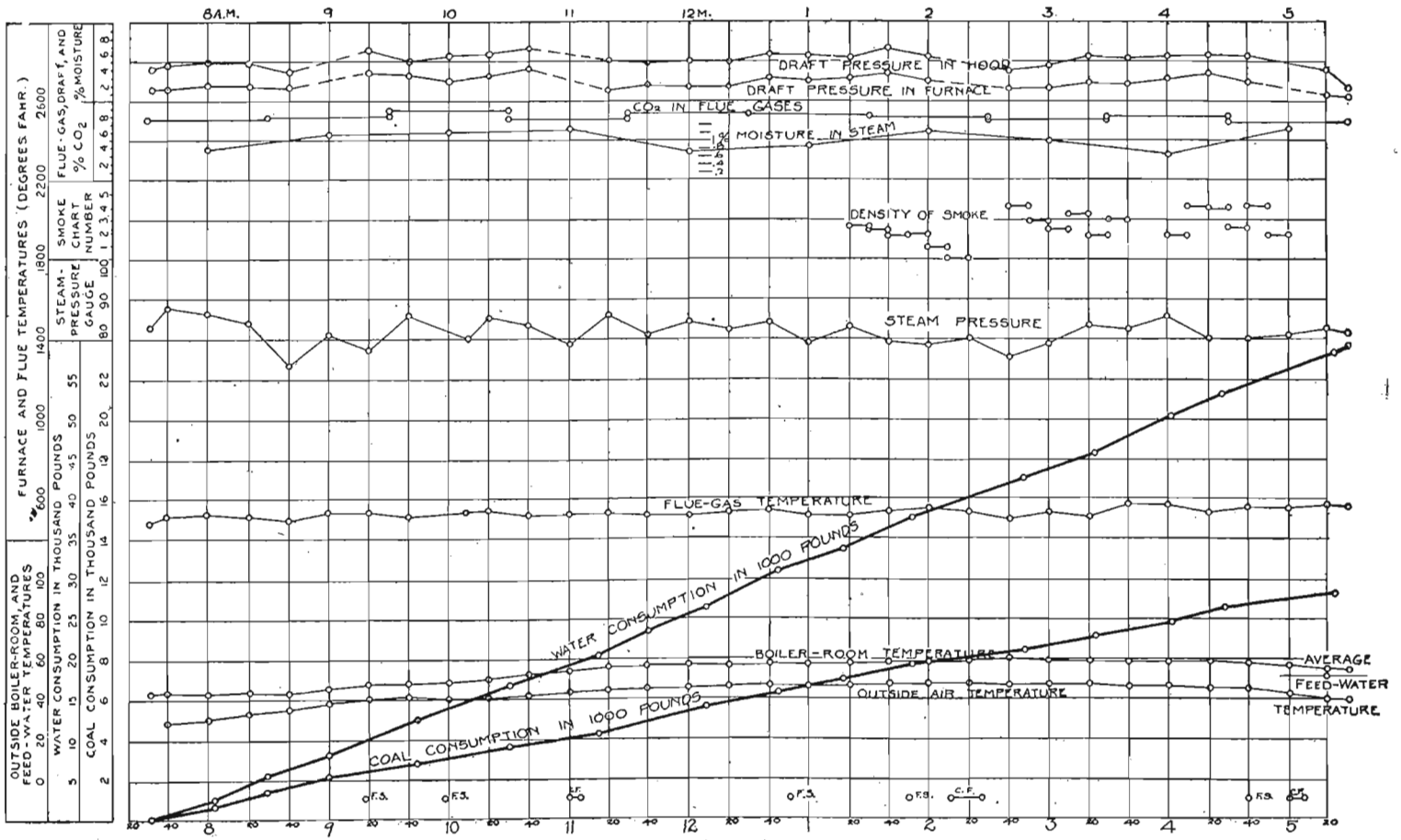
REMARKS.

Dry coal per indicated horsepower hour=3.77 pounds.
Dry coal per electrical horsepower hour=4.66 pounds.

*Calculated from chemistry of ash.

PRODUCER-GAS TESTS

The general results of tests of gas producer and gas engine using Iowa No. 2 coal are shown in the following tables:



Graphic log sheet, Iowa No. 5 coal (nut, medium bright).

LOG OF PRODUCER-GAS TEST ON IOWA NO. 2 COAL, JANUARY 30, 31, 1905.
(Coal from mine No. 5 of the Mammoth Vein Coal Company, Hamilton, Iowa.)

Time	Coal consumed by producer (pounds)	Gas meter (cubic feet)	Temperature of gas (°F.)	Water meter (cubic feet)	Manometers at gas meter (inches water)		Auxiliary motors		Speed counters on gas engine		Load		Temperature of gas leaving producer (°C.)	Manometers at producer		Gas calorimeter						
																Temperatures					B. T. U.	
					1	2	Watt meter	Ammeter	1	2	Volts	Amperes		Air entering (inches mercury)	Gas leaving (inches water)	Gas (°F.)	Water (°C.) Inlet	Water (°C.) Outlet	Cubic centimeters of water collected	Cubic feet of gas	As read	Standardized
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
9.30 a. m. *a*	300																					
10.05 a. m.		1,001,250	51	47,015	2.0	— 0.7	85,100		0,000		242	624	290									
10.25 a. m.		1,007,800	55		2.3	+ 0.6			2,035		220	624	440	0.4	5.0	52	4.2	10.9	1,020	0.2	135.3	133.8
10.45 a. m.	300	1,013,700	58		2.4	+ 1.0			4,061		230	624	500			52	4.2	11.0	1,120	.2	150.7	148.0
11.05 a. m.		1,020,950	63	47,190	2.2	.6	87,000		6,061		231	624	490			56	4.2	10.9	1,120	.2	148.8	147.2
11.25 a. m.	300	1,026,700	63		2.2	.0			8,076		228	619	490			63	4.6	17.6	450	.2	115.9	116.3
11.45 a. m.		1,032,900	65		2.3	.7			10,119		227	624	440	.45	5.5	64	4.3	12.3	970	.2	154.0	151.8
11.55 a. m.	300																					
12.05 p. m.		1,038,750	67	47,305	2.4	1.0	89,150		12,161		238	624	390			64	4.2	13.4	910	.2	165.9	166.7
12.25 p. m.		1,044,240	68		2.4	1.0			14,202		232	649				69	4.4	13.2	1,020	.2	177.0	179.5
12.30 p. m.	300																					
12.45 p. m.		1,049,800	69		2.4	1.0					239	624				62	4.3	15.4	720	.2	158.3	158.5
1.05 p. m.		1,055,500	69	47,519	2.4	1.0	91,490		18,107		238	624	450			62	4.4	13.9	740	.2	139.3	139.5
1.15 p. m.	300																					
1.25 p. m.		1,061,240	69		2.4	1.0			20,198		240	624	420	.4	5.0	64	4.4	14.5	740	.2	148.0	148.8
1.45 p. m.		1,066,750	70		2.5	1.2			22,248		240	619	460			68	4.6	15.2	830	.2	174.2	176.4
2.05 p. m.		1,072,210	70		2.5	1.2	93,480		24,283		238	584	500									*b*
2.20 p. m.	300																					
2.25 p. m.		1,077,950	71		2.5	1.0			26,277		242	624	510									*b*
2.45 p. m.		1,083,820	72		2.5	1.0			28,280		228	624	490	.5	5.0							*b*
3.05 p. m.	300	1,090,150	71	47,859	2.5	.8	95,500		30,282		239	624	490			68	4.5	14.3	760	.2	147.6	149.4
3.25 p. m.		1,096,000	72		2.5	1.2			32,313		240	604	420			67	4.6	17.5	610	.2	163.5	165.2
3.45 p. m.		1,101,730	72		2.5	1.0			34,106		241	614	470			67	4.6	17.5	610	.2	163.5	165.2
4.05 p. m.		1,107,360	73		2.5	1.0	97,520		36,157		240	604	490			66	4.4	17.4	630	.2	162.3	163.8
4.10 p. m.	300																					
4.25 p. m.		1,113,000	73		2.5	1.0			38,190		240	619	460			67	4.5	17.3	630	0.2	159.9	161.6
4.45 p. m.		1,118,720	72		2.5	1.0			40,227		241	614	460			68	4.5	17.3	630	.2	159.9	161.8
5.05 p. m.	300	1,124,350	73	48,203	2.5	1.0	99,670		42,270		240	614	440	0.3	5.0	68	4.5	17.6	640	.2	166.3	168.4

a January 30. Average barometer for entire test, 29.92 inches.

b Meter connected with calorimeter clogged.

5.25 p. m.		1,130,050	73		2.5	1.0			44,309		238	624	460			69	4.5	17.6	650	.2	168.6	171.1
5.45 p. m.		1,135,730	73		2.4	1.0			46,343		238	624	480			69	4.6	17.6	630	.2	162.3	164.8
6 p. m.	300																						
6.05 p. m.		1,141,280	73		2.5	1.0	101,750		48,383		241	614	410			71	4.5	17.7	610	.2	167.4	170.5
6.25 p. m.		1,146,550	73		2.5	1.2			50,448		236	601	420	.3	4.5	71	4.6	18.0	620	.2	164.7	167.7
6.45 p. m.		1,151,920	73		2.4	1.1			52,461		240	619	415			72	4.6	17.9	620	.2	163.5	166.8
6.50 p. m.	300																						
7.05 p. m.		1,157,350	74		2.4	1.1	103,800		54,475		239	619	490	.45	6.0	72	4.6	17.7	640	.2	166.3	169.8
7.25 p. m.		1,163,100	74		2.4	1.1			56,480		238	624	480			70	4.6	16.2	670	.2	154.3	156.9
7.45 p. m.		1,169,350	73		2.4	1.0			58,519		240	619	510			70	4.5	16.2	660	.2	153.2	155.7
7.50 p. m.	300																						
8.05 p. m.		1,175,750	73		2.4	.8	105,950		60,545		240	619	470			70	4.5	16.6	660	.2	158.3	160.9
8.25 p. m.		1,181,800	73		2.4	1.0			62,577		244	619	490			69	4.5	16.7	700	.2	169.4	171.8
8.30 p. m.	300																						
8.45 p. m.		1,187,550	73		2.4	1.0			64,691		238	624	450			70	4.5	16.6	690	.2	165.5	169.9
9.05 p. m.		1,193,250	74		2.4	1.0			66,631		241	624	420	.4	5.0	70	4.5	16.8	700	.2	169.4	172.2
9.25 p. m.		1,199,100	74		2.4	1.0			68,631		239	624	500			73	4.6	16.2	710	.2	165.5	169.3
9.30 p. m.	300																						
9.45 p. m.		1,204,950	74		2.4	1.0			70,640		242	624	520			68	4.6	15.0	760	.2	156.7	158.7
10.05 p. m.		1,210,900	73		2.4	1.0			72,677		236	624	540			67	4.6	15.0	820	.2	169.0	170.8
10.25 p. m.		1,217,000	73		2.4	1.0			74,715		242	624	550			64	4.4	14.6	760	.2	153.8	154.6
10.30 p. m.	300																						
10.45 p. m.		1,223,400	73		2.3	.5			76,745		240	614	600			66	4.5	13.3	850	.2	148.4	149.8
11.05 p. m.		1,230,300	73	49,035	2.1	— 0.4	111,500		78,754		236	624	620			68	4.6	12.3	1,010	0.2	158.7	160.6
11.15 p. m.	300																						
11.25 p. m.		1,237,350	73		2.1	.0			80,775		244	624	580			70	4.6	12.7	980	0.2	157.5	160.2
11.45 p. m.		1,244,300	74		2.1	.0			82,797		240	614	580	0.5	6.5	70	4.6	12.7	1,000	.2	160.7	163.4
12 p. m.	300																						
12.05 a. m. *a*		1,251,090	73		2.2	+ .3	113,460		84,860		238	614	520			70	4.6	13.8	850	.2	155.1	157.8
12.25 a. m.		1,257,590	74		2.2	.3			86,894		240	624	550			69	4.5	13.4	960	.2	169.4	171.8
12.45 a. m.	300	1,264,300	74		2.2	.3			88,930		236	494	620			70	4.5	12.9	950	.2	158.3	160.9
1.05 a. m.		1,271,410	74		2.2	— .1	115,290		90,943		239	624	550			70	4.6	12.4	1,090	.2	168.6	171.4
1.15 a. m.	300																						
1.25 a. m.		1,278,760	74		2.2	— .3			92,938		235	508	520	.3	6.0	70	4.6	11.3	1,090	.2	144.8	147.2
1.45 a. m.	300	1,285,920	74		2.0	— .1			94,961		237	518	580			70	4.6	12.1	1,000	.2	148.8	151.3
2.05 a. m.	300	1,292,750	74		2.2	+ .2	117,200		97,006		239	518	560	.4	6.0	70	4.4	13.3	880	.2	155.1	157.7
2.25 a. m.		1,299,390	74		2.2	.2			99,047		237	614	490			70	4.6	13.2	950	.2	161.9	164.5
2.45 a. m.	300	1,306,030	74		2.3	.3			101,065		241	604	450	.4	6.0	70	4.4	13.2	950	.2	165.8	168.5
3.05 a. m.		1,312,790	74	49,640	2.2	.1	118,980		103,082		241	560	450			70	4.5	12.6	990	.2	159.1	161.7
3.25 a. m.		1,320,800	73		2.2	— .1			105,040		232	493	520			69	4.5	11.0	1,070	.2	138.0	140.0
3.30 a. m.	300																						
3.45 a. m.		1,326,590	73		2.3	+ .3			107,081		233	466	490			69	4.4	13.2	850	.2	148.4	150.5
4.05 a. m.		1,333,200	73		2.2	.1			109,085		233	404	640			68	4.6	12.0	970	.2	142.4	144.1
4.15 a. m.	300																						
4.25 a. m.		1,340,480	73		2.2	— .4			111,030		239	466	600										*b*
4.45 a. m.		1,347,600	73		2.4	+ .3			113,072		234	404	700			68	4.4	12.4	860	.2	136.5	137.2
5 a. m.	300																						
5.05 a. m.		1,354,600	73		2.4	.8			115,116		248	374	530			68	4.4	13.3	720	.2	127.0	128.6
5.25 a. m.		1,361,500	72		2.3	.8			117,161		244	374	510			68	4.4	15.4	710	.2	154.7	156.6

a January 31.

b Calorimeter reading lost.

LOG OF PRODUCER-GAS TEST ON IOWA NO. 2 COAL, JANUARY 30, 31, 1905—Continued.

Time	Coal consumed by producer (pounds)	Gas meter (cubic feet)	Temperature of gas (°F.)	Water meter (cubic feet)	Manometers at gas meter (inches water)		Auxiliary motors		Speed counters on gas engine		Load		Temperature of gas leaving producer (°C.)	Manometers at producer		Gas calorimeter					B. T. T.	
					1	2	Watt meter	Ammeter	1	2	Volts	Amperes		Air entering (inches mercury)	Gas leaving (inches water)	Temperatures: Gas (°F.)	Temperatures: Water (°C.) Inlet	Temperatures: Water (°C.) Outlet	Cubic centimeters of water collected	Cubic feet of gas	As read	Standardized
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
5.45 a. m.	300	1,367,490	72	50,064	2.3	0.8			119,193		232	454	610			68	4.4	14.3	730	0.2	146.0	147.8
6.05 a. m.		1,373,100	71		2.3	.7	124,100		121,212		236	463	580			67	4.5	15.4	700	.2	151.1	152.7
6.25 a. m.		1,380,400	72		2.3	.5			123,222		230	466	570			68	4.4	14.7	740	.2	151.1	152.8
6.30 a. m.	300																					
6.45 a. m.		1,387,700	72		2.3	.8			125,227		236	476	470			67	4.4	15.3	730	.2	156.3	157.9
7.05 a. m.		1,394,525	72		2.3	.0			127,227		230	476	580			68	4.5	14.5	740	.2	116.8	148.6
7.25 a. m.		1,401,350	72		2.3	.0			129,197		224	466	660			66	4.5	12.7	890	.2	144.8	146.3
7.30 a. m.	300																					
7.45 a. m.		1,408,900	72		2.1	— .5			131,200		226	414	620			65	4.7	10.7	950	.2	113.1	113.8
8.05 a. m.	300	1,416,600	72	50,347	2.2	— 1.0	127,490		133,198		242	324	660									*a*
8.25 a. m.		1,424,300	72		2.2	— 1.0			135,204		238	294	700			65	4.5	10.3	950	.2	109.1	109.8
8.45 a. m.		1,431,850	73		2.2	— 1.0			137,198		236	518	540			66	4.5	11.7	1,020	.2	145.6	147.0
9.05 a. m.		1,439,250	75		2.1	— 1.0	129,100		139,171		234	476	660	.5	6.0	67	4.5	11.4	1,040	.2	142.4	143.8
9.15 a. m.	300																					
9.25 a. m.		1,446,500	76		2.1	— .8			141,177		235	301	610			67	4.6	13.0	860	.2	143.2	144.7
9.45 a. m.		1,453,650	76		2.0	— .7			143,165		248	314	690	.65	7.5	66	4.6	9.7	1,000	.2	99.2	100.1
9.55 a. m.	300																					
10.05 a. m.		1,460,850	77	50,620	2.0	— .6	130,900		145,204		242	424	630			66	4.6	12.8	840	.2	136.5	137.7
10.25 a. m.	300	1,467,650	78		2.1	— .2			145,144		256	344	660			68	4.5	13.0	830	.2	139.7	141.5
10.45 a. m.		1,473,800	78		2.3	+ .8			147,192		246	354	640	.65	7.5	68	4.6	13.2	800	.2	136.5	138.2
11.05 a. m.		1,479,950	77	50,770	2.3	+ .6	132,600		149,229		251	314	680			69	4.7	13.1	790	.2	131.3	133.2

a Flame of calorimeter burner went out.

GAS ANALYSES.

