SUPPLEMENTARY REPORT
(to Report of 1898)

ON THE

COAL DEPOSITS OF INDIANA.

BY GEORGE HALL ASHLEY.

ACCOMPANIED BY A

CHART OF INDIANA COAL AND MINING.

BY EDWIN F. LINES.

AND TWO APPENDICES:

A. RECENT ANALYSES OF INDIANA COAL.
B. DESCRIPTIVE NOTES ON THE STRATIGRAPHIC CHART.

In Cooperation with the
UNITED STATES GEOLOGICAL SURVEY,
GEORGE OTIS SMITH, Director.
LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR.
UNITED STATES GEOLOGICAL SURVEY.

WASHINGTON, February 23, 1909.

Mr. W. S. Blatchley, State Geologist, Indianapolis, Ind.:

Sir—I have the honor to submit herewith my supplemental report to my 1898 report on the Coal Deposits of Indiana, based on field work in 1908. The revision in the field was confined mainly to the area of commercial mining. In the office the stratigraphy and distribution of the coals over the eastern part of the field has been reviewed in the light of our better knowledge of the general stratigraphy.

While intended primarily simply as a supplement to the coal report, this paper has taken the form of a brief restatement of the geology of the coal deposits as a whole, with notes on the recent developments in the use of Indiana coal.

The time in the office devoted to the review of the eastern part of the coal field, now largely undeveloped commercially, while throwing a great deal of light on that area, left many problems unsolved, and cut seriously into the time available for the preparation of the report.

The writer was assisted in the field by Mr. E. F. Lines, and for a short time by Jno. Udden, Jr. In the office Mr. Lines prepared the chart of Indiana coal and mining.

Very respectfully submitted,

GEO. H. ASHLEY.
Geologist, U. S. G. S.

In charge geologic work in Northern Appalachian and Eastern Interior Coal Fields.
**CONTENTS.**

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Letter of transmittal</td>
<td>14</td>
</tr>
<tr>
<td>A quiz on general facts on Indiana coal and coal deposits</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td><strong>CHAPTER I.</strong></td>
<td>Coal industry of Indiana and geologic work in the coal fields</td>
<td>26</td>
</tr>
<tr>
<td><strong>CHAPTER II.</strong></td>
<td>Indiana coal</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Kinds of coal</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Description of kinds of coal</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Physical properties of Indiana coal</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Chemical properties of Indiana coal</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Commercial and economic character of Indiana coal</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Experimental tests by the U.S. Government</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Results of actual experience</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Smokeless combustion</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Domestic use</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Use of Indiana coal in the producer-gas plant</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Weathering of Indiana coal</td>
<td>53</td>
</tr>
<tr>
<td><strong>CHAPTER III.</strong></td>
<td>Indiana coal measures</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>General character and relation</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>Naming and grouping of the coals and rocks</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Generalized section in Sullivan and Greene counties</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>Coal measures above Coal VII north from Sullivan County</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Coal V to Coal VII inclusive north from Sullivan County</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Coals and rocks above Coal VII south from Sullivan County</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>From Coal V to Coal VII inclusive south from Sullivan County</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>Coal III to base of Coal V from Sullivan and Greene counties northward</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Coals below Coal III north of Sullivan County</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Coals below Coal V from Greene County southward</td>
<td>78</td>
</tr>
<tr>
<td><strong>CHAPTER IV.</strong></td>
<td>The coal beds</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>Number of coal beds</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>Thickness of coal beds</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>Extent of coal beds of Indiana</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>The coal chart</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>Coal VII</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>Coal VI</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>Coal V</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>Coal IV</td>
<td>106</td>
</tr>
<tr>
<td></td>
<td>Coal III</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td>Minshall coal and Coal II</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td>Upper Block coal</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>Lower Block coal</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>Cannelton-Shoals coal</td>
<td>115</td>
</tr>
<tr>
<td><strong>CHAPTER V.</strong></td>
<td>Distribution of coal in Indiana by counties</td>
<td>117</td>
</tr>
<tr>
<td></td>
<td>Warren County</td>
<td>117</td>
</tr>
<tr>
<td></td>
<td>Fountain County</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>Parke County</td>
<td>120</td>
</tr>
</tbody>
</table>
REPORT OF STATE GEOLOGIST.

Vermillion County .................................................. 122
Putnam and Owen counties ........................................... 123
Clay County ............................................................ 123
Vigo County ............................................................. 124
Greene County ......................................................... 125
Sullivan County ........................................................ 126
Martin County .......................................................... 126
Daviess County ........................................................ 127
Knox County ............................................................ 128
Orange and Crawford counties ........................................ 128
Dufoid County .......................................................... 128
Pike County ............................................................. 129
Gibson County .......................................................... 130
Perry County ............................................................ 130
Spencer County ........................................................ 130
Warrick County ........................................................ 131
Vanderburgh and Posey counties ...................................... 131
CHAPTER VI.—Structure of the Indiana coal field ................. 132
CHAPTER VII.—The amount of coal in Indiana ....................... 135
APPENDIX A.—Recent analyses of Indiana coal .................... 144
APPENDIX B.—Descriptive notes on the stratigraphic chart ....... 145
Descriptions of sections ................................................ 145

LIST OF ILLUSTRATIONS.

Plate I. Chart of Indiana coal and mining, by E. F. Lines.
Plate II. Stratigraphic chart.
Plate III. Coal chart.
Plate IV. Structure chart.
Figure 1. Skeleton section showing principal coals.
A Quiz on General Facts on Indiana Coal and Coal Deposits.

It is often difficult in a somewhat detailed description to pick out certain simple fundamental facts that the busy man often wants to know. The attempt has been made at this point to bring together a few such facts in the form of questions and answers.

The Coal.

Q. What kind of coal occurs in Indiana?
A. Three varieties of bituminous coal, "bituminous," "block" and "cannel" coal.

Q. How do they differ?
A. The bituminous coal is bright, not strongly laminated; it cakes in burning, and breaks equally well in all directions into small cubes. The block coal is distinctly bedded or laminated, splits readily along the dull bands, which when exposed show charcoal-like surfaces, breaks with difficulty across the bedding, except where large joints nearly at right angles to each other cut the beds into large blocks; does not cake in burning. Cannel coal is a dull, resinous coal, jointed like the block coal, breaking in any direction, with conchoidal fracture, is high in volatile matter, and differs from the two preceding coals in its origin.

Q. Is there any anthracite, semi-anthracite, semi-bituminous, sub-bituminous, or lignite coal in Indiana?
A. No, with the possible exception of some beds of lignite found in the glacial deposits of Gibson County. These beds may range up to 18 inches in thickness, but at present have no commercial value.

Q. What is the chemical character of Indiana coal?
A. It is a high-moisture, high-volatile coal, of variable but medium ash and sulphur content.

Q. How does it compare with the coals of other states in these respects?
A. All of the Appalachian coals differ from the coals farther west, in being drier, having an average of about 2.3 per cent of moisture in the bed, as compared with about 10 per cent in the
Mississippi Valley coals. Otherwise, Indiana coals about grade with the coals of Ohio and the western edge of Pennsylvania and West Virginia. Going eastward, the coals of Pennsylvania and West Virginia gain rapidly in the percentage of fixed carbon, so that on the average they greatly exceed in this respect the Western coals. Compared with the coals of the Mississippi Valley and farther west, the Indiana coals are the peer of any they are likely to have to compete with.

Q. Will Indiana coal coke?
A. Indiana "bituminous" coals will coke, but so far it has not been possible to make from them high-grade cokes that will successfully compete with the Pennsylvania cokes. Recent experiments with Linton coal seem to offer possibilities of greater success.

Q. Will Indiana coal make producer gas?
A. Yes. A number of plants in successful operation demonstrate this beyond question.

THE COAL FIELDS.

Q. Where does coal occur in Indiana?
A. In the western and southwestern part of the State, and there only.

Q. What counties in Indiana have coal?
A. The following counties are practically all underlain by coal measures: Parke, Vermillion, Vigo, Clay, Sullivan, Greene, Knox, Daviess, Martin, Gibson, Pike, Dubois, Posey, Vanderburgh, Warren and Spencer, sixteen in all. The following counties are in greater or less part underlain by coal: Warren, Fountain, Montgomery, Putnam, Owen, Lawrence, Orange, Crawford and Perry, nine counties, or a total of twenty-five counties.

Q. How does the coal occur?
A. The coal occurs in layers or beds, like a layer of rock lying between other layers of rock.

Q. How do the coal beds lie?
A. The coal beds of Indiana, though probably originally laid down horizontally, now slope downward to the west and southwest. The coal measures of Indiana form part of the eastern rim of a basin, of which the lowest part lies in southeastern Illinois.

Q. How thick are the coal measures of Indiana?
A. At least 1,300 feet in Indiana. The full thickness is developed only in Illinois, where it probably reaches 2,000 feet. The main coal-bearing division of the coal measures will be included in 500 feet.
Q. How do the Indiana coal measures correspond in age with the coal measures of other states?
A. The coal-bearing rocks of Indiana correspond closely in age with the Allegheny formation or "Lower Productive Measures" of Pennsylvania, and the upper part of the Pottsville formation of Pennsylvania, West Virginia, and farther south. The block coals are of about the same age as the Kanawha coals of West Virginia and Kentucky. The Indiana coals are of the same general age as the coals of Iowa, Missouri, Arkansas, eastern Kansas and Oklahoma. The coals of the Rocky Mountain states belong to rocks of much later date.

THE COAL BEDS.

Q. How many beds of coal are there in Indiana?
A. The stratigraphic sheet shows coal in at least thirty-four horizons.
Q. How many of these beds are workable?
A. One bed is workable nearly everywhere; eight are workable over large areas, or usually workable, making nine workable beds, and several others are locally workable.
Q. How thick are these coal beds?
A. Taken as a whole, all of the beds will probably average less than 2 feet. One bed will probably average nearly or quite 5 feet, and over large areas will average 6 to 8 feet. Several of the beds will average from 6 to 8 feet over several hundred square miles; over larger areas they may run from 3 to 5 feet; 10 feet 2 inches is the maximum thickness measured. Thicknesses of from 11 to 13 feet have been reported from the swamps or low places in the coal beds.
Q. How extensive are the beds?
A. A few of the beds can be traced the whole length of the Indiana coal field. In many other cases this condition is suggested, but the evidence is insufficient to prove it. In other cases the coals that are thick over large areas can be seen clearly to run out entirely. In some cases coals are irregularly present in some areas and wanting in others. The lower coals, usually contained in basins from a few acres to several square miles, are thick in the center of the basin and thin to a few inches on the ridges between basins.
Q. How minable are the coal beds?
A. In general the Indiana coals can be mined successfully and economically. They are usually soft enough to mine easily, do not
require breaking for marketing, and in general have a good roof, though in a few districts the roof is poor and a source of expense. In a very few cases the floor tends to creep. Gas is met with only to a very slight extent in a few of the deeper mines. Most of the mining has been by shafts at the depth of 50 to 450 feet.

Q. How are the beds named or designated?
A. The principal bituminous beds are numbered in ascending order, using the Roman numerals from II to VII. The smaller intermediate beds use the numeral of the first main bed below with the addition of a letter, as: V, Va for its "rider." The lower coals, which are more irregular and cannot be traced with certainty, have been named, different local names being applied to the beds at about the same position in different parts of the field.

Q. How far apart do the beds lie?
A. The distance between the principal beds varies from 20 feet or less to 150 feet. In two or three cases the interval will average about 100 feet; in several cases 50 feet, and in others 30 feet or less. The intervals all vary from place to place, sometimes only in a local and indefinite way, but sometimes with a general tendency that makes a given interval in one part of the State much less than in some other.

**Distribution of the Coals.**

Q. What coals occur, and how do they lie in:

**Warren County?**
A. Coal II and the upper block coals occur west of Pine Creek, at moderate depths, dipping to the West.

**Fountain County?**
A. Coal II and the upper block coals occur close to the surface or above drainage, and running out in the east part of the county.

**Parke County?**
A. Coal V occurs only in the extreme southwest corner. Coals III and IV occur west of the lower part of Raccoon Creek, above drainage on Raccoon Creek, but deep in the southwest corner of the county. The coals below Coal III are shallow through the western two-thirds of the county, becoming deep where they pass below Coal III. There is little coal in the eastern part of the county.
Montgomery and Putnam counties?
A. Only the thin, lowest coal occurs in the hills in the western part.

Vermillion County?
A. All of the beds; Coal VII only in the southwest corner; Coal VI absent; Coal V in the south and southwest part; Coals IV and III deep in the south part; Coal III absent north of Hillsdale; Coal IV extending northward to Little Vermillion River; Coal II and Minshall coal underlying the others, and coming out to outcrop on Big Vermillion River.

Owen County?
A. The Block coals in the hills in the southwest half of the county reach down to drainage in the southwest corner.

Clay County?
A. Coal V in the extreme southwest corner, near the surface; Coal IV near the surface on the western-central edge and southwest corner; Coal III west of the C. & E. I. and E. & I. railways in the uplands, going below drainage southwest of Eel River. The Block coals outcrop along the eastern edge, below drainage, under most of the county, and deep along the western edge.

Vigo County?
A. Coal VII occurs west of the E. & T. H. R. R., and the C. & E. I. R. R., except near the Sullivan County line, where it laps over to the eastward. Coal VI is wanting. Coal V is found west of the river to Durkees Ferry, then west of a line from there to the southeast corner of the county. Coal IV underlies all but the northeast corner of the county. Coal III underlies practically all of the county. The lower coals underlie all of the county, but deep. All of the coals are deep in the southwest part of the county and west of the Wabash River bluffs. Their presence in the southwest corner of the county has not yet been demonstrated.

Greene County?
A. Coal VII just overlaps the west edge. Coals VI and V extend in a few miles from the western edge. Coals IV and III underlie the western line of townships. The coals below III are found in the hills west of White River, and pass under the other coals in the western townships. The lowest coals extend out into the hills nearly to the eastern line of the county.
Sullivan County?
A. All coals are present. The upper coals outcrop along the eastern edge, are 150 to 250 feet deep in the center of the county, and still deeper farther west.

Martin County?
A. The lower coals are above drainage, high in the hills in the eastern part of the county, and down to drainage in the western part.

Daviess County?
A. Coal V is in the hills about Washington. Coals IV and III are shallow over all the central part of the county. The coals below III are outerropping above drainage on the eastern edge of the county, and dip under the other coals to the westward.

Knox County?
A. The upper coals just outcrop on the eastern edge. Coal VII is nearly 400 feet deep at Vincennes, and the other coals correspondingly deeper, so that the coals are fairly deep over all of the county.

Lawrence, Orange and Crawford counties?
A. Only the lowest coals are found in the hilltops near the western edge.

Perry County?
A. The lowest coals are in the hilltops in the eastern part of the county, reaching drainage at the west.

Dubois County?
A. Coal III overlaps the western edge of the county. The coals below Coal III lie above drainage to the eastward, and the lowest coals are near the hilltops along the eastern edge.

Spencer County?
A. The Cannelton coal is just at drainage along the eastern edge. Coal V is in the tops of the "Knobs" in the southwest part of the county. Coals IV and III are shallow, but outcrop in the southwest part of the county.

Pike and Warrick counties?
A. Coal V is above drainage in the eastern half of the counties, only in the hilltops toward the eastern edge, and shallow in the western part. Coals VI and VII are close together in the hills in the western part of the counties. Coals III and IV outcrop along the eastern margin; the lower coals underlie.
Gibson, Vanderburgh and Posey counties?

A. All of the coals except Coal VII over a small area in Gibson County, are below drainage at the eastern edge of these counties. Coal V is down 250 to 400 feet in the center of Gibson and Vanderburgh counties, and still deeper in western Gibson and Posey counties. The highest coals of the coal measures outcrop in western Gibson and Posey counties.

Quantity of Coal in Indiana.

Q. How much coal is there in Indiana?
A. On a very conservative basis, counting everything, it is estimated there are 50 billion tons.

Q. How much of this is workable?
A. On the basis of what is considered workable today in Indiana, a conservative estimate will place the amount at 14 billion tons.

Q. What is the present rate at which it is being mined?
A. In 1907 about 13 1/4 million tons.

Q. How long would it last if mining continued at that rate?
A. About one thousand years.

Q. Is the rate of production increasing in Indiana?
A. Yes; in recent years at about the rate of one million tons a year.

Q. If this rate of increase in production continues, how long will the Indiana coal last?
A. About one hundred and fifty years; see qualifications in text.

Q. What county in Indiana has the most coal?
A. Probably Sullivan, where it may be said 10 billion tons are “in sight,” 4 billion of which are recoverable under present standards, and if the rest of the county is as rich as the part that has been drilled, the workable coal may amount to two or three times that figure.

Q. What is the total maximum thickness of all the beds in Indiana?
A. Adding together the maximum thickness of each bed, a total of about 100 feet is reached.

Q. What is the greatest thickness known at any one point?
A. Several reliable deep drillings show a total thickness of from 30 to 35 feet, without passing through all of the coal meas-
ures. In one of these, in Sullivan County, considering as workable only beds 3 feet 10 inches, or more, in thickness, there is a total of 26 feet 3 inches of workable coal.

**Cost of Coal in Indiana.**

The following figures are based on a very careful and detailed study made in 1898 and 1899, and given in the 1898 report. They will need to be revised to meet the present wage scales and changes in cost.

**Q.** What do coal lands cost in Indiana?

**A.** From $25 to $150; more or less in exceptional cases.

**Q.** How much are royalties?

**A.** From 2 to 12½ cents a ton; 3 to 10 cents a ton is most common. This may have changed in recent years.

**Q.** What does it cost to open a mine?

**A.** The cost varies according to the amount of drilling and prospecting, the kind of opening, the depth of shaft, etc., etc.; a shipping mine under the most favorable conditions, of shallow shaft, simple but good machinery, for a daily output of 200 tons can hardly be opened under $10,000, while to open and equip a modern deep mine will usually cost from $50,000 up. In 1897 one ton of coal was mined for every 37 cents of capital represented.

**Q.** What does it cost to mine coal in Indiana?

**A.** In 1899, based on figures of various types of mines, including labor cost of all kinds, operating materials and office expenses, the running expenses of mining were estimated at from 55 cents to 85 cents a ton, run of mine, to which must be added royalties and interest on equipment.

**Q.** What does coal sell for at the mines?

**A.** In 1907 the average selling price of Indiana coal, according to the report of Mineral Resources of the U. S. Geological Survey, was $1.08.

**Markets for Indiana Coal.**

**Q.** Where is Indiana coal used, and for what?

**A.** It is used for all purposes, over all of Indiana, except the northeast corner, the eastern edge, and the southeastern corner, or area bordering the Ohio River; it is used largely in Chicago and eastern Illinois, and to a smaller extent in St. Louis and points in western Illinois, and farther west, as well as northwest of Chicago. Most of the "bituminous" coals find their main use as steam coals,
though the "block" coal and Linton coals are in demand for household purposes.

Q. To what extent can Indiana coal compete with coals from other states?

A. The best evidence that Indiana coal is able to hold its own in competition with other states is the fact that it does, as evidenced by the rapid increase in its production, by the fact that regardless of size of coal field, Illinois is the only State west of the Appalachian field that surpasses it in production, and by the fact that Indiana is a little more than holding its own in rank in the coal-producing states.
A SUPPLEMENT

to the

COAL DEPOSITS OF INDIANA.

BY GEORGE HALL ASHLEY.

CHAPTER I.

COAL INDUSTRY OF INDIANA, AND GEOLOGIC WORK IN
THE COAL FIELDS.

Brief Résumé.

The earliest mention of coal in America was by Father Hennepin, who had noticed coal on the Illinois River, near Fort Creve Coeur. In 1763 Colonel Croghan noted coal on the Wabash River. In making the land surveys in Indiana in the first part of the last century (1804) the surveyors frequently made note on their plots of seeing coal beds. In 1812 Robert Fulton dug some coal at Fulton, Perry County, Ind., which he took aboard his steamboat, the "Orleans," then making her first trip down the Ohio River.

By the end of the first third of the last century coal was being mined at numerous points in Indiana, principally for blacksmithing. Some of this coal was advertised for sale in the newspapers of that day. It might be said that the coal industry of Indiana had its birth about that time. Mining increased rapidly until in 1840 small quantities of coal were being shipped in flat boats down the Wabash, Ohio and White rivers. The industry took a new step forward in 1837, when the American Cannel Coal Company of Cannelton, Ind., was incorporated.

Meanwhile, in 1837 and 1838, David Dale Owen, who had been made State Geologist, made a reconnaissance survey of the State and published the first official report in 1837. A second report appeared in 1839. Other brief papers, mostly by outside geologists, appeared in the 40's. These first reports quite clearly delimited the coal area of the State.
In 1850 the first coal shaft in Indiana was sunk by John Hutchinson, near Newbury, Warrick County. A year later the discovery of non-caking block coal in Indiana gave a new impetus to the mining of coal in that State, and soon led to the building of many iron furnaces, as block coal at first was used in the furnaces in the raw state. What this discovery meant may be realized if note is made of the position of Clay County among the coal-producing counties. In 1880 the coal production of Clay County was exceeded by only nine other counties in the United States, of which only three were outside of Pennsylvania. Clay County not only led in production over the other counties in Indiana up to 1901, but over many of these years its production was more than double that of any other county, and in some years was more than any three counties combined, in fact, frequently yielding more than one-third of the State’s production.

By 1870 the State’s production had reached about 500,000 tons, by 1880 between 1,500,000 and 2,000,000 tons. In 1879 the first mining law of the State was passed and a Mine Inspector appointed. Meanwhile, much geologic work had been done. In 1859 a geological reconnaissance of the State was provided for, leading to a report in 1862 by Richard Owen, that treated briefly of all of the coal counties. In 1869 the office of State Geologist was revived and has continued to the present, at first under E. T. Cox, then under John Collett, Morris Thompson, and S. S. Gorby, leading up to the election of the present State Geologist, Mr. W. S. Blatchley. The early reports treated, with more or less fulness, of the coal counties. Some of the reports were quite complete, and others far from so. The last of these county reports appeared in 1883.

In 1886 natural gas was discovered in Indiana, and this soon changed the State from a nearly purely agricultural one into a manufacturing State of some importance. Ten years later signs were not lacking that the gas fields were becoming exhausted, and that within a very few years there would be a large demand for information about the coal deposits of Indiana. Appreciating this, Mr. Blatchley, who had recently been elected State Geologist, made plans for a detailed economic survey of the Indiana coal field. This survey was entered upon in 1896, and prosecuted during 1896, 1897 and 1898, under the direction of the writer, assisted part of the time by E. M. Kindle, Claude Siebenthal, J. A. Price and J. T. Scoville. The complete report, covering nearly 1,600 pages, and profusely illustrated, was published in September, 1899. About 1890 the U. S. Geological Survey completed the topographic map-
ping of two quadrangles in southern Indiana, covering one degree wide from east to west, and one-half degree from north to south, or an area about 54 miles by 35 miles, lying in Pike, Warrick, Gibson, Vanderburgh and Posey counties. On this base the writer, who meanwhile had become a member of the U. S. Geological Survey, and others of that organization, prepared detailed maps of the coals and other geologic features. At the time of the State report (1898) Indiana had reached a coal production of 5,000,000 tons. Notwithstanding the finding of gas had cut off most of the home market, there had been a nearly steady rate of increase, averaging, for the eighteen years just preceding 1898, 166,666 tons a year. Had that rate of increase been maintained for the ten years since 1898 the production in 1908 should have been about 6,166,666 tons. However, it was predicted that the rate of increase of coal production in Indiana would be larger after 1898 than before, due to the exhaustion of the gas, until a more or less complete failure of the gas would have brought things to a state of equilibrium, when the rate would fall back and remain more constant.

That the production of coal in the State of Indiana since 1898 has increased by leaps and bounds is due not alone to the exhaustion of the gas fields, but to a number of other factors, having great influence. In 1902 was the great anthracite strike. For a time much of the summer market for anthracite turned to the western Pennsylvania bituminous coals for supplies. In many cases the result was so satisfactory that manufacturers continued to use bituminous coal. This in turn depleted the stocks of Eastern bituminous coal in the central and western markets, which in turn sought the coal fields closer at home, and in many cases found that the Illinois coals would give them greater service per dollar of cost than the Eastern coals they had been using. The result was to increase the demand and resulting prices for Indiana and other central and Western coals, so that the Indiana production increased from less than 7,000,000 tons in 1901 to nearly 9.5 millions in 1902. High prices and large demand continued into 1903, so that in that year Indiana produced nearly or quite 11,000,000 tons. The high prices and good times in the coal fields had their effect. It made the coal industry an inviting place for the investment of capital, new companies being formed often by people little acquainted with Indiana mining and markets, and in 1904 and 1905 it led to a great consolidation of coal properties in a few hands. During this period eighty-one large mines changed hands, seventy-two of them being gathered into six large companies. As has often been the case in consolidations in other lines of trade, individual mines are
reported to have been bought up far above their actual value, and often above what they could pay dividends upon, resulting in their closing soon after their purchase. The final result of this rush of capital to the coal fields was the opening of more mines than the market demanded and a general slumping of prices and prosperity. The low prices eliminated many of the less profitable mines, and gradually the pendulum has been swinging the other way until in 1908 the industry in the State gave promise of soon picking up and entering upon a new era of moderately good times. Meanwhile another factor has been seriously affecting, for good, the market for Indiana and Illinois coals. Probably no place in the United States has given more attention to the economics of fuel than the city of Chicago and the industries centered about that place. In many cases plants using a large amount of coal have been finding that in the long run it was much cheaper to build or adapt their boilers to the use of a low-grade fuel, which could be bought at a low price, than to attempt to work with the best coal in the market. This has increased the market for the lower grades of Indiana and Illinois coals, coals which formerly were considered wasted, or which were actually given away. With a constant tendency in this direction this is bound to reduce the market for the higher grades of Eastern coals, which must also be brought into Chicago at higher prices, and to open up a larger and larger market for the somewhat lower grade coals of Indiana and Illinois, until it is possible to see the Indiana and Illinois coals monopolize the Chicago and farther west markets, except for some special purposes.

Still another factor which promises great things for the future of the Indiana field, though the effects have as yet been but little noticed, is the discovery, if it may be so called, that the low-grade coals of Indiana and Illinois can be successfully used in producer gas plants in the manufacture of producer gas for use in gas engines, the result of such use being an efficiency above that which can be obtained by the use of the highest grade Eastern coals through the ordinary steam boiler. This is largely a result of the experiments carried on by the U. S. Geological Survey coal testing plant at St. Louis during the World’s Fair. The fact was demonstrated that low-grade coals, even coals containing 20 or 30 or a higher per cent of ash, and large quantities of sulphur, can be successfully used. The ultimate result of this discovery can hardly yet be foreseen, as there is opened up an entirely new field and market for the lowest grade coals of the Indiana coal area.

From another standpoint, the events subsequent to the appearance of the earlier coal report in 1899 are of interest. In 1898
the coal production of Indiana was 5,000,000 tons; in 1907, nine years later, 13,250,000 tons, or nearly three times as much. This increased production was only to a very small extent due to the enlarging of the output of the mines then existing. In fact, nearly all of the mines in operation in 1898 had been worked out and abandoned in 1907. The increased production, then, was obtained almost entirely by the opening of new mines. While, as previously stated, in many cases the opening of these new mines was the result of the influx of capital from outside, to a still larger degree they are the result of enlarged activity on the part of the existing companies. So, too, while many new mines have been opened on the basis of imperfect knowledge, and without the advantage of expert advice, often with disastrous financial results, on the other hand, more of the mines have been located after a large amount of prospecting with the drill and a careful consideration of all the economic factors involved. Several of the larger companies have spent as high as $50,000 in prospecting with the drill. In a large number of cases this drilling was followed by the opening of mines, sometimes in territory entirely unoccupied before, sometimes on beds below those previously worked, and these mines largely supplemented the information already gained by the drill. The result has been that today the south part of Vermillion and Parke counties, Vigo, Clay and Sullivan counties, western Greene and northern Knox counties, are practically an open book as regards the general relations of the coals existing in that area, and their general position in the ground.