Time	CO_2.	O_2.	CO.	H_2	CH_4	N.	Total	B.T.U.
10.30 a. m.*	9.4	0.0	12.6	7.8	5.6	64.6	100.0	127.8
12.30 p. m	10.6	.2	11.2	22.1	8.2	47.7	100.0	199.3
2.30 p. m	10.4	.2	12.0	6.8	6.8	63.8	100.0	138.0
4.30 p. m	9.8	.2	12.6	12.0	7.4	58.0	100.0	164.5
6.30 p. m	10.2	.2	13.0	6.7	9.2	60.7	100.0	166.7
8.30 p. m	9.6	.2	13.6	5.8	9.2	61.6	100.0	165.6
10.30 p. m	10.4	.2	13.0	5.5	7.3	63.6	100.0	142.3
12.30 a. m.†	11.0	.0	11.2	6.5	6.8	64.5	100.0	134.1
2.30 a. m	11.8	.0	8.4	4.9	8.9	66.0	100.0	141.2
4.30 a. m	13.0	.0	6.2	3.9	7.8	69.1	100.0	118.3
6.30 a. m	12.0	.0	9.8	5.6	8.8	63.8	100.0	147.2
8.30 a. m	13.4	.4	9.8	3.8	.0	72.6	100.0	117.6

*January 30.
†January 31.

PRODUCER-GAS TEST ON IOWA NO. 2. COAL.

1.	Duration of test, in hours	13.33
	AVERAGE TEMPERATURE, °F.	
2.	Gas leaving producer	893
	OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
3.	Total steam used by producer, pounds	3,065
4.	Steam used by producer per hour, do	230
5.	Equivalent in pounds of coal per hour	45.9
6.	Equivalent in pounds of dry coal per hour	38.2
7.	Equivalent in pounds of combustible per hour	28.7
8.	Average horsepower required to drive auxiliary machinery	10.9
9.	Total water used in scrubber and tar extracter, cubic feet	2,133
10.	Cubic feet of water per hour per horsepower of producer plant	.64
11.	Cubic feet of water per 1,000 cubic feet of gas produced	9.12
	COAL CONSUMED IN PRODUCER.	
12.	Total coal consumed, pounds	4,833
13.	Moisture in coal, per cent	16.69
14.	Total dry coal consumed, pounds	4,030
15.	Refuse from dry coal, per cent	24.85
16.	Total refuse from coal, pounds	1,000
17.	Total combustible consumed, do	3,030

COAL PER HOUR.

18.	Coal consumed in producer.....pounds..	362.5
19.	Dry coal consumed in producer.....do....	302.5
20.	Combustible consumed in producer.....do....	227.5
21.	Equivalent coal used by producer plant.....do....	408.4
22.	Equivalent dry coal used by producer plant.....do....	340.7
23.	Equivalent combustible used by producer plant.....do....	256.2

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

24.	Coal as fired .....pounds..	9.43
25.	Dry coal .....do....	7.87
26.	Combustible .....do....	5.92

BRITISH THERMAL UNITS FROM COAL.

27.	Per pound of coal as fired.....	8,735
28.	Per pound of dry coal.....	10,489
29.	Per pound of combustible.....	13,950
30.	From coal as fired, per hour.....	3,175,000
31.	From dry coal, per hour.....	3,175,000
32.	From combustible, per hour.....	3,175,000

GAS PRODUCED, CUBIC FEET.

(Gas at 62° F. and 14.7 pounds pressure.)

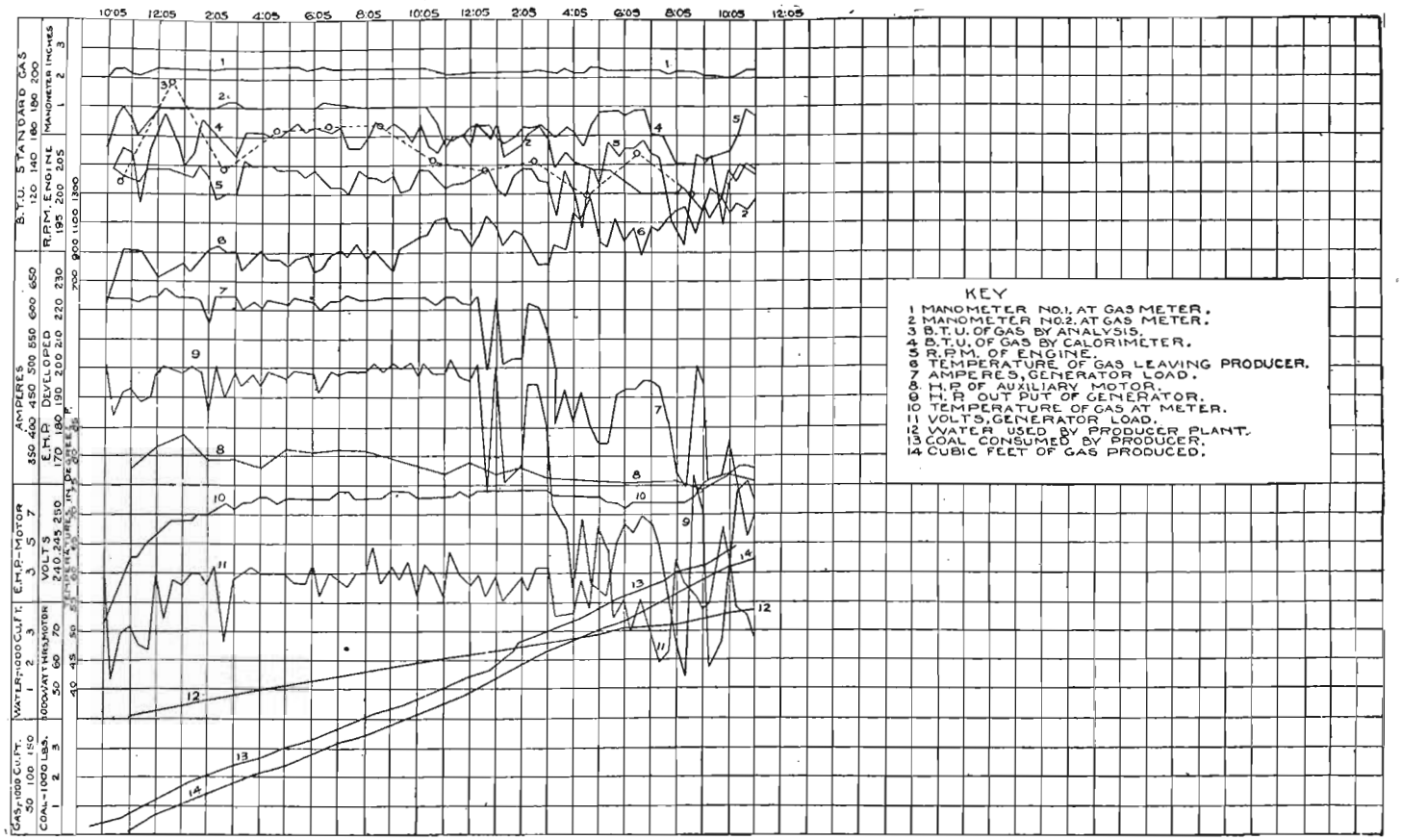
33.	Total	234,110
34.	Per hour	17,570
35.	Per pound coal consumed in producer.....	48.5
36.	Per pound dry coal consumed in producer.....	58.1
37.	Per pound combustible consumed in producer.....	77.2
38.	Per pound equivalent coal used by producer plant.....	43
39.	Per pound equivalent dry coal used by producer plant....	51.6
40.	Per pound equivalent combustible used by producer plant..	68.5

BRITISH THERMAL UNITS FROM STANDARD GAS.

41.	Per cubic foot.....	160.2
42.	Per pound dry coal burned in producer.....	9,300
43.	Per hour per brake horsepower.....	12,130

AVERAGE HORSEPOWER DEVELOPED.

44.	Electrical horsepower available for outside purposes.....	186.6
45.	Electrical horsepower developed at switch board.....	197.5
46.	Brake horsepower available for outside purposes.....	219.5
47.	Brake horsepower developed at engine.....	232.3



Graphic log sheet, producer-gas test, Iowa No. 2 coal.

COAL PER HORSEPOWER PER HOUR

		Coal as fired	Dry coal	Combustible
48.	Pounds consumed in producer per electrical horsepower available for outside purposes.	1.94	1.62	1.22
49.	Pounds consumed in producer per electrical horsepower developed at switch board....	1.84	1.53	1.15
50.	Pounds consumed in producer per brake horsepower* available for outside purposes	1.65	1.38	1.04
51.	Pounds consumed in producer per brake horsepower* developed at engine	1.56	1.30	.98
52.	Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	2.19	1.83	1.37
53.	Equivalent pounds used by producer plant per electrical horsepower developed at switch board	2.07	1.73	1.30
54.	Equivalent pounds used by producer plant per brake horsepower* available for outside purposes	1.86	1.55	1.17
55.	Equivalent pounds used by producer plant per brake horsepower* developed at engine	1.76	1.47	1.10

AVERAGE COMPOSITION OF COAL AND GAS.

56. Coal:	Per cent
Moisture	16.69
Volatile matter	31.42
Fixed carbon	31.19
Ash	20.70
	100.00
Sulphur	5.50

57. Gas by volume:	Per cent.
Carbon dioxide (CO_2)..	10.06
Oxygen (O_2)	.17
Carbon monoxide (CO)..	12.57
Hydrogen (H_2)	9.53
Methane (CH_4)	7.67
Nitrogen (N_2)	60.00
	100.00

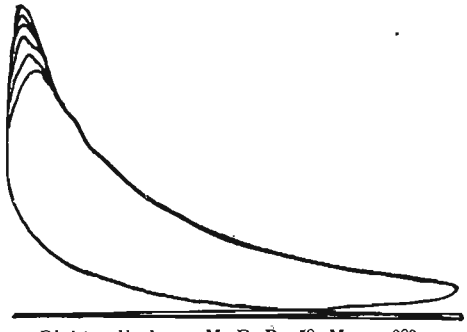
This coal was very high in sulphur (5.50 per cent), but did not clinker in the producer. The results were, however, not so satisfactory as might be expected. There is no doubt that better records can be made from this coal in a second test. The lack of uniformity in the gas made it difficult to adjust the engine to meet the changes.

Fifty gallons of black tar were extracted.

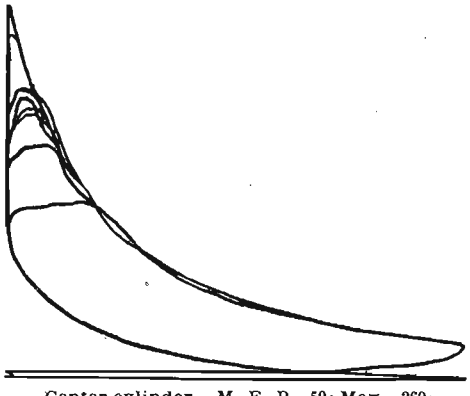
*Based on an assumed efficiency of 85 per cent for generator and belt.

GAS ENGINE.

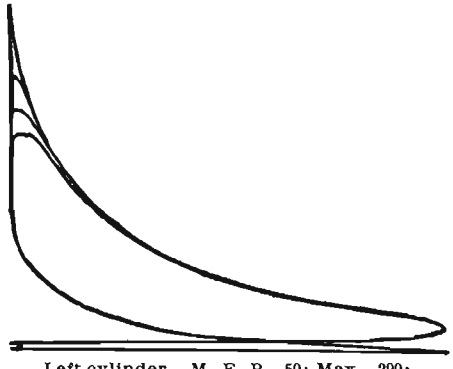
The report covers the records taken from 10:45 a. m. January 30 to 12:05 a. m. January 31, a period of 13:33 hours. After 12:05 a. m. January 31 it was impossible to carry full load on the engine.



Right cylinder. M. E. P., 58; Max., 280; Rel., 24; I. H. P., 93.2



Center cylinder. M. E. P., 59; Max., 260; Rel., 26; I. H. P., 94.8



Left cylinder. M. E. P., 50; Max., 290; Rel., 24; I. H. P., 80.3

Figure 103. Indicator diagrams taken January 30, 1905, during gas-engine test on Iowa No. 2 coal. Revolutions per minute, 204.1.

The results of tests made on the gas engine are given below:

REPORT OF GAS-ENGINE TEST ON IOWA NO. 2. COAL.

Coal: General number, Iowa No. 2; special number, G. P. 22. Car initials and number, 43574, Wabash.

Duration of test, in hours	13.33
Revolutions per minute (mean)	202.7
Explosions per minute (mean)	101.35
Cubic feet gas per hour, by meter	17,820
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure)	17,560

Maximum pressure:	
First cylinder	272
Second cylinder	282
Third cylinder	272
Pressure at release:	
First cylinder	24
Second cylinder	26
Third cylinder	24
Mean effective pressure:	
First cylinder	58
Second cylinder	59
Third cylinder	54
Indicated horsepower:	
First cylinder	93
Second cylinder	95
Third cylinder	87.05
Total indicated horsepower	275.05
Horsepower delivered (electrical horsepower)	197.5
Mechanical efficiency (engine and generator combined)....per cent..	71.8
Cubic feet standard gas per hour per indicated horsepower	63.9
Cubic feet standard gas per hour per electrical horsepower	88.9

COKING TESTS ON IOWA COALS

IOWA NO. 1.

Lump and fine coal from mine No. 2, Anchor Coal Company, Laddsdale, Iowa.

In this test, as in all those on Iowa coals, the charge was of washed coal (page 474). The charge weighed 9,500 pounds, and after burning 46 hours yielded 4,828 pounds of coke and 572 pounds of breeze and ash. The coke was brittle, with cracks lengthwise and crosswise through it. It was also high in sulphur and ash.

Analysis of Iowa No. 1 coal.

Character of coal	Chemical laboratory number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Remarks
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Washed	1356	12.84	35.91	41.00	10.25	4.61	Used for coking test.

Coking test and coke production.

Test number	When charged	When drawn	Time in oven *Hours*	Coal charged (wet) *Lbs.*	Large coke *Lbs.*	Medium coke *Lbs.*	Total coke made *Lbs.*	Breeze and ash *Lbs.*	Per ct. of yield			
									Large	Medium	Total	Breeze and ash
31 (washed)--	Nov. 3, 3 p. m--	Nov. 5, 1 p. m--	46	9,500	916	3,912	4,828	572	9.5	41.2	50.8	6.0

Physical and chemical properties of coke produced.

Test number	Grams in 1 cubic inch		Pounds in 1 cubic foot		Percentage by volume		Compressive strength per cubic inch (one-fourth ultimate strength) *Lbs.*	Height of furnace charge supported without crushing *Feet.*	Hardness	Specific gravity	Chemical laboratory number	Chemical analysis					
	Dry	Wet	Dry	Wet	Coke	Cells						Moisture *Per cent*	Volatile matter *Per cent*	Fixed carbon *Per cent*	Ash *Per cent*	Sulphur *Per cent*	Phosphorus *Per cent*
31-------	11.4	19.75	43.32	75.05	49	51	180	72	2.2	1.87	1371	10.53	1.63	70.39	17.45	3.89	0.051

The coke produced with this washed coal showed cracks lengthways and crossways. It was very brittle and broke up into small pieces in handling. These pieces seemed to be fairly hard and of good cell structure. The ash, sulphur, and phosphorus are high, making the coke unfit for blast furnace and foundry purposes, and the smallness of the pieces would make it undesirable for use in lead or zinc works.

IOWA NO. 2.

Run-of-mine coal from mine No. 5, Mammoth Vein Coal Company, Hamilton, Iowa.

The charge in this test consisted of 10,000 pounds of washed coal (page 474), which was burned for 64 hours. The coke (3,866 pounds, with 1,153 pounds of breeze and ash) was all in small pieces sintered together and with no bond.

Analysis of Iowa No. 2 coal.

Character of coal	Chemical laboratory number	Moisture Per ct.	Volatile matter Per ct.	Fixed carbon Per ct.	Ash Per ct.	Sulph'r Per ct.	Remarks
Washed	1483	18.85	35.44	35.43	10.28	3.93	Used for coking test.

Coking test and coke production.

Test number	When charged	When drawn	Time in oven Hours	Coal ch'ged (wet) Lbs.	Total coke made Lbs.	Breeze and ash Lbs.
49 (washed)	Nov. 26, 5 p. m.	Nov. 29, 9 a. m.	64	10,000	3,866	1,153

This charge made some coke, all in small pieces, sintered together, which broke up in drawing so that ash and breeze formed one-fourth of the total product. This coke could be used only for domestic purposes and would not be very desirable, even for such use, on account of its high ash and sulphur. The small-sized pieces of this coke would make a poor fuel at lead or zinc furnaces.

IOWA NO. 3.

Lump coal from mine No. 4, Gibson Coal Mining Company, Altoona, Iowa.

The charge in this test consisted of 8,000 pounds of washed coal (page 475), which was burned for 43 hours. It yielded 3,336 pounds of fine-fingered, brittle coke that was high in sulphur and ash, and 585 pounds of breeze and ash.

Analysis of Iowa No. 3 coal.

Character of coal	Chemical laboratory number	Moisture Per ct.	Volatile matter Per ct.	Fixed carbon Per ct.	Ash Per ct.	Sulphur Per ct.	Remarks
Washed	1389	16.83	39.27	35.87	8.03	4.55	Used for coking test.

Coking test and coke production.

Test number	When charged	When drawn	Time in oven Hours	Coal charged Lbs.	Large coke Lbs.	Medium coke Lbs.	Total coke made Lbs.	Breeze and a-h Lbs.	Per ct. of yield: Large	Medium	Total	Breeze and ash
35 (washed)	Nov. 8, 2 p. m.	Nov. 10, 9. a. m.	43	8,000	865	2,471	3,336	535	10.8	30.9		7.3

Physical and chemical properties of coke produced.

Test number	Grams in 1 cubic inch: Dry	Grams in 1 cubic inch: Wet	Pounds in 1 cubic foot: Dry	Pounds in 1 cubic foot: Wet	Percentage by volume: Coke	Percentage by volume: Cells	Compressive strength per cubic inch (one-fourth ultimate strength) Lbs.	Height of furnace charge supported without crushing Feet	Hardness	Specific gravity	Chemical laboratory number	Chemical analysis: Moisture Per cent	Volatile matter Per cent	Fixed carbon Per cent	Ash Per cent	Sulphur Per cent	Phosphorus Per cent
35	13.1	22.42	49.78	85.19	43	57	165	66	2.8	1.88	1399	5.73	1.87	75.49	16.91	4.57	0.018

This coal made a brittle, fine-fingered coke, in small pieces, which broke up easily, although they were hard. The cell structure was high and the ash and sulphur very high, which would exclude any of this coke from metallurgical use.

IOWA NO. 4.

Lump coal from mine No. 3, Centerville Block Coal Company, Centerville, Iowa.

The coke produced in this test was of the same general character as that obtained from Iowa No. 3, except that it was not quite so high in either sulphur or ash. The charge consisted of 8,000 pounds of washed coal (page 475), which was burned for 40 hours, producing 3,722 pounds of coke and 426 pounds of breeze and ash.