As an illustration, in 1898 there were no mines west of the Wabash River in Vigo County, except a few small mines on a surface bed coal, Coal VII. Oil wells and a drilling west of the river, of which no record could be obtained, reported the next coal to be about 6 feet thick, at a depth of from 110 to 160 feet below the coal being mined.

Though this interval was much greater than between coals VII and VI in Sullivan County, there was a long gap between, so naturally the lower coal was called Coal VI. Today that section has been literally riddled with drillings, and many large mines have been opened, not only to surface coal, but to two of the lower coals, and borings have tested all of the beds. We therefore know today that Coal VI is missing in that region, that the first "lower" vein is Coal V, and that coals IV and III are of workable thickness, and that there are still below those all the block coals.

One result of this drilling and new development had been to produce the growing conviction that in addition to some minor mis-
takes in correlation, the writer, in his 1898 report, made one gross error. A broad belt of prairie and lowland cuts diagonally across the Indiana coal field, extending from the Wabash Valley at and north of Terre Haute southeastward across the southeast part of Vigo County, and joins the big overflow area of Elk River in Clay County, cutting across the southwest corner of that county. Through this belt ran the old Erie & Wabash Canal, and across this belt almost no information about the coal was obtained in the former survey. To tie the coals across this belt it was necessary to depend on a general comparison of the stratigraphic columns either side. Curiously, the two sections of coals either side of this belt seemed to have a hundred resemblances on the assumption that the coal worked at Seelyville was the same as the No. VI coal of Sullivan County. There seemed to be a close correspondence between all of the coals of the series either side of the break, not only in their distance apart, but in the small details of partings, characteristics of the roof, floor, etc. The slight differences were no more than constantly appeared in the same coals in single mining districts. Coal VI of Sullivan County corresponded with the Seelyville coal in thickness, parting, roof, etc., not only in a general way, but in the tendency toward certain variations of these features. Coal VII of Sullivan County likewise closely resembled the rider coal at Seelyville as mined at the Soule mine, or what is now the Glen Ayre mine, not only in the lack of partings and some other characteristics of the coal, but in such features as the fact that both coals tend to have stringers of coal rising into a roof of sandstone so as to let "pots" drop down. and in many other ways the resemblance was very close. Coal V, or the Alum Cave bed, with its solid bed, black shale roof and overlying limestone, had its counterpart in the rider of the block coals; the Linton coal with the Upper Block, and the lower coal at Linton, of which little was known, seemed to resemble the Lower Block. So striking is this resemblance that in some cases the last persons to admit that the beds with these resemblances are not the same are the miners who have worked in what had been supposed to be the same beds on both sides of the break.

As drilling and development progressed it became evident to those most familiar with the results of the drilling that the block coals of Clay County, instead of joining coals III and IV at Linton, ran under those coals, and that the lower coal at Linton (Coal III), was the same as the main coal at Seelyville (formerly called Coal VI). At the same time the fact that the drilling of any one company was usually confined to certain localities, gave opportuni-
ties for unsuspected changes to take place in the coal beds, which were not recognized, leading to an almost endless confusion. And, furthermore, as certain beds were of much higher grade than other beds in the same region, the tendency to the assumption at any given mine by the owners that they were working one of the better beds, has led to no small amount of feeling among the operators.

It was these conditions, combined with the exhaustion of the edition of the 1898 report, that led to the preparation of the present report. For this report the writer spent some two months in the field in 1898, assisted by Mr. Edwin F. Lines, and for a short time, in the collection of well records, by Mr. John Udden, Jr. As plans are in progress for a new, comprehensive report on the Eastern Interior coal region as a whole, a collection of the fossils was made at many mines by Mr. T. E. Willard for study by David White, the United States Geological Survey's expert on coal measure plants. Mr. White also spent a short time in northern Indiana. In nearly all cases, through the kindness of operators, we were given free access to the records of the thousands of drillings that have been made.

This report is not a new revised edition of the 1898 report. Time did not permit a re-examination of the great eastern belt of the coal field, which would have occupied one or two whole field seasons. Indeed, until that area has been covered by detailed topographic maps, the writer doubts the value of such a re-examination.

The field work was therefore confined to the area of the great recent development, to visiting all of the new mines, and to the re-examination of a few critical points. In the office the whole field has been reviewed in the light of the better understanding of the stratigraphy now held. The report is thus only a supplement to the report of 1898. It attempts:

1. To revise and correct the stratigraphy of the whole field, not in detail but in such way that the reader may work out his own details;

2. To show in a general way, by a small scale map, the outcrop and distribution of the principal coals, as now correlated;

3. To show the general structure of the coal field by the use of contour lines;

4. To show the location of the active mines and most of the old mines of the State;

5. To discuss briefly the character and possible uses of Indiana coal, in view of recent tests and experience.
As is well known, coal is a rock occurring in beds in the earth. It is composed largely of the element, carbon, with some oxygen, hydrogen and a few other elements, and is economically important as fuel. It is usually black, massive or bedded, has a hardness of 1.2 to 1.8 in the scale of hardness, a weight of 75 to 80 pounds per cubic foot, and a varying fracture.

Kinds of Coal.—All of the coal found in Indiana belongs in the bituminous class. As far as known, there is no anthracite, semi-anthracite, or semi-bituminous coal in the State, nor are the low-grade sub-bituminous and lignite coals found. However, several varieties of bituminous coal occur, namely, so-called "bituminous" coal (used to distinguish from the next), "block" coal, and cannel coal. The first two differ but little chemically, but when typically developed, show rather marked physical differences. The cannel coal is physically a block coal, but differs chemically from either of the other coals.

Description of the Kinds of Coal in Indiana.—The characteristics and differences of the three kinds of coal in Indiana may be described as follows:

The so-called "bituminous" coal of Indiana is pitch black, the color remaining black even when powdered; the luster is bright or vitreous. In structure it is banded or bedded, the jointing and cleavage is cubic, i.e., tending to break up into cubes; the fracture is irregular, and the texture dense to laminated. This coal is brittle, soft and rather light. It burns with a long flame, with a bituminous or sulphurous odor, running together on burning, and leaving much white or red ash. Sulphur is usually present.

The block coal of Indiana differs from the bituminous in being distinctly banded when viewed on the edges of the bedding, by splitting readily along the dull bands, which prove to be bands of charcoal, by breaking with difficulty across the bedding; especially by the very perfect development of the cleavage, the cleavage planes usually extending vertically nearly or quite the full thickness of the coal, dividing the bed into blocks or cubes, often several feet on a side. This character is reflected in the character of the
coal as marketed where it is noted the blocks are commonly in rather thin, square-edged slabs, being square or quadrilateral, often 1 to 2 feet on a side, and 6 inches thick, with charcoal faces. In burning, the coal does not run together or cake, but remains in distinct blocks, like blocks of wood, and burns to a small white ash.

The cannel coal, of which Indiana has but a small amount, is a block coal as regards being divided by the cleavage into distinct blocks, usually the full thickness of the bed. It differs physically in not having the dull or charcoal bands, or any bedding, being quite massive in structure, in its dull, resinous luster, and in its conchoidal fracture. Under the microscope still other differences are seen which need not be discussed here.

The properties of Indiana coal may be divided into physical properties, those not involving change in composition, as hardness, structure, weight, etc., and the chemical properties, or those which relate to the changes in composition that take place when the coal is burned.

*Physical Properties of Indiana Coal.*—From the practical standpoint these affect the mining, the transportation and marketing, and to some extent the use of the coal. The mining of coal is more or less affected by the hardness and the structure of the coal. In hardness the Indiana coals occupy a medium position among "soft" or bituminous coals, as contrasted with the "hard" or anthracite coals. The splint coals of West Virginia are probably the hardest of the "soft" coals, and the tender coals of Arkansas are possibly among the softest, in the sense of breaking up easily. The splint coals are almost as hard as anthracite, and much tougher. This condition is approached by the cannel coal of Indiana, and to a less degree by the block coal. The hardness may best be indicated in a practical way by the statement that on the average Indiana coal, as at present mined, handled, tipped and screened, will yield 66 to 70 per cent lump coal, over diamond bars 1½ inches apart. The block coals will run some higher, possibly 75 per cent, and in parts of the State the coals will not run that high. This percentage is much affected by mining methods. Where shooting on the solid is allowed and heavy shots permitted, the coal will be more broken up and the percentage of lump smaller.

The structure of the coal, particularly the jointing, affect the ease with which the coal is mined and the size and character of the blocks when mined. In the block coal the joints are few in number and well separated, but strongly developed. In the early days this coal was all pick-mined, the joints, or slips, as they are called
locally, making favorable points of attack, and allowing ready breaking-away of the coal. In the "bituminous" field the joints are not as marked, but more numerous, and vary widely in the extent to which they assist in the operations of mining.

The hardness or strength indicated by the percentage of lump coal, except as this is affected by the methods of mining, will apply to the transportation and marketing of the coal. Indiana coal will stand domestic shipment as well as most of the coals of the eastern United States, and better than many. It will not make a good export coal in this respect.

The "bituminous" coals of Indiana fuse and run together on burning, forming a cake, which must be broken up to secure rapid combustion. This property forms the basis of coke making, and is common to all coals from which coke is made. While it is true that all coking coals are caking coals, it is not equally true that all caking coals will make commercial coke. The block coals of Indiana do not cake in burning and have been used in the raw state in a blast furnace. Between these two extremes are found the semi-block coals, with intermediate caking properties.

Chemical Properties of Indiana Coal.—The burning of coal is a chemical phenomenon, as it involves changes in the composition of the coal; and as this is the only practical use that Indiana, or any other, coal is at present put to, the chemical properties of Indiana coal are of the first moment. This is true whether the ultimate use of the coal be for heat or for power, whether the coal be burned directly in the fire or whether it first be broken up into gases and coke and then burned or exploded. In common language, when coal burns certain parts of the coal unite with the oxygen of the air, forming new compounds and giving off heat in so doing.

If 100 pounds of average Indiana coal, just as taken from the mine, be completely broken up in the chemical laboratory into the elements (except ash) it will show about as follows:

**Ultimate Analysis of 100 lbs. of Indiana Coal.**
(On basis of 19 recent analyses of carload samples.)

<table>
<thead>
<tr>
<th></th>
<th>Lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>61</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>5.5</td>
</tr>
<tr>
<td>Oxygen</td>
<td>18</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>1.1</td>
</tr>
<tr>
<td>Sulphur</td>
<td>3</td>
</tr>
<tr>
<td>Ash</td>
<td>11.4</td>
</tr>
<tr>
<td>Coal</td>
<td>100.0</td>
</tr>
</tbody>
</table>

---

**Chemical Properties of Indiana Coal.**
In the first place, it is evident that the coal contains in the ash and nitrogen, which it is well known will not burn, 12.5 per cent of plainly non-combustible material.

In the second place, as there is an abundance of oxygen in the air for the burning of the other elements, and as we measure the amount of heat given off in the combination of oxygen with any other elements by the amount either of the oxygen or of the other element that enters into the combination, but not by both, it is evident that the oxygen in the coal reduces the combustible part of the coal by at least that much. This would be exactly true only on the condition that the oxygen were not already united with some of the other elements. However, it appears quite certain that some, and probably all, of the oxygen is already in combination with the other elements of the coal. If the coal be put in a dry place it will be found that it will lose about 8 per cent in weight, the loss being in the form of water vapor or moisture, which is composed of eight parts of oxygen and one part of hydrogen, and if the coal be then reanalyzed it will be found to contain that much less oxygen and hydrogen. If next the coal be put in a drying oven four more pounds of moisture may be driven off. Evidently, these 12 pounds of moisture are not combustible. The loss of this moisture will reduce the oxygen in the coal by 10 2-3 pounds, and the hydrogen by 1 1-3 pounds. There is still left 7 1-3 pounds of oxygen.

Leaving out of account the sulphur, which it is known is combined with iron in the coal in the form of pyrite or iron sulphide, it is now known that the 7 1-3 pounds of oxygen left, the 4.2 pounds of hydrogen left, and at least part of the carbon, exist in the form of one or more compounds. Just the nature of these compounds in the raw coal is not known definitely, for as yet no satisfactory method has been devised for separating this part of the coal into its component parts without the use of heat, which, it is known, produces changes, so that the final compounds obtained may be quite different from those originally existing. However, if this thoroughly dried coal be heated in a retort, as is done in the manufacture of illuminating gas, it is found that a gas is given off known as the volatile matter, and there is left in the retort the remainder of the carbon and the ash, forming coke. Analysis of this gas will show about 18 pounds of carbon, 4.2 pounds of hydrogen, and 7.3 pounds of oxygen, the remaining 43 pounds of carbon being left behind with the ash. If this gas be burned it is found to yield only about the amount of heat it would give if it contained only 18 pounds of carbon, and 3.3 pounds of hydrogen;
in other words, the 7 1-3 pounds of oxygen, and one-eighth of its weight of hydrogen, act under these conditions as though already combined in the proportion of water, and therefore not in a condition to yield further heat. It is evident then that not only is all the oxygen an element of no value, but the portion of hydrogen equal to one-eighth of the weight of the oxygen is also of no value for combustion. The remaining part of the hydrogen is known as the available hydrogen. The combined oxygen and hydrogen in the gas is known as the water of constitution, and it is believed to originally form an actual constituent part of the compound, and is commonly called, with the nitrogen which is driven off then, the inert volatile.

The carbon in the volatile matter is called the volatile carbon. The volatile carbon and available hydrogen together constitute the combustible volatile matter. The carbon left in the coke is known as free carbon, or fixed carbon.

We may now regroup the elements of the coal according to their heat-giving possibilities.

*Analysis of 100 lbs. of Indiana Coal on the Basis of Combustion.*

**Combustible Matter (Pounds).**

<table>
<thead>
<tr>
<th>Element</th>
<th>Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed carbon</td>
<td>43</td>
</tr>
<tr>
<td>Volatile carbon</td>
<td>18</td>
</tr>
<tr>
<td>Available hydrogen</td>
<td>3.3</td>
</tr>
<tr>
<td><strong>Total combustible volatile matter</strong></td>
<td>21.3</td>
</tr>
<tr>
<td>Sulphur</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total combustible matter</strong></td>
<td>67.3</td>
</tr>
</tbody>
</table>

**Non-Combustible Matter (Pounds).**

<table>
<thead>
<tr>
<th>Element</th>
<th>Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash</td>
<td>11.4</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>1.1</td>
</tr>
<tr>
<td>Oxygen of water of constitution in gas</td>
<td>7.3</td>
</tr>
<tr>
<td>Hydrogen of water of constitution in gas</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Total inert volatile matter</strong></td>
<td>9.3</td>
</tr>
<tr>
<td>Oxygen in &quot;moisture&quot;</td>
<td>10.7</td>
</tr>
<tr>
<td>Hydrogen in &quot;moisture&quot;</td>
<td>1.3</td>
</tr>
<tr>
<td><strong>Total &quot;moisture&quot; in coal</strong></td>
<td>12</td>
</tr>
<tr>
<td>Total non-combustible matter</td>
<td>32.7</td>
</tr>
<tr>
<td><strong>Total coal</strong></td>
<td>100.0</td>
</tr>
</tbody>
</table>
Heat is measured by calories or British thermal units, commonly called B. T. U.'s. The former is the amount of heat required to raise the temperature of 1 gram of water 1° Centigrade. The latter is the amount of heat required to raise the temperature of 1 pound of water 1° Fahrenheit. Careful experiments have shown that when burned, 1 gram of carbon will yield 8080 calories; 1 pound of carbon will yield 14,544 B. T. U.'s. One gram of hydrogen will yield 34,460 calories, or 1 pound of hydrogen will yield 62,028 B. T. U.'s. One gram of sulphur will yield 2250 calories, or 1 pound of sulphur will yield 4050 B. T. U.'s. The theoretical heat value of the coal just described would therefore be:

**Heat Value of Indiana Coal.**

<table>
<thead>
<tr>
<th></th>
<th>B. T. U.'s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>61 lbs. x 14,544 = 887,184</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>3.3 lbs. x 62,028 = 204,692</td>
</tr>
<tr>
<td>Sulphur</td>
<td>3 lbs. x 4,050 = 12,150</td>
</tr>
</tbody>
</table>

Heat value of 100 lbs. of Indiana coal = 1,104,026

These figures, it should be understood, are only approximately correct, because part of the carbon and hydrogen are united, and those compounds when burned do not yield exactly the same amount of heat as the two elements concerned would if burned separately.

As some of the carload lots that were analyzed as the basis of this determination were lump coal, some run of mine, and some screenings, the figure 11,500 B. T. U.'s per pound of coal may be taken as the fair average of commercial Indiana coal, that is, the coal as delivered to consumer. Actual determinations of the heating value of Indiana coal from samples from carload lots will show a little higher value for lump coal and a little lower for run of mine and screenings, individual determinations running from 9500 to 12,000, with an average of about 11,200. However, the samples included more cars of screenings than of lump coal, so the figure of 11,500 is probably not far from an average, which is the equivalent of 6633 calories. If the former number be divided by 963.9, the latent heat of steam, there is obtained practically 12, which represents the number of pounds of water at the boiling point one pound of coal will convert into steam. This figure is, of course, an ideal or theoretical value, which cannot be realized in practice, because there will always be losses, as follows:

1. Loss due to the converting of the moisture of the coal into steam;
(2) Loss due to converting into steam the moisture formed by the burning of the hydrogen.
(3) Loss due to heat carried away by dry chimney gases;
(4) Loss due to radiation;
(5) Loss due to incomplete combustion of the carbon (burning only to CO instead of to CO₂);
(6) Loss due to other forms of incomplete combustion.

These losses will vary with the boiler, manner of firing, etc. Probably 60 per cent of the heat in a good boiler is absorbed by the boiler, as a fair average. This will be discussed more at length farther on.

A comparison of the average analyses given with many of the older analyses, or with analyses often secured by coal mine owners, may show a difference in favor of the older analyses. It may not be out of place, therefore, to point out where the difference arises. The analyses made by Mr. Cox in the early days of the Survey, and many of those made for mine owners, were made from small hand specimens picked up, or more often, selected from a pile, wrapped up and taken to the laboratory, where they were placed on a shelf until the analyses could be made. Later the method of cutting a strip the whole thickness of the coal, as described in Appendix A, or of taking selected shovelfuls of coal from a car or cars, was adopted. In addition the samples were at once put into tight glass jars, and so conveyed to the laboratory and kept until used. Samples taken in this way, even though analyzed by many different chemists, showed a great increase in the percentage of moisture and of ash, with necessarily a corresponding decrease in the percentage of other constituents. Then, more recently experiments have shown that some types of fruit jars and metal screw-top cans used for holding the samples are not entirely air-tight, and that unless the sample be analyzed within a day or two of being taken certain special precautions must be used to insure that there is no loss of moisture or of other gases. For this purpose sealing with bicycle tape has been extensively used.

To show how misleading the older type of analyses may be in showing just what is shoveled into the consumer's coal bin, four analyses are given. The first is of a thoroughly representative sample taken from a car of screenings at the St. Louis testing plant. The second is of a mine sample from the same mine. The third is a representative sample taken by Mr. Epperson in 1896 at the same place. The fourth is an analysis by Mr. Cox of the
same coal from a closely-adjoining mine. All the samples are of Coal VI, from near Star City, in Sullivan County:

**Comparative Analyses of Coal from Near Star City, and Vicinity, Sullivan County, Indiana.**

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>13.99</td>
<td>14.86</td>
<td>9.40</td>
<td>4.00</td>
</tr>
<tr>
<td>Fixed carbon</td>
<td>42.29</td>
<td>46.14</td>
<td>48.77</td>
<td>51.50</td>
</tr>
<tr>
<td>Volatile matter</td>
<td>29.40</td>
<td>31.65</td>
<td>38.53</td>
<td>43.50</td>
</tr>
<tr>
<td>Ash</td>
<td>14.32</td>
<td>7.35</td>
<td>8.74</td>
<td>1.00</td>
</tr>
<tr>
<td>Sulphur</td>
<td>2.31</td>
<td>2.26</td>
<td>2.18</td>
<td></td>
</tr>
</tbody>
</table>

A.—Car sample (screenings); see U. S. G. S. Bull. 290, p. 97, 1906.
B.—Mine sample, same mine, taken 4,000 feet southeast of shaft, same reference.
C.—Star City mine, Geol. Surv. of Ind. 21st Ann. Rept., p. 105, 1896.

Since the appearance of the 1898 report, attention has been called by Professor Parr, of the Illinois Survey, to the difference in the quality of the volatile matter of different coals. Though it has long been known that the oxygen in the volatile matter of the coal added nothing to its heating power, and that a part of the hydrogen equal in weight to one-eighth of the weight of the oxygen, was likewise of no avail in the combustion of the coal, yet it has been customary to speak of the gas or volatile matter as though it were all combustible, and to add this weight to the weight of the fixed carbon in determining the total amount of combustible matter. This was done in the 1898 report. To determine the amount of "water of constitution" of the volatile matter requires an ultimate analysis, and only approximate analyses were being made. Furthermore, it was not appreciated that the different coals differed greatly in the proportion of their volatile matter that was in the form of water constitution. By means of diagrams Professor Parr, in 1904, showed that in Pocahontas coal 22 per cent of the volatile matter is non-combustible; in Illinois coal 40 per cent of the volatile matter will not burn, while in lignites this "inert" volatile matter rises to nearly 50 per cent.

There is another reason why this subject has been neglected. In Pocahontas coal while 22 per cent of the volatile matter is inert, as the volatile matter forms only 18 per cent of the coal, the inert volatile makes only 4 per cent of the coal. In Illinois coal, on the contrary, the total volatile matter is 35 per cent of the whole, so that the inert volatile is 14 per cent of the whole. It could, therefore.
very well be neglected in the Eastern coals, but going westward it reaches a value, or rather a lack of value, that very materially affects the efficiency of the coal. The difference is made more striking if it be noted that this overlooked element in a ton of Pocahontas coal amounts to 50 pounds of unconsidered waste, while in a ton of Illinois coal it may amount to 280 pounds of unconsidered waste.

**Commercial and Economic Character of Indiana Coal.**—In the 1898 report the utilization of Indiana coal was entered into at considerable length, nearly fifty pages being given to that subject. It will, therefore, not be necessary to go over that discussion again beyond repeating one or two general conclusions then reached. Attention will be given mainly to summarizing the results of some recent tests and calling attention to present tendencies in the use of coal.

Not many years ago it was customary for manufacturing plants to buy their coal largely on the basis of quality, other facts being but little considered, if at all. Today many of the large plants are giving the whole subject most careful consideration, and in many cases reach the conclusion that it pays to spend money to adapt their power plants to the use of a cheap coal rather than to use an ordinary furnace and buy high-priced coal. Thus, more and more the use of screenings and low-grade coals is coming to be the practice of large plants. Particularly is this true of the Chicago market. The question becomes not "Which is the best coal?" but "How can I get the power I need for the least money?"

It has long been true that in most coal fields the profits of coal mining come mainly or altogether from the larger sizes of coal, the smaller sizes being sold for what they would bring, and it is still true in Indiana that the demand for screenings is not as great, proportional to the amount made, as for the screened coal. The result is that screenings are often sold at barely the cost of mining, or even less. Large power plants are more and more taking advantage of this fact to adapt their furnaces to the burning of this size of coal, and it is probable that before many years the demand for screenings will place their sale well on the credit side of the ledger. Special attention is therefore called to the results of boiler tests with Indiana screenings.

**Experimental Tests by the United States Government.**—The detailed report of these tests is contained in the U. S. Geological Survey Bulletins Nos. 261, 290, 316, 323, 325, 333, 334, 336, 339, 341, 343, and Professional Paper No. 48. As the Geological Sur-
vey's stock of many of these publications has already been exhaus­ted, some of the results of those tests may be summarized here. The following table gives some of the results of the steaming tests of Indiana coal, and there are also added the results of tests on some of the coals with which it has to compete:
Table Showing Results of Steaming Tests of Indiana and Other Coals, as Obtained in the U. S. Geological Survey Fuel Testing Plant at St. Louis.