Analysis of Iowa No. 4 coal.

Character of coal	Chemical laboratory number	Moisture Per ct.	Volatile matter Per ct.	Fixed carbon Per ct.	Ash Per ct.	Sulphur Per ct.	Remarks
Washed	1378	17.80	37.59	37.39	7.14	3.59	Used for coking test.

Coking test and coke production.

Test number	When charged	When drawn	Time in oven *Hours*	Coal charged (wet) *Lbs.*	Large coke *Lbs.*	Medium coke *Lbs.*	Total coke made *Lbs.*	Breeze and ash *Lbs.*	Per ct. of yield			
									Large	Medium	Total	Breeze and ash
34 (washed)	Nov. 7, 5 p. m.	Nov. 9, 9 a. m.	40	8,000	1,114	2,608	3,722	426	13.9	32.6	46.5	5.3

Physical and chemical properties of coke produced.

Test number	Grams in 1 cubic inch		Pounds in 1 cubic foot		Percentage by volume		Compressive strength per cubic inch (one-fourth ultimate strength) *Lbs.*	Height of furnace charge supported without crushing *Feet*	Hardness	Specific gravity	Chemical laboratory number	Chemical analysis					
	Dry	Wet	Dry	Wet	Coke	Cells						Moisture *Per cent*	Volatile matter *Per cent*	Fixed carbon *Per cent*	Ash *Per cent*	Sulphur *Per cent*	Phosphorus *Per cent*
34	12.6	21.6	47.88	82.08	45	55	160	64	2.6	1.82	1400	13.05	2.32	73.10	11.53	2.97	0.013

The coke from this coal showed the same structure as the other Iowa cokes. It was fine fingered, very brittle, and broke up into small pieces. The cell structure was high, ash and phosphorus normal, but sulphur very high. Lead and zinc works could use it, but it is not very desirable even for them on account of the small size of the coke.

IOWA NO. 5.

Run-of-mine coal from Inland mine No. 1, Inland Fuel Company, Chariton, Iowa.

The result of this test, made on 9,000 pounds of washed coal (page 475), and burned for 66 hours, was a mixture of unburned coal, charred coke, and ash.

Analysis of Iowa No. 5 coal.

Character of coal	Chemical laboratory number	Moisture *Per ct.*	Volatile matter *Per ct.*	Fixed carbon *Per ct.*	Ash *Per ct.*	Sulphur *Per ct.*	Remarks
Washed	1419	19.25	31.07	41.75	7.93	2.28	Used for coking test.

Coking test.

Test number	When charged	When drawn	Time in oven	Coal ch'ged (wet)	Remarks
			Hours	*Lbs.*	
40 (washed)--------	Nov. 14, 3 p. m--	Nov. 17, 9 a. m--------	66	9,000	No coke.

Though this washed coal started off very well in a hot oven, all that was gotten out of it was unburned coal mixed with pieces of charred coal and ashes. There was no sign of fusing and the coal was manifestly noncoking.

All of the Iowa coals tested are too high in sulphur to produce blast-furnace coke, and as the sulphur occurs largely as gypsum it can not be removed by washing. The ash is also high in relation to the fixed carbon.

BRIQUETTING TEST WITH IOWA COAL

Iowa No. 4.—One ton of this coal was briquetted with 7 per cent of pitch E.* The briquettes were well pressed, of a grayish color, but on cooling crumbled decidedly. They weighed 6.73 pounds each. As they did not contain an excess of pitch, 7 tons more of this coal were briquetted with 8 per cent of pitch E, in order to have a sufficient quantity for a steam test. The resultant briquettes were bluish black in color, but were not quite hard enough, although fairly strong, and would stand considerable rough treatment in transportation. In burning they held together until consumed. They weighed, on an average, 6.77 pounds each. The eggettes made from this same mixture were stronger than the briquettes, had a polished surface, but were very brown in color. In the cook stove they burned satisfactorily, crumbling little until consumed.

The steaming test made of these briquettes gave considerably better results than the original coal, indicating that the coal has been much improved by briquetting. The results of the boiler tests of both the coal and briquettes are given in the table below:

*Pitch E shows the following composition.

Proximate analysis; moisture, 1.02; volatile matter, 54.11; fixed carbon, 44.04; ash, 0.83; sulphur, 0.66.

Ultimate analysis; Hydrogen, 4:22; carbon, 91.30; nitrogen, 1.00; oxygen, 1.99; sulphur, 0.66.

Analyst, Mr. E. E. Somermeier, St. Louis Testing Station. See Prof. Paper No. 48, p. 1397, U. S. Geological Survey. See also Bull. 343, p. 52, U. S. Geological Survey.

Results of steam test of Iowa No. 4 coal and briquettes.

Fuel	Chemical composition					Duration of trial *Hours*	Total coal consumed *Lbs.*	Horsepower developed by boiler	Dry coal burned per square foot of grate surface per hour *Lbs.*	Equivalent evaporation from and at 212° F. per lb. of dry coal *Lbs.*	Dry coal per indicated horsepower hour *Lbs.*	Dry coal per electrical horsepower hour *Lbs.*
	Fixed carbon *Per cent*	Volatile matter *Per cent*	Moisture *Per cent*	Ash *Per cent*	Sulphur (separately determined) *Per ct.*							
Briquettes	37.85	36.50	13.24	12.41	3.90	10.02	9,900	184.5	21.11	7.43	3.80	4.70
Coal, mine run	37.28	34.09	13.48	15.15	5.04	10.00	9,385	167.3	20.02	7.11	3.98	4.91

WASHING TESTS WITH IOWA COALS.

IOWA NO. 1.

Lump and fine coal from mine No. 2, Anchor Coal Company, Laddsdale, Iowa.

About 5 tons of this coal were washed for a coking test, but the coal was not tried in a raw condition, and consequently the coking test affords no clue to the improvement made by washing. The change is shown by the chemical analyses:

Analyses showing effect of washing Iowa No. 1 coal.

	Car sample	Washed coal for coking
Ash	16.0	10.25
Sulphur	5.03	4.61

IOWA NO. 2.

Run-of-mine coal from mine No. 5, Mammoth Vein Coal Company, Hamilton, Iowa.

About 5½ tons of coal were washed for a coking test. The reduction of impurities effected by washing was not great, as shown by the following analyses:

Analyses showing effect of washing Iowa No. 2 coal.

	Car Sample	Washed coal for coking
Ash	15.22	10.28
Sulphur	4.66	3.93

IOWA NO. 3.

Lump coal from mine No. 4, Gibson Coal Mining Company, Altoona, Iowa.

About 4½ tons of this coal were washed for a coking test. The improvement in the quality of the coal effected by washing is shown in the following analyses:

Analyses showing effect of washing Iowa No. 3 coal.

	Car sample	Washed coal for coking
Ash	14.01	8.03
Sulphur	6.15	4.55

IOWA NO. 4.

Lump coal from mine No. 3, Centerville Block Coal Company, Centerville, Iowa.

A charge consisting of about 4½ tons of this coal was washed for coking purposes. The results were not so satisfactory as those obtained on other samples from this state. The analyses are given below:

Analyses showing effect of washing Iowa No. 4 coal.

	Car sample	Washed coal for coking
Ash	10.96	7.14
Sulphur	4.26	3.59

IOWA NO. 5.

Run-of-mine coal from mine No. 1, Inland Fuel Company, Chariton, Iowa.

A charge consisting of nearly 5 tons of this coal was washed for a coking test, but the coal did not coke, although the washing was fairly successful in reducing the impurities, as shown by the following analyses:

Analyses showing effect of washing Iowa No. 5 coal.

	Car sample	Washed coal for coking
Ash	12.63	7.93
Sulphur	3.19	2.28

ANALYSES OF IOWA COALS

BY JAMES H. LEES AND A. W. HIXSON.

COLLECTION OF SAMPLES

While the present volume was in preparation it was thought well to compile as complete a list of analyses of Iowa coals as possible. It soon became apparent, however, that these analyses were not comparable with one another since they were made by different persons and under widely varying conditions. Hence it seemed desirable that a series of samples should be collected and analyzed under conditions as nearly uniform as could be secured. The Assistant State Geologist collected such a series and the analyses have been made by Professor A. W. Hixson, of the department of Mining at the State University of Iowa.

Sixteen mines were sampled, selected as representative of the important mining districts of the state. Practically the same method of mine sampling was used as was employed by the United States Geological Survey in collecting the samples which were analyzed at its coal-testing station at the Louisiana Purchase Exposition at St. Louis in 1904. The method was about as follows: The room or entry selected for sampling was one from which coal was being mined at the time the sample was taken and thus a fresh face was assured. A portion of the face was cleaned to remove powder smoke or coal which had been exposed to the air for any considerable period of time. A strip was then cut across the seam from floor to roof and about three inches wide and one inch deep. All bony streaks or sulphur bands over one-fourth inch thick were thrown out. The coal cut down in this way was collected, as it fell, upon a rubber cloth to avoid any danger of mixture with dirt or moisture on the floor. Immediately upon arrival above ground the sample was

broken up, on a clean hard surface, into fragments one-half inch or less in diameter. It was then thoroughly mixed and quartered, alternate quarters rejected and the remaining quarters mixed and further pulverized and again quartered, until about a quart remained. This was put into a clean can with a tight fitting lid which was driven down solid and the joint sealed by wrapping with tire-tape, so that it would be air-tight. In short every effort was made to the end that the sample should represent as closely as might be the commercial output of the mine and that the original characteristics of the coal should be preserved until it was analyzed.

A slip of paper giving the number of the sample together with the name and location of the mine was enclosed in the can to render identification certain. The sample number was also marked on the outside of the can. The sample was later shipped by express to the laboratory at Iowa City.

The following papers by Marius R. Campbell give an outline of methods of mine sampling. Commercial Value of Coal-Mine Sampling: Trans. Am. Inst. Min. Eng., Vol. 36, pp. 1053-1065. The Value of Coal-Mine Sampling: Economic Geology, Vol. II, No. 1, pp. 48-57, 1907.

LABORATORY METHODS

The methods followed in the analytical work were essentially those adopted in the report of the committee on coal analysis of the American Chemical Society and those employed in the chemical laboratory of the coal testing plant of the United States Geological Survey at the Louisiana Purchase Exposition at St. Louis in 1904.

The analytical work consisted of the proximate analysis of the coal samples with the determination of sulphur and calorific value in addition.

PREPARATION OF THE SAMPLE

When the sample arrived at the laboratory it was immediately given a serial number for identification purposes in the laboratory. The number and description on the tag were compared with the number and description on the slip of paper within the can to make sure they agreed. They were then entered in a book for permanent record together with any notes concerning

the condition of sample when it arrived. The coal was then poured out upon a well cleaned bucking board, crushed, mixed and quartered down to one pint. One-half of this was spread out upon a shallow tinned iron tray ten inches in diameter, weighed, and then set aside for air drying. The other half was run through a coffee mill and a portion of this was placed in a tightly stoppered bottle for the moisture determination. The crushing and quartering down of the sample were done as quickly as possible to prevent loss of moisture. The coal was air dried for ninety-six hours and then weighed. The time at which the weighing was done together with the temperature and humidity of the air was recorded. The air dried sample was then crushed and quartered down to 150 grams. The final crushing was to 100 mesh. This sample was then placed in a tightly stoppered bottle and used for determinations other than moisture. All samples were mixed on a rolling cloth before weighing out for each determination to insure a perfectly homogeneous sample. All determinations were made in duplicate.

Moisture

One gram of the coarsely ground fresh coal was dried in a weighed porcelain crucible at 105° C. for one hour, in a double walled bath heated by electricity. The crucible and contents were then cooled in a dessicator and weighed covered. Moisture in the air dried sample was determined in like manner. It was found that the moisture determination in the finely ground fresh sample was not reliable since a considerable amount of moisture was lost in grinding and for this reason the sample used for the moisture determination was ground in a coffee mill.

Ash

The portion of powdered coal used for the determination of moisture in the air dried sample was burned at first over a Bunsen burner with a very low flame until all of the volatile matter was expelled. The final burning was done in a case gasoline muffle furnace, the temperature being kept at that of low redness. Burning was continued until the ash was burned to constant weight.

Note—For convenience the following equivalents are given: 1 gram=15.43 grains, 1 cm. (centimeter)=0.394 inch, 1 cc. (cubic centimeter)=.061 cubic inch. 100°C. is the equivalent of
212°F., the boiling point of water.

Volatile Combustible Matter

One gram of the air dried sample was weighed into a previously ignited and weighed platinum crucible with a tightly fitting cover. This was heated for seven minutes over the full flame of a Bunsen burner, then cooled and weighed. The crucible was supported on a pipe clay triangle resting upon a tripod, the bottom of the crucible being 7 cm. from the top of the burner. The burner when burning freely gave a flame from 17 to 20 cm. high. The flame was protected from air currents by an asbestos chimney surrounding the burner. The volatile combustible matter was found by subtracting the per cent of moisture from the loss found here.

Fixed Carbon

It is the difference between the sum of the other constituents determined and 100. Sulphur which goes partly into the volatile combustible matter and partly into the coke was not considered here. Fixed carbon may also be found by subtracting the per cent of ash from the per cent of residue left after expelling the volatile matter.

Sulphur

This was determined by the Eschka method. One gram of the finely powdered air dried coal was weighed in a platinum dish of 100 cc. capacity. To this was added 1.5 grams of an intimate mixture of 1 part dry sodium carbonate and 2 parts magnesium oxide. The coal and the mixture were well mixed together with a glass rod. The contents of the dish were then heated over a Bunsen burner very gently until all of the volatile matter was expelled. This required about thirty minutes. Then the heat was increased until all traces of carbon disappeared. To prevent any sulphur from the gas contaminating the determination the platinum dish was fitted into a hole in a piece of asbestos board.

After all traces of carbon were removed the contents of dish were transferred to a numbered beaker and digested with 75 cc. of water for thirty minutes. The solution was then filtered, and the residue was washed twice by decantation with 50 cc. of boil-

ing water. The residue was then transferred to the filter paper and again washed with hot water until the filtrate gave only a slight opalescence with nitric acid and silver nitrate. The filtrate at this point amounted to about 200 cc.

10 cc. of saturated bromine water and 3 cc. of concentrated hydrochloric acid were then added to the solution. The solution was boiled slowly until all of the bromine was expelled. Then the sulphur was precipitated by adding to the boiling solution 10 cc. of a ten per cent solution of barium chloride. This was added drop by drop and the solution stirred vigorously. The precipitate was allowed to stand two hours at a temperature slightly below boiling. The barium sulphate was then filtered off and was washed with hot water until free from chlorides.

The filter with the moist precipitate was transferred to a weighed porcelain crucible which was heated over a low flame until the paper was burned off. The heat was then raised until the precipitate became a dull red and the heating continued until the carbon was burned out. The crucible and precipitate were then cooled in a dessicator and weighed.

Blank determinations were made, using all of the reagents in the same quantities and the determination was carried out exactly as with the coal. Any barium sulphate found was subtracted from that obtained in the coal determination. The true weight of barium sulphate multiplied by 0.1373 gave the weight of sulphur.

Calorific Value

This was determined with a Parr Standard Calorimeter, which was installed in a room as free as possible from fluctuations in temperature. The apparatus was carefully standardized, the water equivalent being determined by different methods. The correction components used for the chemical, iron wire fuse, and for the varying compositions of the different coals were those determined by Prof. S. W. Parr of the State University of Illinois.

The thermometers used were standardized by the Bureau of Standards in Washington, D. C.

One gram of the powdered air dried coal was weighed into the bomb of the calorimeter. To this was added one gram of accelerator (Potassium Chlorate) and 15 grams of perfectly dry and pure sodium peroxide. The false cap was then put in position and screwed firmly in place and the ingredients mixed by shaking the bomb thoroughly. The material was then shaken to the bottom of the bomb, the false top removed, the ignition device inserted and firmly screwed in place. The bomb now complete was put in place into the can which contained exactly two liters of distilled water. The lid was then placed on the calorimeter tub, pulley attached and the thermometer inserted so that the bulb was half way to the bottom. The water was stirred by metal wings attached to the bomb which was revolved by a belt from a small motor.

The motor was started and apparatus allowed to run for five minutes before ignition in order that the rate of change of temperature might be noted by taking reading each minute. At the end of the fifth minute the charge in the bomb was ignited by closing a switch which allowed an electric current of four and one-half amperes to quickly fuse a 34 gauge iron wire, four inches long, which extended into the charge in the bomb. The temperature was read at the end of each minute until the maximum was reached, then for five minutes to obtain the rate of change of temperature due to radiation.

The apparatus was then taken apart, each piece dried thoroughly, and prepared for a new charge. The room temperature was taken during each determination.

The calorific value was then calculated by multiplying the number of British Thermal Units corresponding to one degree increase in temperature by the total rise of temperature obtained after the correction factors had been subtracted.

The calorific value was also calculated in calories.

METHOD OF STATEMENT

All of the analyses were made upon the air dried samples. The results on the sample as received were calculated by correcting the analyses for loss of moisture in air drying. The results of the actual analyses on the air dried sample and those corrected to sample as received follow in the tables.

DESCRIPTION OF MINES SAMPLED

Sample No. 1

Operator.—High Bridge Coal Company, Madrid.

Mine.—High Bridge mine, High Bridge, Dallas county, on Boone division Chicago, Milwaukee and St. Paul Railroad.

Sample collected.—May 12, 1909.

Description.—The sample was collected from the face of the west entry, about 1,300 feet from the shaft. The coal is here 3 feet 11 inches thick. It has a clay roof and about three inches of black shale on the floor. This is underlain by gray fire clay. The present capacity of the mine is 300 tons daily. See page 89.

Sample No. 2

Operator.—Ogden Coal Company, Ogden*.

Mine.—Ogden No. 1, two miles north of Ogden, Boone county, on switch from main line Minneapolis and St. Louis Railroad.

Sample collected.—May 14, 1909.

Description.—The sample was taken from the fourth northeast entry. The coal is here 4 feet 4 inches thick and is free from sulphur bands or balls as well as from rock. It is the "lower vein" of the Boone county mines and averages 4½ to 5½ feet. The "upper vein" is about fifty feet above and is about 3½ feet thick.

The shaft is 275 feet deep. It was completed in August of 1907. The mine now has an output of 400 tons, of three grades, lump, range and steam. The railroad company uses 125 tons daily. About 200 men are employed in the mine. Electric haulage is being installed. The same company is sinking a second shaft two miles south of Ogden. See page 74.