<table>
<thead>
<tr>
<th>NAME OF MINE</th>
<th>Duration of Test</th>
<th>Heating Value of Dry Coal</th>
<th>Water Apparently Evaporated per Pound of Coal as Fired</th>
<th>Water Evaporated from and at 212°F, per Pound of Coal as Fired</th>
<th>Efficiency of Boiler</th>
<th>Pounds of Coal Fired per Indicated Horsepower Hour</th>
<th>Pounds of Coal Fired per Electrical Horsepower Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indiana No. 1, Run of mine, Mildred..........................</td>
<td>9.93</td>
<td>13.277</td>
<td>5.87</td>
<td>7.06</td>
<td>61.00</td>
<td>3.68</td>
<td>4.92</td>
</tr>
<tr>
<td>Indiana No. 3, Mixed out and slack, Wrenley No. 3..........................</td>
<td>9.65</td>
<td>11.699</td>
<td>6.14</td>
<td>7.10</td>
<td>61.72</td>
<td>4.68</td>
<td>4.90</td>
</tr>
<tr>
<td>Indiana No. 4, Screenings, Cons. Ind. C. Co. No. 29.........................</td>
<td>10.05</td>
<td>11.977</td>
<td>5.74</td>
<td>6.44</td>
<td>62.41</td>
<td>4.25</td>
<td>5.26</td>
</tr>
<tr>
<td>Indiana No. 5, Run of mine, Cons. Ind. C. Co. No. 33.........................</td>
<td>10.02</td>
<td>11.894</td>
<td>5.92</td>
<td>7.00</td>
<td>63.25</td>
<td>4.27</td>
<td>4.78</td>
</tr>
<tr>
<td>Indiana No. 6, Run of mine, Cons. Ind. C. Co. No. 34.........................</td>
<td>9.97</td>
<td>12.035</td>
<td>6.30</td>
<td>7.30</td>
<td>63.02</td>
<td>3.87</td>
<td>4.78</td>
</tr>
<tr>
<td>Indiana No. 7A, Lump, Littles, Pike Co..........................</td>
<td>10.02</td>
<td>12.143</td>
<td>6.80</td>
<td>7.90</td>
<td>63.25</td>
<td>3.87</td>
<td>4.91</td>
</tr>
<tr>
<td>Indiana No. 7B, Screenings, Littles, Pike Co..........................</td>
<td>10.03</td>
<td>12.338</td>
<td>6.85</td>
<td>8.06</td>
<td>64.00</td>
<td>4.56</td>
<td>4.68</td>
</tr>
<tr>
<td>Indiana No. 8, Lump, Deep Vein mine..........................</td>
<td>9.88</td>
<td>12.038</td>
<td>6.34</td>
<td>7.38</td>
<td>64.31</td>
<td>4.30</td>
<td>4.25</td>
</tr>
<tr>
<td>Indiana No. 9A, Lump, Redbird mine..........................</td>
<td>9.92</td>
<td>12.181</td>
<td>5.27</td>
<td>7.44</td>
<td>64.99</td>
<td>4.25</td>
<td>4.25</td>
</tr>
<tr>
<td>Indiana No. 9B, Run of mine, Redbird mine..........................</td>
<td>6.7</td>
<td>12.740</td>
<td>6.85</td>
<td>7.24</td>
<td>62.28</td>
<td>4.91</td>
<td>4.91</td>
</tr>
<tr>
<td>Illinois No. 6, Lump, Defers, Pike Co..........................</td>
<td>10.05</td>
<td>12.865</td>
<td>6.63</td>
<td>7.74</td>
<td>65.03</td>
<td>4.62</td>
<td>4.62</td>
</tr>
<tr>
<td>Illinois No. 11, Lump, Defers, Pike Co..........................</td>
<td>9.65</td>
<td>13.423</td>
<td>6.61</td>
<td>7.88</td>
<td>64.22</td>
<td>4.25</td>
<td>4.25</td>
</tr>
<tr>
<td>Illinois No. 12, Run of mine, Hartwell, Pike Co..........................</td>
<td>10.08</td>
<td>12.118</td>
<td>5.85</td>
<td>7.02</td>
<td>64.16</td>
<td>4.03</td>
<td>4.97</td>
</tr>
<tr>
<td>Illinois No. 13, Run of mine, C. VII, W. Terre Haute..........................</td>
<td>10.00</td>
<td>12.494</td>
<td>6.35</td>
<td>7.50</td>
<td>66.45</td>
<td>3.77</td>
<td>3.65</td>
</tr>
<tr>
<td>Illinois No. 14, Run of mine, Steilville..........................</td>
<td>9.82</td>
<td>11.668</td>
<td>6.30</td>
<td>7.20</td>
<td>64.39</td>
<td>3.89</td>
<td>4.29</td>
</tr>
<tr>
<td>Illinois No. 15, Run of mine, Linton, Coal IV..........................</td>
<td>9.7</td>
<td>13.099</td>
<td>6.34</td>
<td>7.36</td>
<td>62.65</td>
<td>3.83</td>
<td>4.72</td>
</tr>
<tr>
<td>Illinois No. 16, Run of mine, Linton, Coal V..........................</td>
<td>10.03</td>
<td>12.300</td>
<td>6.47</td>
<td>7.51</td>
<td>64.29</td>
<td>4.39</td>
<td>4.65</td>
</tr>
<tr>
<td>Illinois No. 17, Run of mine, Bicknell, Coal V..........................</td>
<td>9.88</td>
<td>12.229</td>
<td>6.41</td>
<td>7.46</td>
<td>61.70</td>
<td>3.70</td>
<td>4.68</td>
</tr>
<tr>
<td>Illinois No. 18, Lump, Argus, Pike Co..........................</td>
<td>10.11</td>
<td>13.545</td>
<td>6.70</td>
<td>7.79</td>
<td>62.10</td>
<td>3.63</td>
<td>4.48</td>
</tr>
<tr>
<td>Illinois No. 19, Screenings, Upper block, Diamond..........................</td>
<td>7.97</td>
<td>11.500</td>
<td>5.92</td>
<td>7.15</td>
<td>63.25</td>
<td>3.96</td>
<td>4.88</td>
</tr>
<tr>
<td>Illinois No. 20, Lump, Argus, Pike Co..........................</td>
<td>10.02</td>
<td>12.752</td>
<td>6.89</td>
<td>7.66</td>
<td>64.54</td>
<td>4.09</td>
<td>4.28</td>
</tr>
<tr>
<td>Illinois No. 21, S. Redbird, Lump..........................</td>
<td>10.03</td>
<td>11.668</td>
<td>5.87</td>
<td>7.10</td>
<td>64.00</td>
<td>4.00</td>
<td>4.48</td>
</tr>
<tr>
<td>Illinois No. 22, Lump, Argus, Pike Co..........................</td>
<td>7.82</td>
<td>13.045</td>
<td>5.90</td>
<td>7.00</td>
<td>63.25</td>
<td>3.59</td>
<td>4.53</td>
</tr>
<tr>
<td>Indiana No. 23, Lump, Argus, Pike Co..........................</td>
<td>8.68</td>
<td>12.336</td>
<td>6.41</td>
<td>7.78</td>
<td>62.56</td>
<td>3.64</td>
<td>4.50</td>
</tr>
<tr>
<td>Iowa No. 1, Run of mine, Neosho..........................</td>
<td>30.04</td>
<td>11.844</td>
<td>5.35</td>
<td>8.30</td>
<td>81.10</td>
<td>3.00</td>
<td>3.53</td>
</tr>
<tr>
<td>Iowa No. 2, Run of mine, Neosho..........................</td>
<td>10.0</td>
<td>11.675</td>
<td>5.19</td>
<td>7.15</td>
<td>58.79</td>
<td>3.00</td>
<td>3.53</td>
</tr>
<tr>
<td>Iowa No. 3, Run of mine, Neosho..........................</td>
<td>9.9</td>
<td>11.144</td>
<td>7.04</td>
<td>8.35</td>
<td>65.24</td>
<td>3.18</td>
<td>3.91</td>
</tr>
<tr>
<td>Iowa No. 5, Run of mine, Neosho..........................</td>
<td>8.13</td>
<td>14.414</td>
<td>7.33</td>
<td>8.94</td>
<td>62.56</td>
<td>3.18</td>
<td>3.91</td>
</tr>
<tr>
<td>Kentucky No. 1, Run of mine, Neosho..........................</td>
<td>9.78</td>
<td>14.271</td>
<td>8.01</td>
<td>9.69</td>
<td>66.94</td>
<td>2.94</td>
<td>3.63</td>
</tr>
</tbody>
</table>
### TABLE SHOWING RESULTS OF STEAMING TESTS—Continued.

<table>
<thead>
<tr>
<th>NAME OF MINE</th>
<th>Duration of Test</th>
<th>Heating Value of Dry Coal</th>
<th>Water Apparently Evaporated per Pound of Coal as Fired</th>
<th>Water Evaporated From and at 212°F., per Pound of Coal as Fired</th>
<th>Efficiency of Boiler</th>
<th>Pounds of Coal Fired per Indicated Horsepower Hour</th>
<th>Pounds of Coal Fired per Electrical Horsepower Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kentucky No. 7, Central City, western field, lump</td>
<td>9.60</td>
<td>12,564</td>
<td>6.67</td>
<td>8.01</td>
<td>67.95</td>
<td>3.53</td>
<td>4.30</td>
</tr>
<tr>
<td>Maryland No. 1, George's Cr., run of mine</td>
<td>10</td>
<td>11,289</td>
<td>7.29</td>
<td>8.90</td>
<td>63.95</td>
<td>3.18</td>
<td>3.92</td>
</tr>
<tr>
<td>Ohio No. 1, Wellsburg, run of mine</td>
<td>9.92</td>
<td>11,704</td>
<td>6.36</td>
<td>7.44</td>
<td>66.42</td>
<td>3.80</td>
<td>4.69</td>
</tr>
<tr>
<td>Ohio No. 3, Perry Co., run of mine</td>
<td>9.78</td>
<td>13,277</td>
<td>8.95</td>
<td>8.12</td>
<td>65.44</td>
<td>3.46</td>
<td>4.27</td>
</tr>
<tr>
<td>Penna. No. 4, Greensburg, Pitts. bed, lump</td>
<td>10</td>
<td>13,979</td>
<td>8.10</td>
<td>9.47</td>
<td>67.01</td>
<td>2.99</td>
<td>3.69</td>
</tr>
<tr>
<td>Penna. No. 5, Washington Co., Pitts. bed, 1 in. coal</td>
<td>10</td>
<td>14,029</td>
<td>8.29</td>
<td>9.92</td>
<td>71.25</td>
<td>2.88</td>
<td>3.63</td>
</tr>
<tr>
<td>Penna. No. 8, Cambria Co., run of mine</td>
<td>9.88</td>
<td>14,486</td>
<td>8.63</td>
<td>10.12</td>
<td>67.27</td>
<td>3.97</td>
<td>4.67</td>
</tr>
<tr>
<td>West Virginia No. 13, Loop Cr., Kanawha coal, run of mine</td>
<td>10</td>
<td>14,999</td>
<td>8.71</td>
<td>10.12</td>
<td>67.40</td>
<td>3.79</td>
<td>4.45</td>
</tr>
<tr>
<td>West Virginia No. 15, Clarksburg, Pittsburg bed, run of mine</td>
<td>8.78</td>
<td>14,136</td>
<td>7.65</td>
<td>9.06</td>
<td>62.70</td>
<td>3.14</td>
<td>3.88</td>
</tr>
</tbody>
</table>
Result of Actual Experience.—A large amount of correspondence was carried on for the 1898 report with manufacturers and others in regard to their use of Indiana coal. As a result of that the general conclusion was reached that considered from the standpoint of cost per horsepower of power, or for other use, no outside coal can compete with Indiana coal, except in the northeast corner of the State, along the eastern edge and the southeast corner, or in the area bordering the Ohio River. The experience of those in the area mentioned seems to be that the difference in the freight rates between the Indiana field and the Eastern fields is hardly sufficient to compensate for the difference in the quality of the coals. Thus, for example, at South Bend it was found that a number of large plants there had experimented and watched their expense accounts carefully, with somewhat diverse results, showing that the cost, all things considered, was just about even between the Indiana field and the Eastern field, though that did not apply to the poorer coals from Ohio and the western edge of Pennsylvania, in which case the advantage over the Indiana coal hardly made up for the difference in freight, but was true of the higher grade coals of Pennsylvania. In the same way, along the Ohio River the area which can be supplied by coals sent down from the Monongahela locks by boat, that coal is able to compete not alone on account of its somewhat superior quality, but on account of the lower freight rate. With these exceptions, however, the testimony seemed universal that for power production in Indiana, Indiana coal was far cheaper than any other coal.

Smokeless Combustion.—Another fact that is going to have great influence on the use of Indiana coal is, first, the increasing legislation against smoke in the cities, and, second, the great advance that is taking place in securing smokeless combustion in the high-gas coals.

It is well recognized that the higher the percentage of gas or volatile matter in a coal the greater the tendency of the coal to smoke. In this respect the coals of the Illinois-Indiana field suffer by comparison with the coals of much of the Appalachian field. Many of the coals of the eastern part of that field which have 20 per cent or less of gas are often called smokeless. It is generally recognized that they are so only if properly fired. Aside from the objection to smoke as it comes from the chimney, it is well known that it represents just so much loss of heating power of the fuel, its blackness being due to the uncomsumed carbon it contains. Efforts have therefore been directed toward securing complete combustion, in which case there is no free carbon left over to produce smoke.
Notwithstanding the belief of many that smokeless combustion of bituminous coal is not possible, many plants in Chicago and elsewhere are demonstrating that it is possible. Mr. A. Bement, the consulting engineer, of Chicago, who is giving the subject much attention, has published a number of pictures of Chicago power plants in full operation in which, to judge by the picture, one might suppose that the plant had suspended operation. Mr. Bement has stated the requirements for smokeless combustion briefly as follows:

"(1) That the evolution of gas from the coal shall proceed uniformly; (2) that the gases distilled uniformly from the coal shall enter a fire-brick chamber, either (a) of sufficient length to allow their complete natural combustion, or (b) provided with such auxiliary mixing and baffling devices as will effect the artificial mixture and complete combustion of the gases before their exit from the chamber."

To secure these conditions it is of the utmost importance that the stoking be regular and uniform. This is almost impossible with hand-fired furnaces. The best results are secured with some form of chain-grate stoker that automatically receives the coal at one end, moves it forward regularly, and discharges the ashes at the other end. Some forms of underfeed stokers can also be successfully used. Where such a stoker is not available complete combustion can be more or less successfully secured by adapting the form and construction of the combustion chamber of the furnace to that end, the object being, by the use of fire-brick walls, arches, etc., to increase the length of the chamber, or to so compel the mixing of the gases in the chamber that the combustion of the gases given off from the fresh coal is insured. Where the firing is intermittent it is often necessary to temporarily supply some additional oxygen immediately after firing, when for a short time a large volume of gas will be given off. A steam jet is often used for this purpose, being put into service only for a short time following the introduction of the fresh coal.

In some cities the smoke laws are so rigid and so rigidly enforced that bituminous coal, as formerly fired, is almost out of the question. For example, in the city of Washington today no more smoke can be seen than could be seen in Indianapolis when the use of natural gas was at its height.

Recent practice has clearly demonstrated that the old idea that smokeless combustion cannot be obtained with bituminous coal with

economy is a fallacy, and that mechanical stokers in small plants give not only smokeless combustion but good economy.

Domestic Use.—The rapid change from the old-time base-burner for household use to the modern furnace for steam or hot water is introducing a new use for Indiana coal. In the past the fact that the soft coals of the Illinois-Indiana field were dirty to handle, dusty through the house, difficult to regulate, and often did not keep fire as well as anthracite coal, gave off smoke, soot, and noxious gases, has greatly hindered their use. One difficulty has been that the attempt has been made to use bituminous coal in stoves and furnaces adapted for anthracite coal. Now, however, many manufacturers are endeavoring to design and supply stoves and furnaces especially for the use of bituminous coal. It cannot be said that as yet the manufacturers and dealers have been able to keep pace with the need and demand. Such items as the delivery of coal in bags by the retailer, and the proportioning of stoves to better utilize the high-gas coals of Indiana and Illinois, is a distinct advance, and will doubtless be followed by many others. The use of Indiana coal in the form of coke is another advance, provided that the by-products of the coke-making be also used.

At the Engineering Experiment Station at the University of Illinois studies are being made in the anthracitization of Illinois coals; that is, in the production by slight changes in the coal which while only slightly reducing its heating value, will tend to render its combustion more or less nearly smokeless. The process consists in heating the coal at a low temperature. Some of the volatile matter and oil products are driven off, as well as the moisture. An interesting thing about the experiments to date is that apparently there is a greater proportionate loss in the water of constitution or the inert volatile matter than in the more valuable hydro-carbons. Chemically the product resembles the so-called smokeless coals of Pennsylvania and West Virginia. To complete the process the coal should be briquetted, as the product of the experiment is quite fragile. In this form it would not only be practically smokeless, but would be as clean as anthracite to handle and to burn.

To pass over the objectionable features connected with the combustion of Indiana coal for household use, there can be no question of its economy. Some of the results obtained in a study of this question by the experiment station of Illinois may be of interest here. First is given a table showing the relative cost of various coals and cokes at Urbana, and their B. T. U. value for comparison. This table is as follows:*

Cost of Various Fuels.