Sample No. 3

Operator.—Willow Grove Coal Company (Henry McElheny), Angus.

Mine.—Willow Grove mine, on northwest border of Angus in Greene county. No railroad connections.

Sample collected.—May 14, 1909.

Description.—This sample was taken from the fourth east-south entry. The seam is here 4 feet 2 inches thick. The coal

*The Fort Dodge, Des Moines and Southern Railroad Company (electric) has since purchased a controlling interest in the property. (July,1909.)

breaks with angular fracture and shows bright clean faces. Thin films of lime or gypsum occur along joints and stratification planes. The vein worked is called the lower vein. Its thickness ranges from 4 to 5½ feet. The "middle vein" is separated from the lower by a sandstone roof 3½ to 20 feet thick, with an average of 14 feet. Owing to the character of the roof the mine is very wet. See page 361.

Sample No. 4

Operator.—Atwood Coal Company, What Cheer.

Mine.—Blyth mine, three miles northwest of Rose Hill, Mahaska county, on long switch from Knoxville branch Chicago, Rock Island and Pacific Railroad.

Sample collected.—May 18, 1909.

Description.—The mine was sampled in the fifth north entry on the west side of the mine, 840 feet from the shaft. The vein dips steeply in this entry. It shows a thickness of 5 feet 1 inch where sampled. The coal is very clean looking, without sulphur bands or rock. Only one vein is present. The mine has been running four years, the first two as a country mine, and at present employs 100 men. See page 202.

Sample No. 5

Operator.—Armstrong Brothers Coal Company, What Cheer.

Mine.—Armstrong, one mile east of What Cheer, Keokuk county. No railroad connections.

Sample collected.—May 19, 1909.

Description.—The sample was taken from the first north entry off the west main entry. The coal here showed a thickness of 4 feet 2 inches and was clean and free from impurities. See page 288.

Sample No. 6

Operator.—Crescent Coal Company, Oskaloosa.

Mine.—Crescent No. 5, White City, Mahaska county, on Buxton branch Chicago and North-Western Railroad.

Sample collected.—May 19, 1909.

Description.—This sample was cut from the first room on the eighth north entry on the east side of the mine, about one mile from the shaft. The coal was 7 feet 8 inches thick, with about

8 inches of slaty coal near the roof. It was dipping steeply away from the entry.

The shaft is seventy-two feet deep. The mine is equipped with tail-rope haulage on the main entry about one-half mile in, to the main parting. See page 216.

Sample No. 7

Operator.—Phillips Fuel Company, Ottumwa.

Mine.—Bear Creek mine, at Bear Creek, Wapello county, four miles southwest of Ottumwa, on Chicago, Milwaukee and St. Paul Railroad.

Sample collected.—May 20, 1909.

Description.—The sample is from the first south entry. Here the coal is 4 feet 6 inches thick and is in the main clean and free from rock except near the roof, where some bowlders occur. One of these near the place of sampling measured ten inches in thickness.

The mine was opened in the fall of 1908. At the time it was sampled forty miners were employed and tail-rope haulage was already installed in the main entry. Hoisting is done by a double engine, geared to the drum. The shaft is forty-six feet deep. See page 302.

Sample No. 8

Operator.—Phillips Fuel Company, Ottumwa.

Mine.—Rutledge No. 5, at Rutledge, Wapello county, on Chicago, Milwaukee and St. Paul Railroad.

Sample collected.—May 20, 1909.

Description.—The mine was sampled in the seventeenth west entry on the north side of the shaft, about one mile from the bottom. The seam is here 3 feet 10 inches thick and is free from rock, although there are some sulphur concretions. The average thickness of the bed is 42 inches. See page 298.

Sample No. 9

Operator.—Wapello Coal Company, Hiteman.

Mine.—Wapello No. 4, three miles northwest of Hiteman, Monroe county, on branch from main line Chicago, Burlington and Quincy Railroad.

Sample collected.—May 21, 1909.

Description.—The sample is from the seventeenth room off the tenth west entry off the sixteenth north entry. The vein measured where sampled 5 feet 4 inches and is free from sulphur and rock. The average thickness is about 5½ feet.

The mine uses tail-rope haulage for about a mile underground and the entries run in one-half mile farther. The output is about 900 tons daily. See page 242.

Sample No. 10

Operator.—Campbell Coal Company, New Market.

Mine.—Campbell No. 1, nearly one mile east of New Market, Taylor county, on Keokuk, Shenandoah and Red Oak division Chicago, Burlington and Quincy Railroad.

Sample collected.—May 22, 1909.

Description.—The sample was collected from the second west entry off the second north entry. The bed was 16 inches thick where sampled. It varies from 16 to 20 inches in different parts of its extent. In some places it shows thin streaks of sulphur or clay one-eighth to one-half inch thick. The coal is brittle and breaks easily with angular fracture. The mine is on the right-of-way and is served by a short siding. See page 383.

Sample No. 11

Operator.—Bolton-Hoover Coal Company, Oskaloosa.

Mine.—Bolton No. 2, Bolton, Mahaska county, on long switch from Oskaloosa and Tracy line Chicago, Burlington and Quincy Railroad.

Sample collected.—June 15, 1909.

Description.—The sample is from the first room on the fifth north entry, about 1,200 feet in from the mouth of the slope and seventy feet below the surface. The face was here 5 feet 3 inches in height. It showed a few thin sulphur streaks, some up to 1½ inches in thickness, and a few bowlders. The mine has a daily capacity of 400 tons. The coal is hauled out of the mine and overland to the top works, about 1,200 feet distant, by rope. The top works are located on the railroad, at the old slope. The haulage engine is located here also and serves both slopes. The tail-rope runs on the surface nearly one-fourth mile beyond the mouth of the slope and enters the mine through an old drill hole. See page 205.

Sample No. 12

Operator.—English Creek Coal Company, Oskaloosa.

Mine.—Hawkeye mine at Hawkeye, about two miles east of Knoxville, Marion county, on Washington and Knoxville line Chicago, Rock Island and Pacific Railroad.

Sample collected.—June 16, 1909.

Description.—The sample is from room five, thirteenth entry east. The coal here showed a face of 6 feet, with some thin streaks of sulphur and occasional bowlders. The mine employs 125 men. See page 192.

Sample No. 13

Operator.—Colfax Consolidated Coal Company, Colfax.

Mine.—Mine No. 8, four miles southeast of Colfax, on Colfax Northern Railroad.

Sample collected.—June 17, 1909.

Description.—The sample was cut from the end of the main west entry, 1,700 feet west from the shaft. The seam was here 5 feet 7 inches thick and presented a clean face except for a half inch sulphur band one foot from the bottom.

The shaft is 164 feet deep and penetrates the "first vein," one to two feet thick, eighty feet from the surface. The mine employs 400 men and has an output of 800-900 tons per day. See page 159.

Sample No. 14

Operator.—Keystone Coal Mining Company, Des Moines.

Mine.—Keystone mine, Des Moines, Polk county, at west city limits, on Chicago, Milwaukee and St. Paul Railroad.

Sample collected.—June 21, 1909.

Description.—The sample was taken from the face of the second north entry, where the vein has just risen from a swamp on to the top of a hill. Where sampled the vein measured 4 feet 2 inches. In the swamp it was 7 feet thick. It will vary from 3 feet 8 inches to 7 feet in different parts of the mine. Some thin sulphur streaks were present in the face, but no rock or thick sulphur bands.

The shaft is 165 feet deep. It was sunk in July of 1908. The mine is not yet well opened up, but already has an output of

seventy-five to eighty tons daily and employs twenty-three men. See page 114.

Sample No. 15

Operator.—Bennett Bros. Coal Company, Des Moines.

Mine.—Bennett mine, Des Moines, Polk county, south side Raccoon river. No railroad connections.

Sample collected.—June 21, 1909.

Description.—The mine was sampled at the end of the fourth west entry off the first south entry. The vein here measured 4 feet 6 inches. Its average thickness is 4 feet 4 inches, with occasional portions up to 5 or 6 feet. The coal is clean, without rock or sulphur bands, and breaks into angular fragments.

The mine is 125 feet deep and employs 100 men who put out 100-300 tons daily. The mine has been running six years and supplies a large local trade. See page 120.

Sample No. 16

Operator.—Enterprise Coal Company, Des Moines.

Mine.—Mine No. 2, Enterprise, Polk county, on St. Paul and Des Moines Railroad.

Sample collected.—June 22, 1909.

Description.—The sample was cut from the break-through near the face of the second west entry off the first south entry. The coal was 5 feet thick here, and carried a two-inch sulphur band one foot from the top. Clay slips are present in places. This mine is considered to be in the second vein and is the only one now working this horizon with the possible exception of the Bennett mine. A daily output of 400 tons is maintained. See page 143.

CHEMICAL ANALYSES OF COALS

Chemical Analysis of Mine Sample No. 1, from High Bridge Mine of the High Bridge Coal Company, High Bridge, Dallas Co., Iowa.

Laboratory sample number	18	.....	18
Loss of moisture on air drying, per cent.....	10.47	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	8.65	per cent.....	19.12
Volatile matter, per cent	33.14	per cent.....	29.34
Fixed carbon, per cent..	45.00	per cent.....	39.84
Ash, per cent.....	13.21	per cent.....	11.70
	100.00		100.00
Sulphur, per cent.....	2.75	per cent.....	2.44
Calorific value, B. T. U....	11,675	B. T. U.....	10,338
Calorific value, Calories...	6,486	Calories	5,743

Chemical Analysis of Mine Sample No. 2, from the Ogden Mine of the Ogden Coal Co., Two Miles North of Ogden, Boone Co., Iowa.

Laboratory sample number	13	.....	13
Loss of moisture on air drying, per cent.....	10.65	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	8.91	per cent.....	19.56
Volatile matter, per cent	37.81	per cent.....	33.43
Fixed carbon, per cent..	43.31	per cent.....	38.29
Ash, per cent.....	9.97	per cent.....	8.82
	100.00		100.00
Sulphur, per cent.....	6.10	per cent.....	5.40
Calorific value, B. T. U....	11,894	B. T. U.....	10,515
Calorific value, Calories...	6,608	Calories	5,841

Chemical Analysis of Mine Sample No. 3, from Willow Grove Coal Company, Angus, Greene Co., Iowa.

Laboratory sample number	17	.....	17
Loss of moisture on air drying, per cent.....	8.08	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	5.57	per cent.....	13.65
Volatile matter, per cent	38.73	per cent.....	35.41
Fixed carbon, per cent..	40.40	per cent.....	30.94
Ash, per cent.....	15.30	per cent.....	14.00
	100.00		100.00
Sulphur, per cent.....	5.37	per cent.....	4.91
Calorific value, B. T. U....	11,234	B. T. U.....	10,274
Calorific value, Calories...	6,241	Calories	5,708

Chemical Analysis of Mine Sample No. 4, from the Blyth Mine of the Atwood Coal Company, Rose Hill, Mahaska Co., Iowa.

Laboratory sample number	10	.....	10
Loss of moisture on air drying, per cent.....	9.53	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	5.58	per cent.....	15.11
Volatile matter, per cent	36.34	per cent.....	32.68
Fixed carbon, per cent..	44.30	per cent.....	39.83
Ash, per cent.....	13.78	per cent.....	12.38
	100.00		100.00
Sulphur, per cent.....	6.51	per cent.....	5.85
Calorific value, B. T. U....	11,814	B. T. U.....	10,623
Calorific value, Calories...	6,563	Calories	5,901

Chemical Analysis of Mine Sample No. 5, from Mine of Armstrong Brothers, What Cheer, Keokuk Co., Iowa.

Laboratory sample number	12	.....	12
Loss of moisture on air drying, per cent.....	7.83	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	7.43	per cent.....	15.26
Volatile matter, per cent	38.21	per cent.....	34.99
Fixed carbon, per cent..	41.10	per cent.....	37.62
Ash, per cent.....	13.26	per cent.....	12.13
	100.00		100.00
Sulphur, per cent.....	5.15	per cent.....	4.72
Calorific value, B. T. U....	11,410	B. T. U.....	10,445
Calorific value, Calories...	6,339	Calories	5,803

Chemical Analysis of Mine Sample No. 6, from Crescent Mine No. 5, of the Crescent Coal Co., White City, Mahaska Co., Iowa.

Laboratory sample number	11	.....	11
Loss of moisture on air drying, per cent.....	6.82	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	6.17	per cent.....	12.98
Volatile matter, per cent	36.71	per cent.....	34.04
Fixed carbon, per cent..	41.72	per cent.....	38.68
Ash, per cent.....	15.40	per cent.....	14.30
	100.00		100.00
Sulphur, per cent.....	5.87	per cent.....	5.47
Calorific value, B. T. U....	11,497	B. T. U.....	10,663
Calorific value, Calories...	6,387	Calories	5,924

Chemical Analysis of Mine Sample No. 7, from Bear Creek Mine of the Phillips Fuel Company, Ottumwa, Iowa.

Laboratory sample number	16	.....	16
Loss of moisture on air drying, per cent.....	7.49	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	4.79	per cent.....	12.28
Volatile matter, per cent	37.59	per cent.....	34.64
Fixed carbon, per cent..	43.22	per cent.....	39.82
Ash, per cent.....	14.40	per cent.....	13.26
	100.00		100.00
Sulphur, per cent.....	6.63	per cent.....	6.11
Calorific value, B. T. U....	11,695	B. T. U.....	10,776
Calorific value, Calories...	6,497	Calories	5,987

Chemical analysis of Mine Sample No. 8, From Rutledge No. 5 Mine of the Phillips Fuel Company, Ottumwa, Iowa.

Laboratory sample number	19	.....	19
Loss of moisture on air drying, per cent.....	7.53	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	5.84	per cent.....	13.37
Volatile matter, per cent	38.78	per cent.....	35.68
Fixed carbon, per cent..	44.14	per cent.....	40.61
Ash, per cent.....	11.24	per cent.....	10.34
	100.00		100.00
Sulphur, per cent.....	6.26	per cent.....	5.76
Calorific value, B. T. U....	12,010	B. T. U.....	11,051
Calorific value, Calories...	6,672	Calories	6,139

Chemical Analysis of Mine Sample No. 9, from Mine No. 4 of the Wapello Coal Company, Hiteman, Monroe Co., Iowa.

Laboratory sample number	15	.....	15
Loss of moisture on air drying, per cent.....	8.21	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	8.40	per cent.....	16.51
Volatile matter, per cent	36.26	per cent.....	33.01
Fixed carbon, per cent..	42.80	per cent.....	38.97
Ash, per cent.....	12.54	per cent.....	11.41
	100.00		100.00
Sulphur, per cent.....	2.10	per cent.....	1.92
Calorific value, B. T. U....	11,564	B. T. U.....	10,528
Calorific value, Calories...	6,424	Calories	5,849

Chemical Analysis of Mine Sample No. 10, from Mine No. 1 of Campbell Coal Co., New Market, Taylor Co., Iowa.

Laboratory sample number	14	.....	14
Loss of moisture on air drying, per cent.....	10.97	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	9.24	per cent.....	20.21
Volatile matter, per cent	34.17	per cent.....	30.05
Fixed carbon, per cent..	43.60	per cent.....	38.33
Ash, per cent.....	12.99	per cent.....	11.41
	100.00		100.00
Sulphur, per cent.....	4.78	per cent.....	4.18
Calorific value, B. T. U....	11,494	B. T. U.....	10,115
Calorific value, Calories...	6,385	Calories	5,619

Chemical Analysis of Mine Sample No. 11, from Mine No. 2 of the Bolton-Hoover Coal Company, Bolton, Mahaska Co., Iowa.

Laboratory sample number	23	.....	23
Loss of moisture on air drying, per cent.....	9.16	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	5.48	per cent.....	14.64
Volatile matter, per cent	40.15	per cent.....	36.26
Fixed carbon, per cent..	44.88	per cent.....	40.53
Ash, per cent.....	9.49	per cent.....	8.57
	100.00		100.00
Sulphur, per cent.....	3.26	per cent.....	2.94
Calorific value, B. T. U....	12,183	B. T. U.....	11,003
Calorific value, Calories...	6,768	Calories	6,113

Chemical Analysis of Mine Sample No. 12, from Hawkeye Mine of the English Creek Coal Mining Company, Hawkeye, near Knoxville, Marion Co., Iowa.

Laboratory sample number	21	.....	21
Loss of moisture on air drying, per cent.....	13.80	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	4.50	per cent.....	18.30
Volatile matter, per cent	36.37	per cent.....	31.12
Fixed carbon, per cent..	44.36	per cent.....	37.95
Ash, per cent.....	14.77	per cent.....	12.63
	100.00		100.00
Sulphur, per cent.....	6.03	per cent.....	5.16
Calorific value, B. T. U....	11,939	B. T. U.....	10,215
Calorific value, Calories...	6,633	Calories	5,675

Chemical Analysis of Mine Sample No. 13, from Mine No. 8 of the Colfax Consolidated Coal Company, near Colfax, Jasper Co., Iowa.

Laboratory sample number	24	.....	24
Loss of moisture on air drying, per cent.....	12.68	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	5.47	per cent.....	18.15
Volatile matter, per cent	39.17	per cent.....	33.91
Fixed carbon, per cent..	42.94	per cent.....	37.18
Ash, per cent.....	12.42	per cent.....	10.76
	100.00		100.00
Sulphur, per cent.....	3.49	per cent.....	3.02
Calorific value, B. T. U....	11,588	B. T. U.....	10,034
Calorific value, Calories...	6,438	Calories	5,574

Chemical Analysis of Mine Sample No. 14, from Mine of the Keystone Coal Mining Company, Third Vein, Des Moines, Polk Co., Iowa.

Laboratory sample number	20	.....	20
Loss of moisture on air drying, per cent.....	8.64	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	4.78	per cent.....	13.42
Volatile matter, per cent	38.06	per cent.....	34.60
Fixed carbon, per cent..	41.83	per cent.....	38.03
Ash, per cent.....	15.33	per cent.....	13.95
	100.00		100.00
Sulphur, per cent.....	6.26	per cent.....	5.70
Calorific value, B. T. U....	11,481	B. T. U.....	10,440
Calorific value, Calories...	6,378	Calories	5,800

Chemical analysis of Mine Sample No. 15, from Mine of the Bennett Bros. Coal Company, Des Moines, Polk Co., Iowa.

Laboratory sample number	22	.....	22
Loss of moisture on air drying, per cent.....	8.77	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	4.62	per cent.....	13.39
Volatile matter, per cent	38.88	per cent.....	35.30
Fixed carbon, per cent..	44.20	per cent.....	40.14
Ash, per cent.....	12.30	per cent.....	11.17
	100.00		100.00
Sulphur, per cent.....	5.15	per cent.....	4.68
Calorific value, B. T. U....	12,139	B. T. U.....	11,023
Calorific value, Calories...	6,744	Calories	6,124

Chemical Analysis of Mine Sample No. 16, from Mine No. 2 of the Enterprise Coal Company, Second Vein, Enterprise, Polk Co., Iowa.

Laboratory sample number	25	.....	25
Loss of moisture on air drying, per cent.....	8.61	.....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent.....	6.08	per cent.....	14.69
Volatile matter, per cent	41.01	per cent.....	37.25
Fixed carbon, per cent..	44.17	per cent.....	40.12
Ash, per cent.....	8.74	per cent.....	7.94
	100.00		100.00
Sulphur, per cent.....	3.79	per cent.....	3.44
Calorific value, B. T. U....	12,454	B. T. U.....	11,313
Calorific value, Calories...	6,919	Calories	6,285

The analyses on the following pages for which G. E. Patrick is given as authority are taken from Iowa Geological Survey, volume II, pp. 504-509, 1894. Samuel Calvin, Geologist.

Those given on authority of Rush Emery are taken from Geology of Iowa, Vol. II, pp. 361-395. 1870. C. A. White, State Geologist.

Those given on authority of G. Hinrichs are quoted from First and Second Annual Report of the State Geologist, pp. 222-224, 1868. C. A. White, State Geologist.

Those for whom J. D. Whitney is given as authority are taken from Geology of Iowa, Vol. I, pp. 403-414. 1858. James Hall, State Geologist.

Where the Iowa State College is quoted as authority the analyses are given in Volume XVII of Iowa Geological Survey, pp. 170 ff, 529, 530, or, in the various county reports published by the present Survey.

Those analyses given on authority of N. W. Lord are found in U. S. G. S., Bull. No. 261, pp. 41-43, and Professional Paper No. 48, pp. 221-225, 270. The analyses were made at the fuel testing plant at St. Louis in 1904.

The analysis given by D. D. Owen is found in Geol. Iowa, Wisconsin and Illinois, p. 53, 1839.

Those credited to the State University are here published for the first time.

Analyses credited to George W. Prentiss are from the laboratory of the Chicago, Milwaukee and Saint Paul Railway, West Milwaukee, Wis. With the exception of the analyses from Foster, Moravia and F. W. Cox, Excelsior, sulphur was not determined separately, but one-half is assigned to volatile combustible and one-half to fixed carbon.

It should be noted that the high moisture content of the mine samples analyzed at the St. Louis Testing Station is due in part at least to the fact that these samples were put immediately upon being gathered into air-tight tin flasks and thus retained all their moisture when received at the chemical laboratory. The same is true of the mine samples analyzed at the State University. In the case of the car samples the coal would naturally lose several per cent of moisture by evaporation before it was delivered to the boiler. It is probable, therefore, that the analyses of these car samples correspond in general to most of the analyses from other sources.

CHEMICAL ANALYSES OF IOWA COALS

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR			Calorimetry B. T. U.	AUTHORITY
							In sulphides	In sulphates	Total		
ADAMS COUNTY—											
Plowman shaft, Briscoe, top	8.97	80.48	10.55	36.44	44.04	54.59	3.15	.11	3.26	------	G. E. Patrick
Same, middle of seam	9.09	74.95	15.96	32.04	42.91	58.87	2.46	.13	2.59	------	G. E. Patrick
Same, bottom of seam	8.72	77.39	13.89	32.01	45.38	59.27	3.67	.27	3.94	------	G. E. Patrick
Wyles mine, Carbon, average	8.01	80.12	11.87	35.26	44.86	56.73	4.25	.11	4.36	------	G. E. Patrick
Reese mine, Carbon, average	9.12	81.51	9.36	35.71	45.79	55.12	3.89	.18	4.07	------	G. E. Patrick
Hinton mine, Eureka, average	8.68	81.91	9.70	33.85	47.72	57.43	4.38	.19	4.58	------	G. E. Patrick
Rawson mine, Quincy, "fresh coal"	10.41	83.66	5.93	35.13	48.53	54.46	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	93.38	6.62	39.20	54.18	60.80	------	------	------	------	Rush Emery
Same "opened fourteen months"	10.29	85.54	4.17	38.32	47.22	51.39	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	95.35	4.65	42.71	52.64	57.29	------	------	------	------	Rush Emery
Average of county, two samples	10.35	84.60	5.05	36.72	47.88	52.93	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	94.37	5.63	40.96	53.41	59.04	------	------	------	------	Rush Emery
Average of 6	8.76	79.34	11.89	34.22	45.12	------	------	------	3.60	------	Iowa State Col'ge
APPANOOSE COUNTY—											
Diamond mine, Centerville, top	9.66	82.06	8.28	34.72	47.34	55.62	2.57	.14	2.71	------	G. E. Patrick
Same, middle of seam	10.12	83.67	6.21	35.63	48.04	54.25	2.13	.07	2.20	------	G. E. Patrick
Same, middle of seam, calculated on dried coal	------	93.09	6.91	39.64	53.45	------	2.45	.08	2.53	------	G. E. Patrick
Same, bottom of seam	10.28	84.64	5.08	36.89	47.75	52.83	2.67	.13	2.80	------	G. E. Patrick
Scandinavian mine, Centerville, average	9.23	40.46	6.97	36.21	47.58	54.55	2.79	.12	2.91	------	G. E. Patrick

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR			Calorimetry B. T. U.	AUTHORITY
							In sulphides	In sulphates	Total		
Appanoose mine, Cincinnati, sample of room	6.54	80.37	13.09	36.20	44.17	57.26	4.40	.13	4.53	------	G. E. Patrick
Same, vein above clay seam	6.20	78.11	15.69	34.00	44.11	59.80	3.67	.16	3.83	------	G. E. Patrick
Same, vein below lower clay seam	7.53	75.14	17.33	29.31	45.83	63.16	6.73	.82	7.55	------	G. E. Patrick
Thistle mine, Cincinnati, top	3.18	85.22	11.60	36.55	48.67	60.27	3.57	.11	3.68	------	G. E. Patrick
Same, middle of seam	5.80	90.71	3.49	37.71	53.00	56.49	2.97	.05	3.02	------	G. E. Patrick
Same, middle of seam, calculated to dry basis	------	96.29	3.71	40.03	56.26	------	3.15	.05	3.20	------	G. E. Patrick
Same, bottom of seam	6.02	87.80	6.18	36.90	50.90	57.08	3.13	.17	3.30	------	G. E. Patrick
Same, below sulphur band	2.88	72.69	24.43	29.03	43.66	68.09	3.61	.43	4.04	------	G. E. Patrick
Whitebreast No. 19, Forbush, average	9.70	82.98	7.31	35.84	47.14	54.45	4.14	.27	4.41	------	G. E. Patrick
Average 12	7.26	83.54	9.20	35.87	47.67	------	------	------	3.75	------	Iowa State Col'ge
Centerville Block Coal Co	11.49	82.03	6.52	33.47	48.56	------	------	------	2.92	12,681	Iowa State Col'ge
Same	------	92.64	7.36	37.79	54.85	------	------	------	3.29	12,681	Iowa State Col'ge
Centerville Block Coal Co., lump coal	14.00	74.80	10.90	35.50	39.30	------	------	------	4.26	10,723	Iowa State Col'ge
Same, Mystic seam, mine sample No. 1	17.13	75.80	7.07	35.44	40.36	------	------	------	4.00	10,931	N. W. Lord
Same, air-dried sample	8.53	83.67	7.80	39.12	44.55	------	------	------	4.42	12,065	N. W. Lord
Same, Mystic seam, mine sample No. 2	16.14	72.78	11.08	34.94	37.84	------	------	------	4.76	------	N. W. Lord
Same, air-dried sample	8.25	79.63	12.12	38.23	41.40	------	------	------	5.21	------	N. W. Lord
Same, Mystic seam, car sample	14.08	74.96	10.96	35.59	39.37	------	------	------	4.26	10,723	N. W. Lord
Same, air-dried sample	10.02	78.49	11.48	37.27	41.22	------	------	------	4.46	11,227	N. W. Lord
Same, washed coal	17.88	74.98	7.14	37.59	37.39	------	------	------	3.57	------	N. W. Lord
Same, air-dried sample	14.81	77.78	7.41	38.99	38.79	------	------	------	3.70	------	N. W. Lord
Same, coke sample	13.05	75.42	11.53	2.32	73.10	------	------	------	2.97	------	N. W. Lord
Same, air-dried sample	2.30	84.74	12.96	2.60	82.14	------	------	------	3.33	------	N. W. Lord

Lodwick Bros. Coal Co., Mystic	16.21	78.74	5.05	32.74	46.00	------	------	------	2.64	12,780	Iowa State Col'ge
Same	------	93.98	6.02	39.07	54.91	------	------	------	3.15	12,780	Iowa State Col'ge
*Same, Walnut Valley	12.58	79.41	4.69	34.65	44.76	------	------	------	3.32	------	Geo. N. Prentiss
Moravia	6.18	79.52	14.30	40.73	38.79	------	------	------	4.06	------	Geo. N. Prentiss
Anchor Coal Co., steam coal	10.00	74.70	15.30	33.00	41.70	------	------	------	------	9,963	Iowa State Col'ge
Same, lump coal	8.20	75.70	16.00	30.70	45.00	------	------	------	5.03	11,027	Iowa State Col'ge
BOONE COUNTY—											
Angus mine, Angus, average	8.62	82.75	8.64	38.33	44.41	53.05	2.59	.08	2.67	------	G. E. Patrick
Dalby mine, Angus, top of seam	2.71	87.26	10.03	39.90	47.36	57.39	5.17	.15	5.32	------	G. E. Patrick
Same, middle of seam	2.13	92.14	5.73	44.21	47.93	53.66	3.72	.10	3.82	------	G. E. Patrick
Same, bottom of seam	3.69	85.70	10.61	45.12	40.58	51.19	4.10	.16	4.25	------	G. E. Patrick
Northwestern mine, Boonesboro, top	13.23	81.21	5.56	37.52	43.69	49.25	------	------	------	------	Rush Emery
Same, bottom of seam	11.51	82.60	5.89	38.86	43.74	49.63	------	------	------	------	Rush Emery
Same, top of seam, calculated on dried coal	------	93.61	6.39	43.25	50.36	56.75	------	------	------	------	Rush Emery
Same, bottom of seam, calculated on dried coal	------	93.34	6.66	43.91	49.43	56.09	------	------	------	------	Rush Emery
Average of county, 2 samples	12.37	81.91	5.72	38.19	43.72	49.44	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	93.48	6.52	43.58	49.90	56.42	------	------	------	------	Rush Emery
Crowe Coal Co., Boone	4.03	88.09	7.88	39.79	48.30	------	------	------	3.99	12,729	Iowa State Col'ge
Same	------	91.79	8.21	41.46	50.33	------	------	------	4.16	12,729	Iowa State Col'ge
Street Railway Power Plant	11.49	64.16	24.36	26.33	37.83	------	------	------	9.53	------	Iowa State Col'ge
Boone Coal & Mining Co., Frazer mine	14.77	73.71	11.48	37.67	36.05	47.53	2.76	0.19	2.95	------	Iowa State Col'ge
Average of 6	6.82	85.44	7.74	40.99	44.45	------	------	------	4.01	------	Iowa State Col'ge
Johnson Coal Co., Boone, slack, 9 samples	11.70	48.20	40.10	22.10	26.10	------	------	------	------	7,363	Iowa State Col'ge
Same, lump, 5 samples	15.30	69.30	15.20	27.70	41.60	------	------	------	------	11,412	Iowa State Col'ge
Rogers Coal Co., Boone, slack, 3 samples	12.00	46.50	41.20	20.40	26.10	------	------	------	------	7,463	Iowa State Col'ge
Heaps & Crowe, Boone, lump coal	13.30	60.70	26.00	27.80	32.90	------	------	------	------	9,905	Iowa State Col'ge
Same, slack, 4 samples	12.00	46.00	42.00	14.80	31.20	------	------	------	------	7,588	Iowa State Col'ge
Ogden Coal Co., Ogden	19.56	71.72	8.82	33.43	38.29	------	------	------	5.40	10,515	State Univ. Iowa
Same, air-dried sample	8.91	81.12	9.97	37.81	43.31	------	------	------	6.10	11,894	State Univ. Iowa

*Sulpbur not separately determined.

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR			Calorimetry B. T. U.	AUTHORITY
							In sulphides	In sulphates	Total		
DALLAS COUNTY—											
Tudor mine, Dawson, top	4.64	81.73	13.63	39.84	41.89	55.52	2.08	.13	2.21	------	G. E. Patrick
Same, middle of seam	5.62	79.86	14.52	36.79	43.07	57.59	4.69	.24	4.93	------	G. E. Patrick
Same, bottom of seam	6.55	84.00	9.45	37.45	46.55	56.00	3.27	.08	3.35	------	G. E. Patrick
Keeler mine, Linden, average	7.41	67.97	24.61	27.86	40.10	64.72	6.53	.65	7.18	------	G. E. Patrick
Redfield mine, Redfield, top	11.36	78.15	10.49	38.46	39.69	50.18	2.76	.04	2.80	------	G. E. Patrick
Same, middle of seam	10.55	75.60	13.85	30.18	45.42	59.27	3.83	.24	4.07	------	G. E. Patrick
Same, bottom of seam	12.76	72.94	14.30	34.72	38.22	52.52	3.01	.10	3.11	------	G. E. Patrick
Tabor mine, Woodward, average	7.15	77.94	14.90	35.54	42.40	57.30	5.74	.69	6.44	------	G. E. Patrick
Redfield mine, Des Moines Coal Co	12.83	83.74	3.43	37.30	46.44	49.87	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	96.07	3.93	42.79	53.28	57.21	------	------	------	------	Rush Emery
Average of 8	8.25	77.28	14.47	35.11	42.17	------	------	------	4.24	------	Iowa State Col'ge
Platt Pressed and Fire Brick Co., Van Meter	------	91.58	8.42	40.54	51.04	------	------	------	3.68	11,941	Iowa State Col'ge
High Bridge Coal Co., High Bridge	19.12	69.18	11.70	29.34	39.84	------	------	------	2.44	10,338	State Univ. Iowa
Same, air-dried sample	8.65	78.14	13.21	33.14	45.00	------	------	------	2.75	11,675	State Univ. Iowa
DAVIS COUNTY—											
Dye mine, Laddsdale, bottom	4.48	87.40	8.12	44.26	43.14	51.26	4.26	.12	4.38	------	G. E. Patrick
Sickles mine, Laddsdale, top of seam	3.06	92.34	4.60	42.82	49.52	54.12	5.19	.23	5.42	------	G. E. Patrick
Same, middle of seam	2.06	90.66	7.28	43.84	46.82	54.10	6.51	.29	6.80	------	G. E Patrick
Same, bottom of seam	2.59	75.41	22.00	36.97	38.44	60.44	7.05	.22	7.27	------	G. E. Patrick
Same, average	2.57	86.13	11.29	41.21	44.43	56.22	6.25	.24	6.49	------	G. E. Patrick

Bloomfield	5.24	87.66	7.10	37.00	50.66	------	------	------	2.25	13,204	Iowa State Col'ge
Average of 5	2.95	86.29	10.66	41.82	44.47	------	------	------	6.07	------	Iowa State Col'ge
Lumsden Coal Co	------	92.52	7.48	39.06	53.46	------	------	------	2.38	12,097	Iowa State Col'ge
DECATUR COUNTY—											
Coals from veins penetrated in Sharp's prospect, Leon. See p. 247 of this vol.											
Vein No. 1	4.98	80.31	14.71	34.79	45.52	------	------	------	2.51	------	U. S. Geol. Surv.
Veins Nos. 1 and 2	5.59	79.52	15.89	40.33	38.19	------	------	------	3.55	------	Iowa State Col'ge
Vein No. 3	4.22	88.07	7.71	40.23	47.84	------	------	------	4.05	------	U. S. Geol. Surv.
Vein No. 3	4.76	85.14	10.10	39.68	45.46	------	------	------	3.62	------	Iowa State Col'ge
Vein No. 4	5.09	80.94	13.97	42.62	38.32	------	------	------	2.68	------	Iowa State Col'ge
Vein No. 5	5.02	84.60	10.32	44.30	40.30	------	------	------	3.78	------	U. S. Geol. Surv.
Vein No. 5	5.45	79.95	14.60	41.01	38.94	------	------	------	8.75	------	Iowa State Col'ge
Veins Nos. 7 and 8	3.85	88.70	9.45	47.80	40.90	------	------	------	3.70	------	Iowa State Col'ge
GREENE COUNTY—											
Bussey mine, Rippey	9.92	87.92	2.16	44.39	43.53	45.69	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	97.60	2.40	49.28	48.32	50.72	------	------	------	------	Rush Emery
Kennedy mine, Rippey, top of seam	7.01	84.08	8.91	43.94	40.14	49.05	3.62	.06	3.68	------	G. E. Patrick
Same, middle of seam	9.40	81.64	8.96	39.76	41.88	50.84	3.39	.05	3.44	------	G. E. Patrick
Same, bottom of seam	9.70	82.90	7.40	40.36	42.54	49.94	2.94	.06	3.00	------	G. E. Patrick
Average of 4	9.01	84.14	6.86	42.11	43.03	------	------	------	3.37	------	Iowa State Col'ge
Willow Grove Coal Co., Angus	13.65	66.35	14.00	35.41	30.94	------	------	------	4.91	10,274	State Univ. Iowa
Same, air-dried sample	5.57	79.13	15.30	38.73	40.40	------	------	------	5.37	11,234	State Univ. Iowa
GUTHRIE COUNTY—											
Eclipse mine, Fanslers, top of seam	7.73	86.44	5.83	39.85	46.59	52.42	3.62	.05	3.67	------	G. E. Patrick
Same, middle of seam	7.04	83.61	9.35	37.94	45.67	55.02	4.32	.07	4.39	------	G. E. Patrick
Same, bottom of seam	6.89	76.23	16.88	32.67	43.56	60.44	9.50	.68	10.18	------	G. E. Patrick
Reese mine, Panora, cannel	4.88	59.09	36.03	30.80	28.29	64.32	10.57	.50	11.07	------	G. E. Patrick
Same, average, bituminous	6.41	80.39	13.19	38.07	42.32	55.51	5.59	.13	5.72	------	G. E. Patrick
Suggett mine, Stuart, top of seam	9.61	79.19	11.20	34.63	44.56	55.76	4.01	.11	4.12	------	G. E. Patrick
Same, bottom of seam	9.30	81.07	9.63	36.80	44.27	53.90	3.48	.05	3.53	------	G. E. Patrick
Marshall mine, Long Branch	13.39	82.50	4.11	34.96	47.54	51.65	------	------	------	------	Rush Emery