Then in another table the relative costs are given, taking into account the actual results obtained, using two different designs of house-heating boilers. The experiments follow the standard methods of the A. S. & E. code. Results are given in the following table. The prices given are those at which the coals were purchased from local dealers, in small lots, such as are usually obtained by householders. It is noticed that the actual cost of evaporating 1,000 pounds of water with anthracite coal is just double the cost of doing the same with Illinois coal, and the latter cost from one-third to one-eighth less than coke or Pocahontas coal:

**Comparison of Fuel Costs—Data and Results.**


<table>
<thead>
<tr>
<th>Kind of Fuel</th>
<th>Cost Per Ton of 2000 Lb at Urbana, Ill.</th>
<th>Cost in Per Cent. Based on Anthracite Coal as 100 Per Cent.</th>
<th>B.t.u. Per Lb as Fired.</th>
<th>B.t.u. in Per Cent. Based on Anthracite Coal as 100 Per Cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthracite coal</td>
<td>88.75</td>
<td>100</td>
<td>12,690</td>
<td>100.00</td>
</tr>
<tr>
<td>Pocahontas coal</td>
<td>5.50</td>
<td>67</td>
<td>14,755</td>
<td>116.0</td>
</tr>
<tr>
<td>Coke (gas-plant by-product)</td>
<td>5.00</td>
<td>61</td>
<td>12,043</td>
<td>94.8</td>
</tr>
<tr>
<td>Coke (Solvay process)</td>
<td>6.00</td>
<td>73</td>
<td>12,488</td>
<td>98.4</td>
</tr>
<tr>
<td>Illinois coal (Christian county), nat.</td>
<td>2.75</td>
<td>34</td>
<td>10,473</td>
<td>82.5</td>
</tr>
<tr>
<td>Illinois coal (Williamson county), washed nat.</td>
<td>3.75</td>
<td>40</td>
<td>12,278</td>
<td>98.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Kind of Fuel</th>
<th>Cost Per Ton of 2000 Lb at Urbana, Ill.</th>
<th>Cost in Per Cent. Based on Anthracite Coal as 100 Per Cent.</th>
<th>B.t.u. Per Lb as Fired.</th>
<th>B.t.u. in Per Cent. Based on Anthracite Coal as 100 Per Cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthracite coal</td>
<td>88.75</td>
<td>100</td>
<td>12,690</td>
<td>100.00</td>
</tr>
<tr>
<td>Pocahontas coal</td>
<td>5.50</td>
<td>67</td>
<td>14,755</td>
<td>116.0</td>
</tr>
<tr>
<td>Coke (gas-plant by-product)</td>
<td>5.00</td>
<td>61</td>
<td>12,043</td>
<td>94.8</td>
</tr>
<tr>
<td>Coke (Solvay process)</td>
<td>6.00</td>
<td>73</td>
<td>12,488</td>
<td>98.4</td>
</tr>
<tr>
<td>Illinois coal (Christian county), nat.</td>
<td>2.75</td>
<td>34</td>
<td>10,473</td>
<td>82.5</td>
</tr>
<tr>
<td>Illinois coal (Williamson county), washed nat.</td>
<td>3.75</td>
<td>40</td>
<td>12,278</td>
<td>98.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Kind of Fuel</th>
<th>Cost Per Ton of 2000 Lb at Urbana, Ill.</th>
<th>Cost in Per Cent. Based on Anthracite Coal as 100 Per Cent.</th>
<th>B.t.u. Per Lb as Fired.</th>
<th>B.t.u. in Per Cent. Based on Anthracite Coal as 100 Per Cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthracite coal</td>
<td>88.75</td>
<td>100</td>
<td>12,690</td>
<td>100.00</td>
</tr>
<tr>
<td>Pocahontas coal</td>
<td>5.50</td>
<td>67</td>
<td>14,755</td>
<td>116.0</td>
</tr>
<tr>
<td>Coke (gas-plant by-product)</td>
<td>5.00</td>
<td>61</td>
<td>12,043</td>
<td>94.8</td>
</tr>
<tr>
<td>Coke (Solvay process)</td>
<td>6.00</td>
<td>73</td>
<td>12,488</td>
<td>98.4</td>
</tr>
<tr>
<td>Illinois coal (Christian county), nat.</td>
<td>2.75</td>
<td>34</td>
<td>10,473</td>
<td>82.5</td>
</tr>
<tr>
<td>Illinois coal (Williamson county), washed nat.</td>
<td>3.75</td>
<td>40</td>
<td>12,278</td>
<td>98.7</td>
</tr>
</tbody>
</table>
Use of Indiana Coal in the Producer Gas Plant.—The subject of the better utilization of Indiana coal opens up most fascinating possibilities, particularly in connection with its use in the gas engine. Considerable space was given to the subject in the 1898 report, and many figures and tables were given. At that time the writer's interest was more particularly directed toward making from the Indiana coal a transportable fuel gas that should in some measure take the place of the natural gas, the decrease in which at that time was being most keenly felt. At that time he was inclined to predict that the time would come when Indiana coal might be converted into a high-grade fuel gas in the mines and piped to the cities in the coal fields and to the eastward, and used in the same way that natural gas was then.

Since then little progress has been made in the production of high-grade fuel gases or their transportation, and indeed, the dangerous nature of water gas, which is apt to enter into any high-grade fuel gas, has proved so objectionable that its use has rather decreased than increased. This certainly seems to be true in regard to its use in connection with ordinary city illuminating gas, as many cities in this country and Europe now have restrictive legislation on the amount that may be used.

On the other hand, great advance has been made in the production of low-grade gases—such as producer gas—in the gas engine, and in the transportation of energy by electricity. In this connection one of the most important results of the experimental work of the St. Louis fuel testing plant of the U. S. Geological Survey was in pointing out the possibility of the use of lower grades of bituminous coal in the producer gas plant. Up to that time it had been the general impression that only anthracite or the highest grade of soft coals could be used. It was plainly demonstrated there that not only the medium grade coals of the Mississippi Valley could be successfully used, but even the lignites and peats. The point of most interest is the comparison of the actual results of using Indiana coal in the steam engine and of changing it into producer gas and using it in the gas engine.

In the following table are given the equivalent pounds of coal as fired per electrical horsepower per hour developed at the switchboard for both the steam and gas plants, first, for a number of Indiana coals, then for comparison of a number of coals from the competing fields:
Table Showing Equivalent Pounds of Coal as Fired per Electrical Horsepower per Hour for Steam and Producer Gas.

<table>
<thead>
<tr>
<th>Fuel Used</th>
<th>Locality</th>
<th>Steam</th>
<th>Producer gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indiana No. 1</td>
<td>Milled</td>
<td>4.96</td>
<td>2.17</td>
</tr>
<tr>
<td>Indiana No. 2</td>
<td>Beechville</td>
<td>4.78</td>
<td>1.88</td>
</tr>
<tr>
<td>Indiana No. 3</td>
<td>Beechville</td>
<td>4.82</td>
<td>1.87</td>
</tr>
<tr>
<td>Indiana No. 5</td>
<td>Hymera</td>
<td>4.74</td>
<td>1.81</td>
</tr>
<tr>
<td>Indiana No. 6</td>
<td>Hymera</td>
<td>4.78</td>
<td>1.84</td>
</tr>
<tr>
<td>Indiana No. 7</td>
<td>Littles</td>
<td>4.39</td>
<td>1.65</td>
</tr>
<tr>
<td>Indiana No. 8</td>
<td>Terre Haute</td>
<td>4.52</td>
<td>1.61</td>
</tr>
<tr>
<td>Indiana No. 9</td>
<td>Marksville</td>
<td>4.63</td>
<td>1.64</td>
</tr>
<tr>
<td>Indiana No. 11</td>
<td>Dugger</td>
<td>4.57</td>
<td>1.73</td>
</tr>
<tr>
<td>Illinois No. 4</td>
<td>Troy</td>
<td>4.47</td>
<td>2.01</td>
</tr>
<tr>
<td>Illinois No. 8</td>
<td>Painesville</td>
<td>5.26</td>
<td>2.04</td>
</tr>
<tr>
<td>Illinois No. 11</td>
<td>Herrin</td>
<td>4.35</td>
<td>1.87</td>
</tr>
<tr>
<td>Illinois No. 16</td>
<td>Herrin</td>
<td>4.37</td>
<td>1.92</td>
</tr>
<tr>
<td>Illinois No. 16</td>
<td>Herrin</td>
<td>4.37</td>
<td>1.92</td>
</tr>
<tr>
<td>Iowa No. 2</td>
<td>Marion Co.</td>
<td>5.82</td>
<td>2.07</td>
</tr>
<tr>
<td>Kansas No. 5</td>
<td>West Mineral</td>
<td>4.11</td>
<td>1.67</td>
</tr>
<tr>
<td>Kentucky No. 5</td>
<td>Big Black Mtn., E. Ky.</td>
<td>3.72</td>
<td>1.41</td>
</tr>
<tr>
<td>Kentucky No. 3</td>
<td>Earlington, W. Ky.</td>
<td>4.58</td>
<td>2.05</td>
</tr>
<tr>
<td>Kentucky No. 7</td>
<td>Central City, W. Ky.</td>
<td>4.36</td>
<td>1.85</td>
</tr>
<tr>
<td>Missouri No. 2</td>
<td>Revere</td>
<td>5.84</td>
<td>2.04</td>
</tr>
<tr>
<td>Ohio No. 3</td>
<td>Shawnee</td>
<td>4.27</td>
<td>1.51</td>
</tr>
<tr>
<td>Ohio No. 6</td>
<td>Niles</td>
<td>4.00</td>
<td>1.30</td>
</tr>
<tr>
<td>Ohio No. 9</td>
<td>Clarksburg</td>
<td>3.81</td>
<td>1.43</td>
</tr>
<tr>
<td>Pennsylvania No. 4</td>
<td>Greensburg</td>
<td>3.63</td>
<td>1.42</td>
</tr>
<tr>
<td>Pennsylvania No. 6</td>
<td>East Millsboro</td>
<td>3.53</td>
<td>1.27</td>
</tr>
<tr>
<td>Pennsylvania No. 8</td>
<td>Ebensburg</td>
<td>3.43</td>
<td>1.28</td>
</tr>
<tr>
<td>Pennsylvania No. 10</td>
<td>Brevard</td>
<td>3.46</td>
<td>1.29</td>
</tr>
<tr>
<td>West Virginia No. 1</td>
<td>Kingsmont</td>
<td>3.96</td>
<td>1.60</td>
</tr>
<tr>
<td>West Virginia No. 2</td>
<td>Ashland</td>
<td>3.83</td>
<td>1.82</td>
</tr>
<tr>
<td>West Virginia No. 18</td>
<td>Pansy</td>
<td>3.45</td>
<td>1.04</td>
</tr>
<tr>
<td>West Virginia No. 20</td>
<td>Ame.</td>
<td>3.46</td>
<td>1.07</td>
</tr>
</tbody>
</table>

In a general way it may be stated that the results showed that to obtain the same results the steam engine required from 1.8 to 3.7 times as much coal as the gas engine, with an average of 2.7 times as much. In this connection some figures given by Mr. H. G. Stott, Superintendent of Motive Power of the Interborough Rapid Transit Company of New York City, are of interest. He shows the losses found in a year's operation of their plant, which is probably one of the most efficient in existence today and therefore typical of the present state of the art. The figures are as follows:

Average Losses in Steam Plant of the Interborough Company in Converting
1 Pound of Coal, Containing 12,500 British Thermal Units, Into Electricity.

<table>
<thead>
<tr>
<th>Loss</th>
<th>British Thermal Units</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss by friction</td>
<td>138</td>
<td>1.1</td>
</tr>
<tr>
<td>Loss in exhaust</td>
<td>7,513</td>
<td>60.1</td>
</tr>
<tr>
<td>Loss in pipes and auxiliaries</td>
<td>275</td>
<td>2.2</td>
</tr>
<tr>
<td>Loss in boiler</td>
<td>1,000</td>
<td>8.0</td>
</tr>
<tr>
<td>Loss in stack</td>
<td>1,987</td>
<td>15.9</td>
</tr>
<tr>
<td>Loss in ashes</td>
<td>300</td>
<td>2.4</td>
</tr>
<tr>
<td>Total losses</td>
<td>11,213</td>
<td>89.7</td>
</tr>
<tr>
<td>Energy utilized</td>
<td>1,287</td>
<td>10.3</td>
</tr>
<tr>
<td></td>
<td>12,500</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Mr. Stott further presents a table showing the thermal efficiency of producer-gas plants, concerning which he says:

"The following heat balance is believed to represent the best results obtained in Europe and the United States up to date in the formation and utilization of producer-gas:"

Average Losses in a Producer-Gas Plant in the Conversion of 1 Pound of Coal, Containing 12,500 British Thermal Units, Into Electricity.

<table>
<thead>
<tr>
<th>Loss</th>
<th>British Thermal Units</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss in gas producer and auxiliaries</td>
<td>2,500</td>
<td>20.0</td>
</tr>
<tr>
<td>Loss in cooling water in jacket</td>
<td>2,375</td>
<td>19.0</td>
</tr>
<tr>
<td>Loss in exhaust gases</td>
<td>3,750</td>
<td>30.0</td>
</tr>
<tr>
<td>Loss in engine friction</td>
<td>813</td>
<td>6.5</td>
</tr>
<tr>
<td>Loss in electric generator</td>
<td>62</td>
<td>0.5</td>
</tr>
<tr>
<td>Total losses</td>
<td>9,500</td>
<td>76.0</td>
</tr>
<tr>
<td>Converted into electric energy</td>
<td>3,000</td>
<td>24.0</td>
</tr>
<tr>
<td></td>
<td>12,500</td>
<td>100.0</td>
</tr>
</tbody>
</table>

At the St. Louis experimental station the relative economics of steam and gas-power plants were estimated as follows:
Relative Economics of Steam and Gas Power Plants at St. Louis in the Conversion of 1 Pound of Coal, Containing 12,500 British Thermal Units, Into Electricity.

<table>
<thead>
<tr>
<th>Steam Power</th>
<th>Gas Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Thermal Units</td>
<td>For Cent.</td>
</tr>
<tr>
<td>Lesse in exhaust, friction, etc.</td>
<td>11,892</td>
</tr>
<tr>
<td>Converted into electric energy</td>
<td>608</td>
</tr>
<tr>
<td>12,500</td>
<td>100.00</td>
</tr>
</tbody>
</table>

It had been hoped to have Mr. W. H. Duncan, Secretary of the Commercial Club of Terre Haute, prepare a supplemental paper on the successful use of the producer-gas plant in Indiana using Indiana coal, as he has given the subject much study and is thoroughly familiar with the results obtained. With this in view the writer did not himself investigate the subject. Pressure of other duties, however, has prevented Mr. Duncan from preparing his paper, and the writer has had to content himself with quoting from a paper on this subject by Mr. R. H. Fernald of the United States Geological Survey. In 1906 Mr. Fernald visited several of the producer-gas power plants of the country with the idea of ascertaining from the owners and operators their exact uses, efficiency and defects. The list included producers made by fourteen manufacturers, and the territory visited extended from Maine to central Nebraska. The deductions made from these visits are:

1. The plants as a whole are giving remarkable satisfaction, considering the very brief period of development that has passed since the introduction of this type of power.
2. The most serious difficulty seems to arise from the lack of competent operators to run the plants rather than from defects or troubles inherent in the plants themselves.
3. Inexperienced salesmen are undoubtedly to blame for serious misrepresentations and misunderstandings.
4. The neglect shown by some manufacturers in respect to their plants after they are installed and paid for has not been far-sighted, and the failure of manufacturers to give the purchasers or operators of plants full information regarding their construction and method of operation has certainly been detrimental to the business.