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR			Calorimetry B. T. U.	AUTHORITY
							In sulphides	In sulphates	Total		
Same, calculated on dried coal	------	95.26	4.74	40.38	54.88	59.62	------	------	------	------	Rush Emery
Wasson mine, Panora	11.90	78.84	9.26	35.86	42.98	52.24	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	89.49	10.51	40.70	48.79	59.30	------	------	------	------	Rush Emery
Lonsdale mine, Deer Creek	13.22	84.08	2.70	37.25	46.83	49.53	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	96.89	3.11	42.92	53.97	57.08	------	------	------	------	Rush Emery
Average of county, three samples	12.84	81.80	5.36	36.02	45.78	51.14	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	93.88	6.12	41.33	52.55	58.67	------	------	------	------	Rush Emery
Average of 7	7.41	78.00	14.59	35.82	42.18	------	------	------	6.08	------	Iowa State Col'ge
HAMILTON COUNTY—											
Silver mine, Webster City	9.00	84.80	6.20	34.19	50.61	56.81	3.09	1.12	4.21	------	G. E. Patrick
Stockdale mine, bottom of seam	7.22	82.61	10.17	35.16	47.45	57.62	5.80	.21	6.01	------	G. E. Patrick
Same, top of seam	8.01	84.96	7.03	37.99	46.97	54.00	5.28	.11	5.39	------	G. E. Patrick
HARDIN COUNTY—											
Fuller mine, Eldora	12.45	79.37	8.18	35.73	43.64	51.82	------	------	------	------	J. D. Whitney
Same, calculated on dried coal	------	90.66	9.34	40.81	49.85	59.19	------	------	------	------	J. D. Whitney
Chaffin mine, Eldora, top of seam	11.32	83.52	5.16	32.69	50.83	55.99	2.02	1.47	3.49	------	G. E. Patrick
Same, middle of seam	10.90	80.17	8.63	38.98	41.49	50.12	1.76	1.89	3.65	------	G. E. Patrick
Same, bottom of seam	9.63	84.29	6.08	34.44	49.85	55.93	2.25	.30	2.55	------	G. E. Patrick
Buckner mine, Eldora	7.92	87.26	4.82	42.54	44.72	49.54	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	94.77	5.23	46.20	48.57	53.80	------	------	------	------	Rush Emery

Sample found at Eldora	7.92	83.62	8.46	40.80	42.82	51.28					Rush Emery
Same, calculated on dried coal		90.81	9.19	44.31	46.50	55.69					Rush Emery
Average of county, 2 samples	7.92	85.44	6.44	41.67	43.77	50.41					Rush Emery
Same, calculated on dried coal		92.79	7.21	45.25	47.54	54.75					Rush Emery
JASPER COUNTY—											
Jasper mine, Colfax, top of seam	7.72	79.97	12.31	38.14	41.83	54.14	3.73	.48	4.21		G. E. Patrick
Same, middle of seam	8.38	77.86	13.76	35.78	42.08	55.84	1.11	.13	1.24		G. E. Patrick
Same, bottom of seam	8.88	77.66	13.46	32.21	45.45	58.91	4.87	.05	4.92		G. E. Patrick
Snook mine, Newton	4.61	87.71	7.68	44.41	43.30	50.98					Rush Emery
Same, calculated on dried coal		91.95	8.05	46.56	45.39	53.44					Rush Emery
Slaughter bank, Newton	8.33	86.23	5.44	41.72	44.51	49.95					J. D. Whitney
Same, calculated on dried coal		94.07	5.93	45.51	48.56	54.49					J. D. Whitney
Jasper County Coal & Mining Co., Colfax	5.45	87.46	7.09	40.49	46.97				2.91	12,134	Iowa State Col'ge
Same		92.51	7.49	42.24	50.27				3.08	12,134	Iowa State Col'ge
Average of 4	7.40	80.81	11.08	37.64	43.17				3.46		Iowa State Col'ge
Colfax Consolidated Coal Co., Colfax, mine No. 6	9.34	79.27	12.39	39.19	39.08				2.84	11,206	Iowa State Col'ge
Same, steam coal	11.50	72.30	16.20	30.80	41.50					10,742	Iowa State Col'ge
Same, mine No. 8	18.15	71.19	10.76	33.91	37.18				3.02	10,034	State Univ. Iowa
Same, air-dried sample	5.47	82.11	12.42	39.17	42.94				3.49	11,588	State Univ. Iowa
*JEFFERSON COUNTY—											
Shaw bank, Perlee	2.00	93.50	4.50	50.20	43.40	47.80					G. Hinrichs
Coalport mine, Fairfield	1.20	94.40	4.40	48.40	46.00	50.40					G. Hinrichs
Richardson mine, Fairfield, top of seam	2.10	92.20	5.70	46.00	46.20	51.90					G. Hinrichs
Same, bottom of seam	0.70	97.70	1.60	48.80	48.90	50.50					G. Hinrichs
Young & Stubbs mine, Fairfield, top of seam	0.90	95.00	4.10	44.60	50.40	54.50					G. Hinrichs
Same, bottom of seam	0.30	88.70	11.10	46.50	42.20	53.30					G. Hinrichs
Read mine, Fairfield	2.50	85.90	11.60	42.00	44.00	55.50					G. Hinrichs
Average for county, 7 samples	1.40	92.50	6.10	46.60	45.90	51.00					G. Hinrichs

*The samples from this county had been in a warmed room about a week previous to being analyzed, hence the small amounts of moisture.

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR			Calorimetry B. T. U.	AUTHORITY
							In sulphides	In sulphates	Total		
KEOKUK COUNTY—											
Pioneer mine, Thornburg, top of seam...	4.78	92.65	2.57	49.17	43.48	46.05	4.38	.20	4.58	------	G. E. Patrick
Same, middle of seam.....	7.79	89.83	2.38	44.05	45.78	48.16	2.06	.39	2.45	------	G. E. Patrick
Same, bottom of seam.....	5.56	86.18	8.28	38.37	47.79	56.07	2.45	.07	2.52	------	G. E. Patrick
What Cheer, No. 5, What Cheer, top of seam	5.40	75.90	18.70	35.16	40.74	59.44	13.79	.92	14.71	------	G. E. Patrick
Same, middle of seam.....	5.96	82.16	11.88	35.89	46.27	58.15	6.56	.29	6.85	------	G. E. Patrick
Same, bottom of seam.....	7.14	76.26	16.60	33.96	42.30	58.90	6.67	.40	7.07	------	G. E. Patrick
Average of 6.....	6.11	83.82	10.07	39.43	44.39	------	------	------	6.36	------	Iowa State Col'ge
Armstrong mine, What Cheer.....	15.26	72.61	12.13	34.99	37.62	------	------	------	4.72	10,445	State Univ. Iowa
Same, air-dried sample.....	7.43	79.31	13.26	38.21	41.10	------	------	------	5.15	11,41(	State Univ. Iowa
*Crescent Coal Co., What Cheer.....	4.75	61.19	22.10	29.77	31.42	59.50	------	------	11.96	------	Geo. N. Prentiss
*Same	1.08	82.00	9.96	34.84	47.16	60.60	------	------	6.96	------	Geo. N. Prentiss
LUCAS COUNTY—											
Cleveland mine, Cleveland, top of seam..	9.95	80.27	9.78	37.70	42.57	52.35	3.69	.07	3.76	------	G. E. Patrick
Same, middle of seam.....	9.39	84.21	6.43	38.62	45.59	52.02	2.69	.06	2.75	------	G. E. Patrick
Same, bottom of seam.....	7.46	82.11	10.43	36.99	45.12	55.55	2.97	.07	3.04	------	G. E. Patrick
Same, average of seam.....	8.92	82.19	8.88	37.77	44.43	53.30	3.11	.07	3.18	------	G. E. Patrick
Lucas mine, Lucas, average.....	11.29	79.88	8.83	37.13	42.69	51.52	2.89	.08	3.98	------	G. E. Patrick
Inland Fuel Co., Chariton, lump coal....	15.30	71.80	12.60	30.40	41.40	------	------	------	3.19	10,242	Iowa State Col'ge
Same, mine sample No. 1.....	18.69	73.58	7.73	31.80	41.78	------	------	------	2.39	10,505	N. W. Lord
Same, air-dried sample.....	10.25	81.22	8.53	35.10	46.12	------	------	------	2.64	11,596	N. W. Lord

Same, mine sample No. 2	18.59	74.26	7.15	34.36	39.90				3.10		N. W. Lord
Same, air-dried sample	12.37	79.93	7.70	36.98	42.95				3.34		N. W. Lord
Same, car sample, run-of-mine	15.39	71.98	12.63	30.49	41.49				3.19	10,242	N. W. Lord
Same, air-dried sample	9.22	77.23	13.55	32.71	44.52				3.42	10,989	N. W. Lord
Same, washed coal	19.25	72.82	7.93	31.07	41.75				2.28		N. W. Lord
Same, air-dried sample	13.45	78.05	8.50	30.30	44.75				2.44		N. W. Lord
Average of 5	9.40	81.73	8.87	37.65	44.08				3.34		Iowa State Col'ge
MADISON COUNTY—											
Clark mine, Northbranch	6.75	77.28	15.97	31.85	45.43	61.40					Rush Emery
Same, calculated on dried coal		82.94	17.06	34.17	48.77	65.83					Rush Emery
MAHASKA COUNTY—											
American mine, Evans, top of seam	3.55	91.84	4.61	46.43	45.41	50.02	3.48	.09	3.57		G. E. Patrick
Same, middle of seam	5.16	90.71	4.13	45.42	45.29	49.42	3.65	.06	3.71		G. E. Patrick
Same, bottom of seam	4.45	83.33	12.22	36.46	46.87	59.09	4.17	.06	4.23		G. E. Patrick
Same, cannel-like part	5.13	84.91	9.96	42.46	42.45	52.41	4.79	.41	5.20		G. E. Patrick
Griffitb mine, Given, average	2.84	83.85	13.31	41.01	42.84	56.15	4.41	.08	4.49		G. E. Patrick
Burns mine, Oskaloosa	4.01	93.83	2.16	47.76	46.07	48.23					Rush Emery
Same, calculated on dried coal		97.74	2.26	49.75	47.99	50.25					Rush Emery
Carey mine, Rose Hill, average	4.91	84.70	10.39	41.69	43.01	53.40	5.00	.09	5.09		G. E. Patrick
Burtis mine, Oskaloosa, top of seam	5.23	90.27	4.50	42.27	48.00	52.50					Rush Emery
Same, calculated on dried coal		95.26	4.74	44.61	50.65	55.39					Rush Emery
Same, bottom of seam	5.38	82.63	11.99	34.03	48.60	60.59					Rush Emery
Same, calculated on dried coal		87.33	12.67	35.96	51.37	64.04					Rush Emery
Garretson & Seever mine, Oskaloosa, top of seam					49.51	48.29	44.35	1.22	92.64	6.14	Rush Emery
Same, calculated on dried coal		98.71	1.29	47.25	51.46	52.75					Rush Emery
Upper part of seam	4.66	80.62	14.72	35.62	45.00	59.72					Rush Emery
Same, calculated on dried coal		84.56	15.44	37.36	47.20	62.64					Rush Emery
Nichol mine, Oskaloosa, top of seam	3.28	95.43	1.29	40.28	55.15	56.44					Rush Emery
Same calculated on dried coal		98.66	1.34	41.65	57.01	58.35					Rush Emery
Same, bottom of seam	4.30	86.50	9.20	34.06	52.44	61.64					Rush Emery
Same, calculated on dried coal		90.39	9.61	35.60	54.79	64.40					Rush Emery
Haddon bank, Oskaloosa	4.83	90.62	4.55	37.76	52.86	57.41					Rush Emery
Same, calculated on dried coal		95.21	4.79	39.68	55.53	60.32					Rush Emery

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR			Calorimetry B. T. U.	AUTHORITY
							In sulphides	In sulphates	Total		
Average of county, 8 samples	4.73	88.07	6.20	39.52	49.55	55.75	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	93.48	6.52	41.48	52.00	58.52	------	------	------	------	Rush Emery
Given mine, Oskaloosa, top of seam	1.70	85.80	12.60	39.90	45.90	58.50	------	------	------	------	G. Hinrichs
Same, bottom of seam	2.90	84.70	13.40	44.50	40.20	53.60	------	------	------	------	G. Hinrichs
Iowa Coal Co. mine, Oskaloosa, top of seam	4.90	92.40	2.70	46.50	45.90	48.60	------	------	------	------	G. Hinrichs
Same, bottom of seam	5.10	88.40	6.50	39.90	48.50	55.00	------	------	------	------	G. Hinrichs
Roberts & Co. mine, Oskaloosa, top of seam	3.90	90.90	5.20	42.10	48.80	54.00	------	------	------	------	G. Hinrichs
Same, bottom of seam	6.40	87.50	6.20	41.00	46.50	52.60	------	------	------	------	G. Hinrichs
Average of 6 samples	4.10	88.20	7.70	42.30	46.00	53.70	------	------	------	------	G. Hinrichs
Whitebreast Fuel Co., Pekay	9.98	83.67	6.35	41.46	42.21	------	------	------	2.53	13,050	Iowa State Col'ge
Same	------	92.95	7.05	46.06	46.89	------	------	------	2.81	13,050	Iowa State Col'ge
Atwood Coal Co., Blyth	15.11	72.51	12.38	32.68	39.83	------	------	------	5.85	10,623	State Univ. Iowa
Same, air-dried sample	5.58	80.64	13.78	36.34	44.30	------	------	------	6.51	11,814	State Univ. Iowa
Crescent Coal Co., White City, No. 5	12.98	72.72	14.30	34.04	38.68	------	------	------	5.47	10,663	State Univ. Iowa
Same, air-dried sample	6.17	78.43	15.40	36.71	41.72	------	------	------	5.87	11,497	State Univ. Iowa
Bolton-Hoover Coal Co., Bolton No. 2	14.64	76.79	8.57	36.26	40.53	------	------	------	2.94	11,002	State Univ. Iowa
Same, air-dried sample	5.48	85.03	9.49	40.15	44.88	------	------	------	3.26	12,183	State Univ. Iowa
Excelsior Coal, Co., Excelsior	5.45	81.30	9.85	40.65	40.65	52.20	------	------	3.40	------	Geo. N. Prentiss
*Same	3.73	87.84	3.83	49.97	37.87	44.00	------	------	4.60	------	Geo. N. Prentiss
F. W. Cox, Excelsior	5.46	85.35	9.19	36.77	48.58	------	------	------	2.59	------	Geo. N. Prentiss
*American Coal Co., Oskaloosa	2.30	85.41	6.44	48.87	36.54	45.90	------	------	5.85	------	Geo. N. Prentiss
*Same	5.82	72.74	18.40	30.56	42.18	62.10	------	------	3.04	------	Geo. N. Prentiss

MARION COUNTY—											
Bousquet mine, Coalport, bottom of seam	5.89	90.79	3.32	43.25	47.54	50.86	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	96.47	3.53	45.94	50.53	54.06	------	------	------	------	Rush Emery
Same, top of seam	5.95	78.60	15.45	34.97	43.63	58.08	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	83.57	16.43	37.18	46.39	62.82	------	------	------	------	Rush Emery
Sherwood mine, Marysville, top of seam	5.62	92.58	1.80	36.61	55.97	57.77	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	98.09	1.91	38.80	59.29	61.20	------	------	------	------	Rush Emery
Same, bottom of seam	6.12	83.19	10.69	31.49	51.70	62.39	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	88.62	11.38	33.54	55.08	66.46	------	------	------	------	Rush Emery
Yanser mine, Marysville, top of seam	5.56	90.54	3.90	40.38	50.16	54.06	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	95.86	4.14	42.75	53.11	57.25	------	------	------	------	Rush Emery
Same, bottom of seam	5.82	87.14	7.04	38.56	48.58	55.62	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	92.53	7.47	40.94	51.59	59.06	------	------	------	------	Rush Emery
Sherwood, Newman & Ferren mine, Oskaloosa, top of seam	5.73	92.14	2.13	46.54	45.60	47.73	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	98.73	2.27	49.36	48.37	50.64	------	------	------	------	Rush Emery
Same, bottom of seam	5.38	87.83	6.79	39.76	48.07	54.86	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	92.82	7.18	42.02	50.80	57.98	------	------	------	------	Rush Emery
Clemen mine, Marysville	6.81	85.29	7.90	36.01	49.28	57.18	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	91.53	8.47	38.64	52.89	61.36	------	------	------	------	Rush Emery
Bussing mine, Knoxville, top of seam	6.56	89.54	3.90	45.29	44.25	48.15	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	95.81	4.19	48.44	47.37	51.56	------	------	------	------	Rush Emery
Same, middle of seam	6.40	79.72	13.88	39.35	40.37	54.25	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	85.17	14.83	42.04	43.13	57.96	------	------	------	------	Rush Emery
Same, bottom of seam	5.72	91.76	2.52	46.30	45.46	47.98	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	97.33	2.67	49.11	48.22	50.89	------	------	------	------	Rush Emery
Average of county, 12 samples	5.97	87.43	6.60	39.88	47.55	54.15	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	92.96	7.04	42.40	50.56	57.60	------	------	------	------	Rush Emery
Roberts & Fisher bank, Otley, top of seam	9.30	84.70	6.00	41.80	42.90	48.90	------	------	------	------	G. Hinrichs
Same, bottom of seam	10.70	81.50	7.80	38.30	43.20	51.00	------	------	------	------	G. Hinrichs
O'Neal bank, Knoxville, upper bed	7.80	82.40	9.80	35.40	47.00	56.80	------	------	------	------	G. Hinrichs
Same, lower bed	7.70	81.60	10.70	35.70	45.90	56.60	------	------	------	------	G. Hinrichs
Nossaman bank, Flagler, top of seam	3.90	90.00	6.20	42.40	47.50	53.70	------	------	------	------	G. Hinrichs
Same, bottom of seam	4.80	77.70	17.50	40.20	37.40	54.90	------	------	------	------	G. Hinrichs
Average of 6 samples	7.40	82.90	9.70	38.90	44.00	53.70	------	------	------	------	G. Hinrichs

*Sulpbur not separately determined.