The situation as a whole at the present time seems to be very
favorable for the producer-gas plant, not only as to cost of installation, operation and maintenance, but also as to reliability. The successful demonstration at the Government fuel-testing plant that bituminous coals, lignites and peats can be utilized with great economy in these plants should lead to an increase in the use of this form of power within the next few years that may surpass even the most sanguine hopes of the manufacturers.

Finally, it must be remembered, as suggested in Mr. Fernald’s paper, that engineers are often not familiar with the gas engine plants, which have improved rapidly, so that sometimes mistakes are made in suggesting where they can be used to advantage. Often the difficulty is in not understanding their running after installation, but the facts all go to show that when properly installed, under the right conditions, they will prove economy of the highest kind.

Weathering of Indiana Coal.—Among the difficulties to be met by Indiana coal is that it does not stand transportation and storage well. Some experiments are now in progress at the Engineering Experiment Station of the University of Illinois on the subject of weathering of Illinois coal. In the preliminary experiments only 25-pound samples were used. Some of the samples were stored out of doors, some indoors, dry and wet, and some under water. In a general way the results of these first experiments show that in nine months the samples stored indoors and out of doors had losses varying from 2 to 10 per cent, with no marked advantage on storage indoors or out of doors, except that where there was a large amount of pyrite the coal was more broken up when wet than when kept dry. The coal, however, that was submerged was found to remain practically unchanged. There are now in progress a series of experiments, using carload lots. For the first six months the analyses show a decrease in the percentage of B. T. U.’s of less than 3 per cent in all cases, and of less than 2.5 per cent in most cases. The smaller loss in these experiments would seem to be due to the fact that the air has less access to the coal. In these experiments, too, the submerged coal does not appear to have as great advantage over the other coal samples. Figures are not yet available in regard to the breaking up of the coal, but it looks now as though the experiments would show that the deterioration is greater in a physical way than in a chemical way.
CHAPTER III.

INDIANA COAL MEASURES.

General Character and Relations.—On the stratigraphic chart, Plate II, is given a comprehensive survey of the coals of the State and the rocks with which they are associated, showing the number of coals, their relation to each other and to other rocks, and to some extent their distribution in the field. To facilitate the correlation the sections have been placed so that the coal mined at Alum Cave, Petersburg, etc., called Coal V in the old reports from Sullivan County southward, shall, where present, always be in the same horizontal line. It is believed, with much confidence, that this coal has been correctly correlated the entire length of the coal field. It has therefore been used as a base from which to measure up and down. It is, without any doubt, the most important bed in the State, having usually a good thickness, and is nearly everywhere characterized by a hard, black, sheety shale roof, commonly containing pyrite bowlders that project downward into the coal, and with a limestone overlying the black shale.

There are only a few points at which some question has arisen as to its identity, and these points do not affect the general correlation, one or two of them being on outliers at some distance to the east of the outcrop, where the character and roof of the coal has changed, and a few of the others well back to the westward of the outcrop, where the coal is met in shafts or drillings, and where some changes have taken place in its character and roof. From the east branch of White River southward to the Ohio River this particular coal is almost the only workable coal in that section of the State, reaching a thickness much in excess of any of the other coals, and in Pike and Warrick counties there are long distances in which it has been exposed by drifting or stripping on almost every 40 acres along its outcrop. Farther to the northward it is distinguished as stated by its large thickness in combination with its peculiar and characteristic roof, composed of black sheety shale, overlain with limestone. Some other coals of the section have this roof, but as a rule they are thin coals, with one exception, which lies several hundred feet stratigraphically lower than Coal V, and therefore is not confused with it today, though it was so confused in the early days of the Survey, and in part of the area in the report of 1898.
One hundred to 150 feet above it is everywhere a somewhat thinner coal, overlain by a light-colored shale or a sandstone, frequently with a rolling roof, and usually underlain, within a few feet, by a limestone. This is Coal VII of the old reports. Between the two, in Sullivan County, appears a thick coal, divided by a remarkable series of thin bands into a number of benches of constant character. This bed has not been recognized in Indiana north of Sullivan County, and it becomes inconstant south of central Knox County.

About 100 feet below No. V coal is usually found a workable bed, which is considered to correlate with the main coal at Linton, old Coal IV. About 70 feet below that coal is generally found a coal that in places reaches a considerable thickness, but which frequently is badly split up by partings, and in some districts runs out entirely. It is correlated as the lower bed at Linton, the main coal at Seelyville, Staunton and Rosedale, the lower coal at Lyford. Below this bed for 200 feet are found a variable number of beds, many of which are locally workable, especially the three at the bottom, which are now correlated as the rider, upper and lower block coals of the Brazil district. Above the uppermost coal just mentioned, Coal VII, come about 1,000 feet of rocks with a number of thin coals, and below the horizon of the Lower Block coal are sandstones and shales, and at least one coal bed.

**Naming and Grouping of the Coals and Rocks.**—In the 1898 report the principal coals were numbered from I to VII, and the whole column of rocks divided up into “divisions,” the base of each division being the bottom of the coal of the same number. In addition coals VIII and IX, lying above Coal VII, afforded the basis of divisions VIII and IX. Not only have these numbers been quite generally used by those in the mining industry of the State, but in many cases these numbers have been used in corporation names, and appear in wage scale agreements and other documents. It appears, therefore, to be very desirable that wherever possible these old numbers be retained. While the errors of the 1898 report have thrown the naming of the beds into confusion in certain districts, it so happens that in the main these districts have not been districts of much recent development, and, as in the Brazil block coal field, the old names antedating the 1898 report have remained current there. This is fortunate, as it allows the continuance of these old names in regions where it would now be difficult to apply a number system. Thus, as old Coal VI of Clay County corresponds to Coal III of most of the State, and as there...
are four workable coals below it, it is evident the system of applying the numbers would have to be modified. Furthermore, a broader knowledge of the field as a whole tends to render more uncertain the correlation of the lower coals outside of the region of their greatest development in the Brazil district.

It is therefore proposed to retain the numbers for coals VII to III as originally applied in Sullivan County, and around Linton; to use the No. II for the coal exposed above drainage at Minshall, for reasons given beyond, and to use local names for the lowest coals.

Starting again with coal V: Coal V, as used in this report, refers to the bed outcropping at Alum Cave, in the eastern edge of Sullivan County, northwest of Coalmont, and to what is believed to be the same bed elsewhere in the State. As thus correlated, Coal V is the thick coal outcropping at Clinton and Lyford, the second bed down or the “lower vein” at West Terre Haute, a similar bed mined in the small area just south and west of Riley, the lowest bed at present worked around Bicknell, and at Wheatland, the old “main” coal around Washington, the coal at Murray’s on White River, southwest of Washington, the main coal around Petersburg, Littles, Winslow, Princeton, Booneville, Evansville, Henderson, the “Knob” coal of Spencer County, and believed to correspond to Coal 9 of Kentucky, and to Coal 5 in southern Illinois, as typically mined at Harrisburg.

Coal VI will refer to Coal VI as used in the old report on Sullivan County, where it occurs 50 to 75 feet above Coal V. It is characterized nearly everywhere in that county by three shale partings, the lowermost about one foot from the floor and overlying a bony bench that is seldom mined, and the upper two coming about 2 feet from the top, and from 4 to 6 inches apart. This coal seems to run out north of Sullivan County, and south of Bicknell is only mined at a few points in Gibson County.

Coal VII is the old Coal VII of Sullivan County, outcropping on Busseron Creek, east of Farmersburg. It is correlated as the coal outcropping on Broulett Creek, in Vermillion County, Coal Creek in northwestern Vigo County, outcropping at water level west of Terre Haute, and along White River, just northeast of Wheatland. It is Coal VII around Hosmer, and outerops just east of Newburg, Warrick County, where it is known as the Little Newburg.

Coal IV is the old Coal IV at Linton. It is correlated as the old Coal VII of northeastern Vigo County, and around Coxville
and Mecca, around Hillsdale, and northward to the Horseshoe of Little Vermillion River. It possibly corresponds to the Grape Creek coal at Danville. It is correlated as the coal mined at Montgomery, Daviess County, and the Survant coal of the Ditney folio, U. S. Geological Survey, in Pike and Warrick counties.

Coal III is the lowest worked bed at Linton and the district north to Coalmont, the thick bed in the hill south of Clay City, the thick bed mined around Seelyville, Staunton, Turner, Fontanet, Coal Bluff, Rosedale, and Coxville, the lower bed at Clinton and Lyford, where it is 170 feet below Coal V. North of that it runs out. South of Sullivan County the horizon of Coal III does not seem to be marked by a regularly workable coal. However, the recurrence of a group of small coals close together, one of which very often is 3 feet thick, suggests that it splits in going southward and becomes unimportant before reaching the Ohio River. Its representative in Pike and Warrick counties is considered to be the Rock Creek coal of the Ditney folio.

From 90 to 150 feet below Coal III in Vermillion, Parke, Clay, and Vigo counties are two coals often coming within 2 or 3 feet of each other, but again separating until 20 to 40 feet apart. Where the space between them allows there is commonly found a limestone having a thickness up to 15 or 18 feet. The two coals have been worked at Minshall, Mecca, Fontanet, Coal Branch of the Big Vermillion River, and at many points in Parke, Fountain and Warren counties. Through a study of the fossils associated with these coals Mr. David White is inclined to correlate the upper of these coals with Coal II of Illinois, as mined in Grundy County, Rock Island County, at Murphysboro, and elsewhere. It is therefore proposed to call the upper coal which outcrops at Minshall, the one over the limestone, Coal II.

For the coals below Coal II, local names will be used. The coal below the limestone at Minshall has been called by the trade the Minshall coal not only at Minshall but at other points in Clay, Vigo, Parke and Vermillion counties. That name will therefore be used for it as a general term, especially for the northern half of the field. From Daviess County southward exact correlation cannot be made at this time, but coals which in that region are thought to come about at the horizon of the Minshall coal have been called the Sugar Creek coal, the Haysville coal, and the Holland coal.

In the Brazil field the Minshall coal overlies two coal beds that have long been known as the Upper and Lower Block coals.
They were called coals IV and III in the 1898 report. As they evidently do not correlate with coals IV and III of most of the field and as it will be easier to drop the numbers here than in the rest of the field, in this report the writer has returned to the old well known names of Upper and Lower Block coal.

The Cannelton coal, Coal II of the old report, is believed to come below the block coals of Brazil. It will be called the Cannelton coal. It is possibly at the same horizon as the lowest coal around Shoals, Martin County, which is there called the Shoals coal.

Another result of great interest from Mr. White's study is that the boundary between the Allegheny and Pottsville formations of the Appalachian coal field is found to come between the two Minshall coals, apparently about the top of the limestone mentioned in the preceding paragraph. The Allegheny formation includes what was formerly known as the "Lower Productive Coal Measures" of Pennsylvania, including the Freeport coals, the Kittanning coals, and the Clarion and Brookville coals. The Pottsville formation in Western Pennsylvania is of small thickness and of little interest from the coal standpoint, but it has a thickness of several thousand feet in the southern anthracite field of eastern Pennsylvania, and carries some of the most valuable coals of Ohio, while in West Virginia it contains the valuable Kanawha series of coals, the New River coals, and the Pocahontas coals. According to this, the main or lower Minshall coal, and the block coals at Brazil, are of Pottsville age. Furthermore, Mr. White's studies have shown that the so-called Mansfield sandstone of Fountain County, which underlies the block coals of the northern part of the State, is much younger, and therefore was deposited much later than the Mansfield sandstone of Martin and Orange counties. So that the exact correlation of these coals along the eastern edge of the field must await the time when good topographic maps are available, and can be supplemented by a detailed paleontologic study of that field.

It is therefore probable that in the future all of the rocks and coals below the limestone between the two Minshall coals, and down to the lower Carboniferous rocks will be grouped into a formation to be called the Pottsville formation, in correlation with the formation of that name in the Appalachian coal field. Such a grouping into a formation will not, however, be attempted until much additional field work has confirmed the evidence now on hand or has allowed the closer delineations of the proposed formation.

Again, Mr. White has found that Coal 7 of Illinois, which is believed to be the same as Coal VII of Indiana, is almost exactly
of the same age as the Upper Freeport coal of Pennsylvania, which comes at the top of the Allegheny formation or old "Lower Productive Measures" of that State. The interval in Indiana between and including coals VII and II, as above defined, is believed to therefore correspond in age with the Allegheny formation of Pennsylvania. It is possible that in the future this group of coals and other rocks will be called the Allegheny formation or given some local name.

For the present it will be sufficient to remember that in a general way the coals from the Minshall coal down to the bottom of the coal measures correspond in age with the Pottsville coals of Pennsylvania; the coals from coal II up to coal VII, to the Allegheny coals; and the coals and rocks above coal VII, to the Conemaugh and higher formations of Pennsylvania; and that where desired it may be allowable in a loose way to group the lower coals as Pottsville coals, and the higher coals as Allegheny coals.