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR			Calorimetry B. T. U.	AUTHORITY
							In sulphides	In sulphates	Total		
Average of 4	6.17	87.06	6.78	37.79	49.27	------	------	------	------	------	Iowa State Col'ge
Mammoth Vein Coal Co., Everist, lump coal	14.20	70.50	15.20	33.10	37.40	------	------	------	4.66	10,019	Iowa State Col'ge
Mine No. 5, Mammoth Vein Coal Co., Hamilton, mine sample No. 1	15.65	72.71	11.64	36.87	35.84	------	------	------	5.10	10,289	N. W. Lord
Same, air-dried sample	7.00	80.17	12.83	40.65	39.52	------	------	------	5.49	11,344	N. W. Lord
Same, mine sample No. 2	15.50	75.31	9.19	36.94	38.37	------	------	------	5.19	------	N. W. Lord
Same, air-dried sample	6.63	83.22	10.15	40.82	42.40	------	------	------	5.74	------	N. W. Lord
Same, car sample, run-of-mine	14.21	70.57	15.22	33.17	37.40	------	------	------	4.66	10,019	N. W. Lord
Same, air-dried sample	4.25	78.76	16.99	37.02	41.74	------	------	------	5.20	11,182	N. W. Lord
Same, car sample, second portion	16.99	68.55	14.46	33.03	35.52	------	------	------	5.15	------	N. W. Lord
Same, air-dried sample	1.76	81.13	17.11	39.09	42.04	------	------	------	6.09	------	N. W. Lord
Same, washed coal	18.85	70.87	10.28	35.44	35.43	------	------	------	3.93	------	N. W. Lord
Same, air-dried sample	9.73	78.83	11.44	39.42	39.41	------	------	------	4.37	------	N. W. Lord
English Creek Coal Co., Hawkeye	18.30	69.07	12.63	31.12	37.95	------	------	------	5.16	10,215	State Univ. Iowa
Same, air-dried sample	4.50	80.73	14.77	36.37	44.36	------	------	------	6.03	11,939	State Univ. Iowa
MONROE COUNTY—											
Chicago and Iowa mine, Albia, average	6.09	81.20	12.67	43.19	38.04	50.71	5.54	.19	5.73	------	G. E. Patrick
Enterprise mine, average	5.09	89.51	5.39	44.62	44.89	50.28	4.91	.29	5.20	------	G. E. Patrick
Iowa and Wisconsin mine, Albia, top of seam	4.02	63.70	32.28	31.15	32.55	64.83	7.17	.87	8.04	------	G. E. Patrick
Same, middle of seam	4.94	83.26	11.80	38.23	45.03	56.83	4.96	.34	5.30	------	G. E. Patrick
Same, bottom of seam	4.00	86.45	9.55	34.95	51.50	61.05	4.09	.29	4.38	------	G. E. Patrick

Smoky Hollow mine, Avery, average	5.05	87.57	7.38	42.64	44.93	52.30	4.20	.59	4.79	------	G. E. Patrick
Deep Vein mine, Foster, top of seam	5.75	81.04	13.21	40.36	40.68	53.89	4.24	.36	4.60	------	G. E. Patrick
Same, middle of seam	6.67	91.03	2.30	44.75	46.28	48.58	3.34	.10	3.44	------	G. E. Patrick
Same, bottom of seam	5.77	79.29	14.94	35.25	44.04	58.98	5.21	.20	5.41	------	G. E. Patrick
Miller mine, Albia, bottom of seam	4.71	89.14	6.15	37.84	51.30	57.45	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	93.54	6.46	39.70	53.84	60.30	------	------	------	------	Rush Emery
Same, top of seam	4.57	89.02	6.41	43.80	45.22	51.63	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	93.28	6.72	45.89	47.39	54.11	------	------	------	------	Rush Emery
Buchanan mine, Albia	5.16	86.09	8.75	40.21	45.88	54.63	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	90.78	9.22	42.40	43.38	57.60	------	------	------	------	Rush Emery
Barber mine, Albia	6.04	92.06	1.90	42.49	49.57	51.47	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	97.97	2.03	45.22	52.75	54.78	------	------	------	------	Rush Emery
Perry mine, Albia	4.43	89.20	6.37	42.69	46.51	52.88	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	93.34	6.66	44.67	48.67	55.33	------	------	------	------	Rush Emery
Miller mine, N. E. of Albia	4.90	91.37	3.73	43.65	47.72	51.45	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	96.08	3.92	45.90	50.18	54.10	------	------	------	------	Rush Emery
Average of county, 6 samples	4.97	89.48	5.55	41.78	47.70	53.25	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	94.16	5.84	43.96	50.20	56.04	------	------	------	------	Rush Emery
Whitebreast Fuel Co., Hilton	6.51	83.04	10.45	37.97	45.07	------	------	------	3.02	12,396	Iowa State Col'ge
Same	------	88.82	11.18	40.61	48.21	------	------	------	3.26	12,396	Iowa State Col'ge
Hocking Coal Co., mine No. 3	6.63	79.25	14.12	38.37	40.88	------	------	------	6.92	------	Iowa State Col'ge
Same, mine No. 1	------	84.88	15.12	40.02	44.86	------	------	------	7.41	12,037	Iowa State Col'ge
Same, mine No. 2	5.80	85.27	9.03	42.56	42.71	------	------	------	3.75	12,560	Iowa State Col'ge
Same	------	90.52	9.48	45.18	45.34	------	------	------	3.98	12,560	Iowa State Col'ge
Consolidation Coal Co., Buxton, mine No. 10	9.48	81.65	10.87	35.58	46.07	------	------	------	2.06	12,030	Iowa State Col'ge
Same	------	93.71	6.29	48.69	45.02	------	------	------	3.58	12,030	Iowa State Col'ge
Same, mine No. 9	6.19	85.90	5.91	43.60	42.30	------	------	------	3.45	------	Iowa State Col'ge
Same, mine No. 11	------	89.92	12.08	37.09	50.83	------	------	------	2.27	10,585	Iowa State Col'ge
Average of 8	5.55	84.80	9.65	40.38	44.42	------	------	------	5.21	------	Iowa State Col'ge
Smoky Hollow Coal Co., Avery, steam coal	10.80	73.20	16.00	35.40	37.80	------	------	------	------	9,719	Iowa State Col'ge
Mine No. 6, Smoky Hollow Coal Co., Avery, "third seam"	12.03	78.59	9.38	40.62	37.97	------	------	------	5.04	------	N. W. Lord
Same, air-dried sample	5.81	84.14	10.05	43.49	40.65	------	------	------	5.41	------	N. W. Lord
Same	15.84	74.78	9.38	36.90	37.88	------	------	------	4.68	10,854	N. W. Lord
Same, air-dried sample	6.07	83.46	10.47	41.18	42.28	------	------	------	5.22	12,114	N. W. Lord
Wapello Coal Co., Hiteman, No. 4	16.51	71.98	11.41	33.01	38.97	------	------	------	1.92	10,528	State Univ. Iowa
Same, air-dried sample	8.40	79.06	12.54	36.26	42.80	------	------	------	2.10	11,564	State Univ. Iowa
*Soap Creek Coal Co., Foster	6.41	81.85	7.87	42.18	39.67	------	------	------	3.87	------	Geo. N. Prentiss
Foster	6.57	81.53	11.90	47.91	33.62	------	------	------	7.60	11,541	Geo. N. Prentiss

*Sulphur not separately determined.

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR			Calorimetry B. T. U.	AUTHORITY
							In sulphides	In sulphates	Total		
POLK COUNTY—											
Redhead mine, Des Moines	4.80	89.00	2.30	44.70	44.30	50.50	------	------	------	------	G. Hinrichs
Christy mine, Des Moines, top of seam	5.53	88.05	6.42	44.70	43.35	49.77	4.78	.09	4.87	------	G. E. Patrick
Same, middle of seam	6.18	84.12	9.70	38.65	45.47	55.17	5.14	.15	5.56	------	G. E. Patrick
Same, bottom of seam	6.60	75.62	17.78	33.84	41.78	59.56	4.79	.19	4.98	------	G. E. Patrick
Same, average	6.10	82.59	11.30	39.06	43.53	54.83	4.99	.14	5.13	------	G. E. Patrick
Gibson mine, Des Moines, average	7.04	82.89	9.72	40.06	43.17	52.89	4.09	.16	4.25	------	G. E. Patrick
Manbeck mine, Des Moines, average	6.82	76.58	16.19	36.93	39.65	56.84	4.44	.29	4.73	------	G. E. Patrick
Marquisville	5.09	91.03	3.88	43.30	47.73	------	------	------	2.60	10,574	Iowa State Col'ge
Average of 5	6.43	83.61	11.96	38.84	44.77	------	------	------	4.87	------	Iowa State Col'ge
Flint Brick Co., Des Moines, steam coal	13.00	69.60	16.20	30.10	39.50	------	------	------	------	9,952	Iowa State Col'ge
Norwood Coal Co., Norwoodville, steam coal	14.20	70.70	15.00	32.30	38.40	------	------	------	------	10,479	Iowa State Col'ge
Gibson Coal Mining Co., Des Moines, lump coal	13.80	72.00	14.00	36.90	35.10	------	------	------	6.15	10,244	Iowa State Col'ge
Marquisville, nut coal	5.80	73.50	20.60	30.00	43.50	------	------	------	------	11,136	Iowa State Col'ge
Mine No. 4, Gibson Coal Mining Co., Altoona, "third vein," mine sample No. 1	14.42	74.59	10.99	37.81	36.78	------	------	------	5.89	10,640	N. W. Lord
Same, air-dried sample	5.33	82.51	12.16	41.82	40.69	------	------	------	6.52	11,770	N. W. Lord
Same, mine sample No. 2	15.90	71.73	12.37	37.42	34.31	------	------	------	6.76	------	N. W. Lord
Same, air-dried sample	5.51	80.59	13.90	42.04	38.55	------	------	------	7.59	------	N. W. Lord
Same, car sample, lump coal	13.88	72.11	14.01	36.94	35.17	------	------	------	6.15	10,244	N. W. Lord
Same, air-dried sample	4.52	79.95	15.53	40.96	38.99	------	------	------	6.83	11,356	N. W. Lord

Same, washed coal	16.83	75.14	8.03	39.27	35.87	------	------	------	4.55	------	N. W. Lord
Same, air-dried sample	10.67	80.71	8.62	42.18	38.53	------	------	------	4.88	------	N. W. Lord
Same, coke sample	5.73	77.36	16.91	1.87	75.49	------	------	------	4.57	------	N. W. Lord
Same, air-dried sample	1.80	80.59	17.61	1.95	78.64	------	------	------	4.76	------	N. W. Lord
Des Moines Coal and Mining Co	------	95.91	4.09	45.62	50.29	------	------	------	2.74	12,041	Iowa State Col'ge
Keystone Coal Mining Co., Des Moines	13.42	72.63	13.95	34.60	38.03	------	------	------	5.70	10,440	State Univ. Iowa
Same, air-dried sample	4.78	79.89	15.33	38.06	41.83	------	------	------	6.26	11,481	State Univ. Iowa
Bennett Coal Co., Des Moines	13.39	75.44	11.17	35.30	40.14	------	------	------	4.68	11,023	State Univ. Iowa
Same, air-dried sample	4.62	83.08	12.30	38.88	44.20	------	------	------	5.15	12,139	State Univ. Iowa
Enterprise Coal Co., Enterprise, mine No. 2	14.69	77.37	7.94	37.25	40.12	------	------	------	3.44	11,313	State Univ. Iowa
Same, air-dried sample	6.08	85.18	8.74	41.01	44.17	------	------	------	3.79	12,454	State Univ. Iowa
POWESHIEK COUNTY—											
Smith & Barrowman mine, Searsboro, top of seam	5.41	89.30	5.29	41.39	47.91	53.26	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	94.41	5.59	43.77	50.64	56.23	------	------	------	------	Rush Emery
Same, bottom of seam	6.28	86.67	7.05	36.51	50.16	57.21	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	92.47	7.53	38.95	53.52	61.05	------	------	------	------	Rush Emery
Same, average of undried coal	5.84	87.99	6.17	38.95	49.04	55.21	------	------	------	------	Rush Emery
Same, average of dried coal	------	93.44	6.56	41.36	52.08	58.64	------	------	------	------	Rush Emery
Smith & Barrowman mine, Searsboro	8.20	89.50	2.40	42.00	47.40	49.80	------	------	------	------	G. Hiurichs
SCOTT COUNTY—											
Havill coal bank, Buffalo	2.87	77.21	19.90	36.39	40.82	60.72	------	------	0.19	------	J. D. Whitney
Same, calculated on dried coal	------	79.50	20.48	37.47	42.03	62.51	------	------	------	------	J. D. Whitney
"Lower coal," Buffalo	3.13	87.85	9.02	38.77	49.08	58.10	------	------	1.57	------	J. D. Whitney
Same, calculated on dried coal	------	90.69	9.31	40.02	50.67	59.98	------	------	------	------	J. D. Whitney
Friedley & Hoyt mine, Buffalo, top of seam	3.48	89.79	6.73	41.32	48.47	55.20	4.99	.54	5.33	------	G. E. Patrick
Same, middle of seam	3.66	87.46	8.88	41.44	46.02	54.90	3.72	.15	3.87	------	G. E. Patrick
Same, bottom of seam	2.89	82.03	15.08	38.09	43.94	59.02	7.80	.38	8.18	------	G. E. Patrick
Hanlon & Blackwell mine, Buffalo, top of seam	2.66	86.66	10.68	42.10	44.56	55.24	3.11	.05	3.16	------	G. E. Patrick
Same, bottom of seam	5.07	83.59	11.34	39.33	44.26	55.60	4.38	.22	4.60	------	G. E. Patrick

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR			Calorimetry B. T. U.	AUTHORITY
							In sulphides	In sulphates	Total		
Friedley mine, Muscatine	3.94	92.98	3.08	37.46	55.52	58.60	3.03	.07	3.10	------	G. E. Patrick
Average of 6	3.61	87.18	9.29	39.95	47.13	------	------	------	4.71	------	Iowa State Col'ge
Duck creek, Sec. 27, Twp. 70, R. 4 E.	------	92.50	7.50	42.50	50.00	------	------	------	------	------	D. D. Owen
TAYLOR COUNTY—											
Adams shaft, New Market	8.00	79.68	12.31	35.41	44.29	56.58	5.29	.59	5.88	------	G. E. Patrick
Anderson mine, New Market, average	8.06	80.57	11.36	34.99	45.58	56.95	4.72	.45	5.17	------	G. E. Patrick
Campbell mine, New Market, top of seam	7.44	80.64	11.92	37.79	42.85	54.77	3.54	.14	3.68	------	G. E. Patrick
Same, middle of seam	8.21	82.77	9.02	35.28	47.49	56.51	3.85	.43	4.28	------	G. E. Patrick
Same, bottom of seam	7.94	79.93	12.13	37.41	42.52	54.65	4.70	.54	5.24	------	G. E. Patrick
Average of 5	5.93	80.71	11.34	36.17	44.54	------	------	------	4.85	------	Iowa State Col'ge
Campbell Coal Co., New Market, mine No. 1	20.21	68.38	11.41	30.05	38.33	------	------	------	4.18	10,115	State Univ. Iowa
Same, air-dried sample	9.24	77.77	12.99	34.17	43.60	------	------	------	4.78	11,494	State Univ. Iowa
VAN BUREN COUNTY—											
Cox coal bank, Hillsboro	7.92	88.50	3.58	41.74	46.76	50.34	------	------	.29	------	J. D. Whitney
Same, calculated on dried coal	------	96.11	3.89	45.33	50.78	54.67	------	------	------	------	J. D. Whitney
Crail bank, Hillsboro	5.30	92.33	2.37	37.98	54.35	56.72	------	------	0.55	------	J. D. Whitney
Same, calculated on dried coal	------	97.50	2.50	40.11	57.39	59.89	------	------	------	------	J. D. Whitney
Slaughter bank, Farmington	8.62	85.50	5.88	38.08	47.42	53.30	------	------	1.02	------	J. D. Whitney
Same, calculated on dried coal	------	93.57	6.43	41.67	51.90	58.33	------	------	------	------	J. D. Whitney

Specimen one-half mile above Farmington	4.62	88.37	7.01	37.27	51.10	58.11	------	------	------	------	J. D. Whitney
Same, calculated on dried coal	------	92.65	7.35	39.07	53.58	61.93	------	------	------	------	J. D. Whitney
Manhard bank, Selma	7.76	88.34	3.90	40.23	48.11	52.01	------	------	1.69	------	J. D. Whitney
Same, calculated on dried coal	------	95.77	4.23	43.62	52.15	56.38	------	------	------	------	J. D. Whitney
Specimen from Business Corners	5.42	87.19	7.39	39.39	47.80	55.19	------	------	0.49	------	J. D. Whitney
Same, calculated on dried coal	------	92.19	7.81	41.65	50.54	58.35	------	------	------	------	J. D. Whitney
Average of 3	8.10	87.44	4.45	40.01	47.43	------	------	------	------	------	Iowa State Col'ge
New York Coal Co. mine, Farmington, top of seam	6.40	87.20	7.10	43.20	44.00	50.10	------	------	------	------	G. Hinrichs
Same, bottom of seam	6.40	88.50	5.10	45.70	42.90	47.90	------	------	------	------	G. Hinrichs
*Business Corner mine, Business Corners, top of seam	1.30	97.40	1.30	51.10	46.20	47.50	------	------	------	------	G. Hinrichs
*Same, bottom of seam	1.30	93.80	4.90	50.10	43.70	48.60	------	------	------	------	G. Hinrichs
Rodefer bank, Independent, top of seam	6.10	91.40	2.50	46.80	44.70	47.10	------	------	------	------	G. Hinrichs
Same, bottom of seam	6.60	86.20	7.20	47.40	38.80	46.00	------	------	------	------	G. Hinrichs
Carmine bank, Sec. 13, Twp. 70, R. 8, top of seam	5.40	86.70	6.90	40.30	46.40	53.30	------	------	------	------	G. Hinrichs
Same, bottom of seam	4.50	87.30	8.30	45.90	41.40	49.70	------	------	------	------	G. Hinrichs
*Carter mine, Bentonsport	1.70	91.30	6.90	41.90	49.40	56.40	------	------	------	------	G. Hinrichs
Average for county, 9 samples	4.40	90.00	5.60	47.00	43.00	50.60	------	------	------	------	G. Hinrichs
WAPELLO COUNTY—											
Whitebreast No. 22, Keb, top of seam	5.54	84.79	9.67	41.24	43.55	53.22	6.35	.11	6.46	------	G. E. Patrick
Same, middle of seam	6.82	82.03	11.15	35.29	46.74	57.89	9.53	.16	9.69	------	G. E. Patrick
Same, bottom of seam	7.55	79.09	13.36	33.43	45.66	59.02	6.05	.25	6.30	------	G. E. Patrick
Same, sample of room	5.08	74.54	20.38	33.66	40.88	61.26	6.49	.28	6.77	------	G. E. Patrick
Eldon mine, Laddsdale, top	3.81	93.39	2.80	41.69	51.70	54.50	2.57	.33	2.90	------	G. E. Patrick
Same, middle of seam	3.72	85.37	10.91	42.88	42.49	53.40	2.93	.66	3.59	------	G. E. Patrick
Same, bottom of seam	3.24	87.97	8.79	45.82	42.15	50.94	2.80	.56	3.36	------	G. E. Patrick
Brigg mine, Eddyville	4.07	94.55	1.38	50.65	43.90	45.28	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	98.56	1.44	52.80	45.76	47.20	------	------	------	------	Rush Emery
Brown & Godfrey mine, Ottumwa	6.50	89.60	3.90	41.35	48.25	52.15	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	95.83	4.17	44.22	51.61	55.78	------	------	------	------	Rush Emery
Wylie mine, Eddyville	3.95	85.69	10.36	36.98	48.71	59.07	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	89.22	10.78	38.51	50.71	61.49	------	------	------	------	Rush Emery

*These samples had been in a warm room about a week before being analyzed, hence the small amount of moisture.

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR			Calorimetry B. T. U.	AUTHORITY
							In sulphides	In sulphates	Total		
Allen mine, Ottumwa, top of seam	5.06	67.93	27.01	27.61	40.32	67.33					Rush Emery
Same, calculated on dried coal		71.55	28.45	29.08	42.47	70.92					Rush Emery
Same, bottom of seam	3.35	91.79	4.86	46.75	45.04	49.90					Rush Emery
Same, calculated on dried coal		94.98	5.02	48.37	46.61	51.63					Rush Emery
Dudley mine, Dudley, top of seam	5.48	92.51	2.01	45.76	46.75	48.76					Rush Emery
Same, calculated on dried coal		97.88	2.12	48.41	49.47	51.59					Rush Emery
Same, bottom of seam	4.97	87.01	8.02	42.50	44.51	52.53					Rush Emery
Same, calculated on dried coal		91.56	8.44	44.72	46.84	55.28					Rush Emery
Evans mine, Chilicothe, top of seam	6.98	89.47	3.55	39.36	50.11	53.66					Rush Emery
Same, calculated on dried coal		96.17	3.83	42.31	53.86	57.69					Rush Emery
Same, bottom of seam	6.16	90.08	3.76	36.96	53.12	56.88					Rush Emery
Same, calculated on dried coal		96.00	4.00	39.39	56.61	60.61					Rush Emery
Marshall mine, Eddyville, top of seam	5.21	87.70	7.09	42.19	45.51	52.60					Rush Emery
Same, calculated on dried coal		92.52	7.48	44.51	48.01	55.49					Rush Emery
Same, bottom of seam	5.85	88.46	5.59	39.69	48.77	54.46					Rush Emery
Same, calculated on dried coal		93.96	6.04	42.16	51.80	57.84					Rush Emery
Inskeep mine, Ottumwa, top of seam	3.87	92.11	4.02	42.96	49.15	53.17					Rush Emery
Same, calculated on dried coal		95.82	4.18	44.69	51.13	55.31					Rush Emery
Same, bottom of seam	3.68	85.49	10.83	42.05	43.44	54.27					Rush Emery
Same, calculated on dried coal		88.77	11.23	43.66	45.11	56.34					Rush Emery
Heacock mine, Chilicothe, top of seam	5.35	87.65	7.00	42.41	45.24	52.24					Rush Emery
Same, calculated on dried coal		92.61	7.39	44.81	47.80	55.19					Rush Emery
Same, bottom of seam	3.89	77.77	18.34	36.94	40.83	59.17					Rush Emery
Same, calculated on dried coal		80.91	19.09	38.43	42.48	61.57					Rush Emery
Average of county, 15 samples	4.96	87.19	7.85	40.94	46.25	54.10					Rush Emery

Same, calculated on dried coal	------	91.76	8.24	43.07	48.69	56.93	------	------	------	------	Rush Emery
Roseland Coal Co., Ottumwa, steam coal	11.20	71.90	15.70	30.70	41.20	------	------	------	------	8,594	Iowa State Col'ge
Average of 11	5.42	83.98	10.60	38.73	45.25	------	------	------	5.85	------	Iowa State Col'ge
Henry Shock & Co., Sec 8, Twp. 78, R. 14, top of seam	7.80	85.00	7.20	38.60	46.50	53.60	------	------	------	------	G. Hinrichs
Same, bottom of seam	6.10	90.00	3.90	41.70	48.30	52.30	------	------	------	------	G. Hinrichs
Alpine Coal Co., Alpine, top of seam	4.20	88.70	7.20	44.70	44.00	51.20	------	------	------	------	G. Hinrichs
Same, bottom of seam	4.90	81.80	13.30	39.10	42.70	56.00	------	------	------	------	G. Hinrichs
Brown & Godfrey mine, Ottumwa, top of seam	7.10	84.90	8.00	43.60	41.30	49.30	------	------	------	------	G. Hinrichs
Same, middle of seam	7.40	88.50	4.20	44.30	44.10	48.30	------	------	------	------	G. Hinrichs
Same, bottom of seam	3.50	86.20	10.30	40.00	46.10	56.50	------	------	------	------	G. Hinrichs
Average for county, 7 samples	6.90	85.40	7.70	41.70	43.70	52.40	------	------	------	------	G. Hinrichs
Mine No. 2, Anchor Coal Co., Laddsdale, middle seam	11.35	78.14	10.51	38.65	39.49	------	------	------	4.72	11,345	N. W. Lord
Same, air-dried sample	3.74	84.85	11.41	41.96	42.89	------	------	------	5.12	12,317	N. W. Lord
Same, lower seam	12.07	75.60	12.33	37.28	38.32	------	------	------	4.99	------	N. W. Lord
Same, air-dried sample	4.43	82.17	13.40	40.52	41.65	------	------	------	5.42	------	N. W. Lord
Same, car sample, lump and fine coal	8.24	75.76	16.00	30.74	45.02	------	------	------	5.03	11,027	N. W. Lord
Same, air-dried sample	5.21	78.27	16.52	31.76	46.51	------	------	------	5.20	11,392	N. W. Lord
Same, washed coal	12.84	76.91	10.25	35.91	41.00	------	------	------	4.61	------	N. W. Lord
Same, air-dried sample	8.92	80.37	10.71	37.53	42.84	------	------	------	4.82	------	N. W. Lord
Same, coke sample	10.53	71.99	17.45	1.63	70.39	------	------	------	3.89	------	N. W. Lord
Same, air-dried sample	2.11	78.80	19.09	1.79	77.01	------	------	------	4.25	------	N. W. Lord
Keb	9.81	82.24	7.95	37.49	44.75	------	------	------	------	------	C., B. & Q. R. R.
Eldon Coal & Mining Co., Laddsdale	4.23	86.68	9.09	40.92	45.76	------	------	------	4.75	13,141	Iowa State Col'ge
Same	------	90.50	9.50	42.72	47.78	------	------	------	4.96	13,141	Iowa State Col'ge
Carbon Coal Co., Willard	------	91.14	8.86	36.94	54.20	------	------	------	2.86	12,245	Iowa State Col'ge
Phillips Fuel Co., Bear Creek mine	12.28	74.46	13.26	34.64	39.82	------	------	------	6.11	10,776	State Univ. Iowa
Same, air-dried sample	4.79	80.81	14.40	37.59	43.22	------	------	------	6.63	11,695	State Univ. Iowa
Same	2.12	82.93	14.95	48.19	34.74	49.69	------	------	6.82	12,304	C., M. & St. P. Ry.
Phillips Fuel Co., Rutledge No. 5	13.37	76.29	10.34	35.68	40.61	------	------	------	5.76	11,051	State Univ. Iowa
Same, air-dried sample	5.84	82.92	11.24	38.78	44.14	------	------	------	6.26	12,010	State Univ. Iowa
Phillips Fuel Co., Rutledge	------	------	------	------	------	------	------	------	------	12,550	Geo. N. Prentiss

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR			Calorimetry B. T. U.	AUTHORITY
							In sulphides	In sulphates	Total		
WARREN COUNTY—											
Bennum mine, Summerset, top	7.31	82.09	10.60	36.63	45.46	56.06	5.02	.09	5.11	------	G. E. Patrick
Same, bottom of seam	9.43	82.14	8.43	36.96	45.18	53.61	3.62	.16	3.78	------	G. E. Patrick
Dillard mine, Spring Hill, top of seam	11.56	83.27	5.17	42.89	40.38	45.55	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	94.15	5.85	48.49	45.66	51.51	------	------	------	------	Rush Emery
Same, middle of seam	14.13	80.60	5.27	36.59	44.01	49.28	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	93.87	6.13	42.61	51.26	57.39	------	------	------	------	Rush Emery
Same, below middle of seam	10.76	82.32	6.92	38.76	43.56	50.48	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	92.25	7.75	43.43	48.82	56.57	------	------	------	------	Rush Emery
Same, bottom of seam	12.64	83.17	4.19	41.62	41.55	45.74	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	95.20	4.80	47.64	47.56	52.36	------	------	------	------	Rush Emery
Average of county, four samples	12.27	82.34	5.39	39.96	42.38	47.77	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	93.87	6.13	45.54	48.33	54.46	------	------	------	------	Rush Emery
Average of four	10.60	82.01	7.36	38.26	43.75	------	------	------	4.44	------	Iowa State Col'ge
WAYNE COUNTY—											
Frey mine, Confidence, below parting	9.26	80.45	10.29	34.21	46.24	36.53	4.71	.26	4.97	------	G. E. Patrick
Same, above parting	9.39	78.69	11.92	34.71	43.98	55.90	2.97	.20	3.17	------	G. E. Patrick
Same, middle of seam	8.01	75.41	16.58	37.22	38.19	54.77	3.24	.09	3.33	------	G. E. Patrick
Same, top of seam	9.37	77.12	13.51	31.78	45.34	58.85	3.53	.37	3.90	------	G. E. Patrick
Average of 4	9.01	77.91	13.07	34.48	43.43	------	------	------	3.84	------	Iowa State Col'ge

WEBSTER COUNTY—											
Collins No. 6, Coalville, average	7.48	84.06	8.44	39.52	44.54	52.99	4.98	.26	5.24	------	G. E. Patrick
Collins No. 4, Coalville, average	7.80	82.88	9.32	37.74	45.14	54.46	3.97	.12	4.09	------	G. E. Patrick
Old Reese mine, Fort Dodge	9.92	48.77	41.31	29.69	22.08	63.39	------	------	------	------	G. E. Patrick
Carlson mine, Kalo, average	10.10	76.53	13.36	32.83	43.69	57.06	1.68	.18	1.86	------	G. E. Patrick
Craig Cannel mine, Kalo, "cannel" coal	5.87	78.26	15.87	39.04	39.22	55.09	6.87	.25	7.12	------	G. E. Patrick
Craig slope, Kalo, bituminous	8.46	81.37	10.17	37.97	43.40	53.57	5.19	.10	5.29	------	G. E. Patrick
Crooked Creek mine, Lehigh, top of seam	7.74	78.94	13.32	34.47	44.47	57.79	4.83	.81	5.64	------	G. E. Patrick
Same, middle of seam	8.52	82.65	8.83	38.64	44.01	52.84	3.71	.48	4.19	------	G. E. Patrick
Same, bottom of seam	8.57	81.86	9.57	37.57	44.29	53.86	3.47	.18	3.65	------	G. E. Patrick
Crooked Creek, shaft, Lehigh, average	6.99	76.66	16.34	34.40	42.26	58.60	5.67	.37	6.04	------	G. E. Patrick
Corey mine, Lehigh, average	7.77	81.27	11.00	38.05	43.21	54.21	7.02	.68	7.70	------	G. E. Patrick
Same	------	85.96	14.04	37.98	47.98	------	------	------	5.90	12,431	Iowa State Col'ge
Colburn mine, Fort Dodge	13.02	80.60	6.38	37.54	43.06	49.44	------	------	------	------	J. D. Whitney
Same, calculated on dried coal	------	92.66	7.34	43.16	49.50	56.84	------	------	------	------	J. D. Whitney
Section 18, T. 88, R. 28	14.95	77.87	7.18	34.98	42.89	50.07	------	------	0.81	------	J. D. Whitney
Same, calculated on dried coal	------	91.56	8.44	41.13	50.43	58.87	------	------	------	------	J. D. Whitney
Section 13, T. 88, R. 28	9.46	73.35	17.19	33.69	39.66	56.85	------	------	2.52	------	J. D. Whitney
Same, calculated on dried coal	------	81.01	18.99	37.21	43.80	62.79	------	------	------	------	J. D. Whitney
Rees mine, Fort Dodge	14.05	77.61	8.34	36.42	41.19	49.53	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	90.32	9.68	42.38	47.94	57.62	------	------	------	------	Rush Emery
"Cannel coal," Sec. 17, Twp. 88 N., R. 29 W.	10.46	74.37	15.17	37.44	36.93	52.10	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	83.06	16.94	41.80	41.26	58.20	------	------	------	------	Rush Emery
Section 17, Twp. 88 N., R. 28 W	10.13	73.33	16.54	37.25	36.08	52.62	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	81.59	18.41	41.44	40.15	58.56	------	------	------	------	Rush Emery
Collins mine, Coalville	13.91	78.83	7.26	37.00	41.83	49.09	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	91.57	8.43	42.98	48.59	57.02	------	------	------	------	Rush Emery
"Cannel coal," Rees mine, Fort Dodge	9.92	48.77	41.31	26.69	22.08	63.39	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	54.14	45.86	29.63	24.51	70.37	------	------	------	------	Rush Emery
Average of county, 4 samples	12.14	76.04	11.82	37.03	39.01	50.83	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	86.64	13.36	42.15	44.49	57.85	------	------	------	------	Rush Emery
Tyson seam, near Lehigh	12.70	77.03	10.27	44.12	32.91	------	------	------	5.33	------	Iowa State Col'ge
Lehigh	17.47	70.94	11.59	31.35	39.59	------	------	------	4.87	------	Iowa State Col'ge
Average of 10	7.83	80.65	11.52	37.23	43.42	------	------	------	5.08	------	Iowa State Col'ge

In 1901-02, at the Iowa State College, Mr. F. M. Weakly made a study of the chemical compositions of Iowa coals, from which the following is quoted:

"The moisture in Iowa coals varies (for the coals tested) from 4.03 to 17.47, the average being 8.08. This moisture is high, as compared with that in coals of other states.

"Eliminating moisture from our comparisons, in volatile matter the Iowa coals are rich, varying from 36.94 to 48.69, with an average of 41.49.

"The fixed carbon ranges from 44.86 to 54.91, with an average of 49.62, slightly lower than that of many coals from other states.

"Total combustibles are high, running from 84.88 to 95.91, with an average of 91.11.

"Ash is low, being from 4.09 to 15.12, with an average of 8.89.

"Sulphur is high, from 2.27 to 7.41, with an average of 3.72.

"The coals high in sulphur are also high in ash."

Concurrently with the work of Mr. Weakly, Messrs Austin and Peshak, under the direction of Professor G. W. Bissell, determined the calorific powers of samples of coal from twenty or more mines from the same district, fourteen of the samples being the same as used by Mr. Weakly.

The following table exhibits the results of the work of Messrs. Austin and Peshak:

CALORIFIC POWER OF IOWA COALS.

PER POUND OF DRY FUEL.

	B. T. U.
Slack coal, Marquisville, Iowa	10574
Lumsden Coal and Mining Company	12097
Saylor Coal Company, Marquisville	8585
Des Moines Coal and Mining Company, Marquisville	12041
Whitebreast Fuel Company, Hilton, Iowa	12396
Whitebreast Fuel Company, Pekay, Iowa	13050
Hocking Valley Coal Company, Mine No. 1	12037
Hocking Valley Coal Company, Mine No. 2	12560
Lumsden Coal Company, Bloomfield, Iowa	13204
Humboldt Electric Company, cannel coal, Kalo, Iowa	10451
Humboldt Electric Company, mine coal, Kalo, Iowa	10922
Centerville Block Coal Company	12681
Eldon Coal and Mining Company, Laddsdale	13141
Consolidation Coal Company, Buxton, No. 10	12030
Consolidation Coal Company, Buxton, No. 11	10585

Lodwick Brothers Coal Company, Mystic	12780
Carbon Coal Company, Willard	12245
Crowe Coal Mining Company, Boone	12729
Boone Electric Light Company	9205
Corey Coal Company, Lehigh	12431
Platt Pressed and Fire Brick Company, Van Meter	11941
Jasper County Coal and Mining Company, Colfax	12134
Empire Coal Company	10881
A. A. Conway Coal Company	10132

An average of 64 analyses by the State Geologist gives the following chemical composition:

*Moisture	8.57
Fixed carbon	45.42
Volatile matter	39.24
Ash	6.77
	100.00

Analyses of coal from 16 mines in Des Moines river district give:

†Moisture	8.08
Fixed carbon	45.60
Volatile matter	38.14
Ash	8.18
	100.00
Sulphur	3.42

or on the basis of oven dried samples,

†Fixed carbon	49.62
Volatile matter	41.49
Ash	8.89
	100.00
Sulphur	3.72

Average of Iowa coals:§

Moisture	13.16
Carbon, volatile	33.36
Carbon, fixed	39.69
Ash	13.76
Sulphur	4.65
Calorific value	10,019 to 11,027

*Steam boiler economy. Kent, p. 74.
†F. M. Weakly, the Iowa Engineer, June, 1902.
§Iowa State College Eng. Exp. Station.