Generalized Section in Sullivan and Greene Counties.—More coals are developed and known in Sullivan and Greene counties than probably any other similar area in the State. It may therefore be helpful to notice the general section of the coal measures as they are there developed, and then trace those measures from that point northward and from that point southward. Starting with Coal V as typically exposed at Alum Cave on the eastern edge of Sullivan County, there are found two coals of workable thickness above it, the first lying on the average about 70 feet above, and the second about 50 feet higher. The first of these two coals will be designated Coal VI, the uppermost of the two Coal VII. Between Coal V and Coal VI is frequently found a thin coal, which may occasionally have a thickness of 2 or 3 feet. About 70 feet above Coal VII occurs a coal that while generally thin, in a few places in the western part of Sullivan County has a thickness of 3 feet or over. Still above that are other coals that in Indiana are always thin and unimportant. Of the other rocks it will be noted that there is a limestone close above Coal V, another limestone close below Coal VII, and other limestones above Coal VIII. The other rocks of the section are shales and sandstones, with clays immediately below the coals. There is no dominant sandstone, except one above what may be called Coal IX, which is believed to be the sandstone outcropping at the top of the bluff at Merom, and from this exposure has been called the Merom sandstone. Below Coal V is a coal that has been very extensively mined around Linton and to the northward for several years. This has been
designated Coal IV. It lies about 100 to 130 feet below Coal V. Between Coal IV and Coal V are usually two thin coals, the lower of which is frequently overlain by black shale and limestone, and is generally known by the miners as the Coal IV rider or Coal IVa. About 70 feet below Coal IV is another thick bed all through the Linton-Jasperville region, known as Coal III. This bed is usually broken up more or less by partings, but in that region has a thickness of over 6 feet. Between coals III and IV is one small coal frequently overlain with a limestone. With the exception of the two limestones mentioned, the one over Coal IVa and the one over IIIa, no limestones are noted in this section between coals III and V except occasionally just below Coal V. Coal IV is frequently overlain by a sandstone, and often underlain by a sandstone, one of the few cases in Indiana where a coal is underlain by some other rock than clay. During recent years considerable drilling has been done east of Jasonville, which has shown that below Coal III exist at least five coal beds, two or three of which may be of workable thickness. One of these has been reached by a shaft at Howesville, where it shows a thickness of 3 or 4 feet. The coals below Coal III are much better known in the Brazil district of Clay County, a little to the northeast of this district. In that district the lower-most of the five coals mentioned is known as the Lower Block coal; the next one above it as the Upper Block coal; the one next above that as the rider Block or Minshall coal. Between the Minshall coal and Coal III are several coals, in this region usually thin. The Minshall coal commonly has a limestone over it, as have also in many places the first two coals below Coal III. This repetition of a limestone closely overlying a coal below Coal III, led to their confusion in the 1898 report, before the amount of drilling now accomplished had been done. Of these coals between the Minshall coal and Coal III, the one next above the Minshall coal has been designated as Coal II. In this region it is not a coal of any importance as far as known. Still below the five coals mentioned outcropping to the eastward from them, below a massive sandstone is found a coal designated Coal I in the old reports. The massive sandstone between this coal and the Lower Block coal is the one that in the old report was designated the Mansfield sandstone, from the exposure at Mansfield, Parke County, where it had long been quarried. The interval from Coal III down to the Minshall coal will run about 100 feet; from the Minshall coal to the Upper Block coal from 20 to 30 feet, and from the Lower Block coal to the Upper Block coal an average of about 30 feet. From the Lower
Block coal to the old "No. 1" coal the interval is little known, but judging from the thickness of sandstone frequently exposed, in most areas is at least 100 feet.

For the purposes of discussion we may take first the coals in the strata above Coal V to the north of Sullivan County, then those above Coal V to the south of Sullivan County, then those below Coal V to the north of Sullivan County, and finally those below Coal V to the south of Sullivan County.

**Coal Measures Above Coal VII North from Sullivan County.** — In the southwest corner of the State the strata above Coal VII reach a thickness approaching 1,000 feet, the full thickness being attained probably only in Illinois. In Sullivan County there are remaining probably not more than 250 feet of these measures. As before stated, the coals contained in them are usually thin. Several of the drillings in Sullivan County west of the E. & T. H. R. R. report a workable thickness for one of the coals above Coal VII. Furthermore, a coal of workable thickness has been reached by shafting at Merom, and by shallow wells on Turman Creek. This coal has been thought to correspond with Coal VII of the Sullivan-Farmersburg district. Comparison, however, of the exposures on Turman Creek with drillings in that region, and with the position of Coal VI at the Scott City mine, seems to point to the fact that the workable coal on Turman Creek and at Merom is at the horizon of Coal VIII, or about 70 feet above Coal VII. This is the only region in which that coal is known to reach a workable thickness. A short distance below the Merom sandstone is commonly found a limestone, which is thought to correlate with what has been called the Somerville limestone of southern Indiana, and possibly with the Carthage limestone of southern Illinois and southwestern Kentucky, though that correlation is rather conjectural than demonstrated. A number of limestones are usually met in the sections in the upper part of this division of the coal measures, as developed in Sullivan County and in the corresponding part of the section elsewhere in this State, so that the determination of which of these limestones corresponds with the Somerville limestone is often difficult, if not impossible.

**Coal V to Coal VII Inclusive North from Sullivan County.** — (Divisions V and VI with Coal VII of 1898 report). — Reference has already been made to the fact that the correlation of the coals of Sullivan County northward as now made differs materially from that of the 1898 report. As a basis for the present correlation, Coal V is traced from Alum Cave to Lewis at the northeast corner
of Sullivan County, thence northward to Riley by way of the Meyers, Ray, and Pierce banks of Pierson township, and the Fox, Pickens and Christy banks in Riley township; thence from the outcrop west of Riley it can be traced by the Foster, Forest Hill, Fleshner, Hazeltine, and East Hulman Street banks to Terre Haute. While these small mines are in some cases well separated, the fact that the coal in each case resembles closely in thickness, character, and the peculiar roof, the coal at Alum Cave, and the fact that the coal in Alum Cave differs in those respects from any of the other coals above it, or for 300 feet stratigraphically below it, is considered good evidence that the coal in these mines is Coal V. Crossing the Wabash River at Terre Haute Coal V is worked at many mines and can be recognized in a large number of drillings between Terre Haute and Clinton, where the rise has brought it to above the level of the bottoms, it having risen to the river level at Durkee’s Ferry. According to this interpretation it is the old Coal VI of the 1898 report at Terre Haute, and the Coal VII of that report at Clinton. It is the “Lower coal” of the operators at West Terre Haute as mined at the Fauvre mine No. 2 and the “Lower Vein” mine, and the upper bed at the “Deep Vein” mine, and the highest worked bed at Clinton.

Assuming the correlation just made to be correct, a comparison of the drillings and sections above Coal V in Sullivan County with those above Coal V in northwestern Vigo County, reveals at once a change in either Coal VI or VII, for whereas all of the sections in Sullivan County show two workable coals above Coal V, in northwestern Vigo County there appears to be only one. It has generally been assumed by the operators of the West Terre Haute district that that one coal is Coal VI. A study of the sections in pl. II, however, leads to the conclusion that that coal is Coal VII.

This condition is one hitherto unsuspected. This conclusion is reached from three general facts: in the first place the interval in the sections given on pl. II is based on hundreds of records in which that particular interval is given; these bring out much more strongly than the few figures presented in that plate, the constancy of that interval from Coal V up to the first coal above, in Vermillion County, with the interval from Coal V to the second coal above in Sullivan County, the interval in Sullivan County tending to run about 10 feet less than near Clinton or northwest of Terre Haute. In the second place, Coal VI in Sullivan County and northern Knox County has a unique and remarkably persistent section, as described beyond. No coal with such a section is known north of
COALS ABOVE VII OF SULLIVAN COUNTY.

Terre Haute. Furthermore, along the northern edge of Sullivan County Coal VI becomes very irregular, and many attempts to mine it have had to be abandoned on account of the coal running out; and many drillings in that region fail entirely to find that coal. In the third place, the rocks above and below the first large coal above Coal V in Vigo and Vermillion counties resembles strongly the rocks near Coal VII in Sullivan County. No workable coal is found above it, but about 70 feet above in each case is a thin coal underlain by one or more thin layers of limestone. Below this upper coal in Vigo County is a conspicuous limestone. In Sullivan County Coal VII is everywhere underlaid by a very similar limestone, while no such limestone appears under Coal VI.

Coal VII of northwestern Vigo and Vermillion counties, as just described, differs greatly in its roof and top from Coal VII of Sullivan County. That fact is almost the only argument against the correspondence. As thus correlated Coal VII agrees with the number given it in the old report at Terre Haute. In the old report, however, it was thought to tie with the surface bed at Clinton, and that the surface bed of Coal Creek and Brouiletts Creek was a higher bed (Coal VIII). It is now clear that the surface bed at West Terre Haute (Coal VII) is also the surface bed on Coal Creek and on Brouiletts Creek in the southwestern part of Vermillion County. The rocks between Coal V and Coal VII pass out of the State to the northwest of Clinton and are but little known for more than a few miles to the north of that town.

Coals and Rocks Above Coal VII South from Sullivan County. —Southward from Sullivan County the strike carries any given coal bed farther and farther to the eastward, and as the general dip in Indiana is south as well as west, the coals are found most deeply buried in the southwestern part of the State. So too, in that part of the State is found the best development of the uppermost coal measure rocks. In Sullivan County only about 250 feet of these rocks as a maximum occur above Coal VII. The first workable coal at Mount Vernon, in Posey County, according to the diamond drilling, is at a depth of nearly 600 feet. To the westward, in Illinois, shafts and drillings have shown a possible thickness for the upper "Barren Measures" of about 1,000 feet. Only a small amount of drilling has been done through these upper rocks south of Sullivan County, but that appears to show a section somewhat similar to that found in Sullivan County. There is first a small coal about 70 feet above Coal VII, called Coal VIII in the old report; then about 50 feet higher another, called Coal IX. Lime-
stone occurs occasionally below the lower of these two coals, and usually between the coals, and generally above the upper coal, in which position it is thought to correspond with the limestone outcropping in the hills around Somerville and called by that name in the Ditney folio. A short distance above the upper limestone, and lying unconformably on the rocks below, is a soft, coarse-grained, quartzitic sandstone believed to correspond to the Merom, though not much weight should be given to that supposed correlation. In the Ditney and Patoeka folios of the U. S. Geological Survey, Coal VII was called the Millersburg coal, and the rocks from that coal up to the bottom of the Somerville limestone called the Millersburg formation. Above the Somerville limestone to the base of the sandstone just described was called the Ditney formation, from its exposures at Ditney Hills in Warrick County. From the base of that sandstone to a coal about 150 feet higher was called the Inglefield formation, the coal at the top of which was called the Parker coal. Above this to the top of the section was called the Wabash formation. Above the Parker coal occurred two other coals in the Wabash formation, which were designated the Aldrich and Friendsville coals. All of these coals reach a local thickness which has led to their being worked locally by country banks, though only the Friendsville reaches a commercially workable thickness. The formation names just mentioned will not be used in this report.

*From Coal V to Coal VII Inclusive South from Sullivan County.*—From the northern edge of Sullivan County well into northern Knox County the relation of coals V, VI, and VII is clear and definite. Coal VI through that distance runs about 70 feet above Coal V, and Coal VII about 40 feet above Coal VI. The interval from Coal VI to VII varies from 25 feet or less up to 70 feet, but the great majority of the large number of drillings made in that county give the interval between 30 and 45 feet, with an average of not far from 40 feet. Practically the same interval is maintained to Edwardsport and Bicknell, the coals and limestones showing the same characteristics as in Sullivan County. Most of the sections in Sullivan County show no coals between Coal VI and Coal VII, and only one coal between Coal V and Coal VI. In some cases, however, a thin coal occurs less than 10 feet below Coal VI. In northern Knox County this coal just below Coal VI is more persistent. It is usually about 1 foot thick, but in some drillings thickens up to 2 or 2½ feet. The limestone over Coal V is quite persistent. That under Coal VII is not noted in most of the sec-
COALS V TO VII SOUTH FROM SULLIVAN COUNTY.

As given in drillings, these regular conditions exist for at least three miles south of Bicknell. Between this point and Wheatland or the new road bridge across White River, northeast of Wheatland, apparently Coal VI pinches out much as it does at the north end of Sullivan County, though not so completely. Coal V is being mined at Wheatland at a depth of 250 feet. Forty feet above it, or about in the position of Coal Va of Sullivan County, is a thin coal. One hundred and twenty feet above it is a 5-foot coal; 223 feet above it, or about 100 feet above the 5-foot coal, is another thin coal. These are reported to be the only coals found in the shaft. The 5-foot coal 120 feet above No. V also outcrops along White River, near the new road bridge, and has been mined in the same region by shafting. In the section at this point Mr. John Collett, the former State Geologist, reported 4 feet 5 inches of coal to come 28 feet below the coal being worked. The writer could only find a thin coal (1 foot 8 inches thick) at this horizon, 24 feet below the worked coal, and this thin coal ran out entirely 150 feet up the river, the roof shale coming down on its underclay without a trace of coal. The upper worked coal at Wheatland and in the river bank resembles Coal VI at Bicknell to the extent of each having a bench of bony coal at the bottom. But it will be noted that the interval at Wheatland from this coal down to Coal V is exactly the same (120 feet) as from Coal VII to Coal V in drillings 3 miles to the north, where Coal VI is fully developed. Again, in all of the sections around Bicknell Coal VII is overlain by a heavy sandstone often 60 to 80 feet thick; so, likewise, is the upper worked bed around Wheatland. The writer has therefore assumed that this upper worked bed around Wheatland is Coal VII, and that Coal VI has become irregular or wanting.

At Vincennes Coal V does not show the typical development that it has along the eastern edge of the county. It has been assumed to be the third coal of workable thickness in drillings at that point. Seventy feet above it is a coal that has been considered to be Coal VI, and 13 to 18 feet above that is a 4-foot bed that has been mined, and is said to show many of the characteristics of Coal VII of Sullivan County. Between the two is usually only clay or soft shale. These two coal beds have therefore been correlated as coals VI and VII.

At Washington, in Daviess County, Coal V is typically developed west of town, but south and east of town the coal thins from 6 or 7 feet down to 3 or 4 feet, and the roof changes from a black shale to a light-colored shale or sandstone. This change
in the roof of Coal V at Washington is an interesting feature. A similar change is noted in the roof of this coal near High Bank in Pike County, south of Algiers, northeast of Oakland, and a tendency toward such a change is seen at points along the eastern outcrop in the north-central part of Pike County. In some of the mines, as at the Blackburn mine, this light-gray shale comes between the coal and the black shale roof, the gray shale occurring as lenses, and the black shale rising above these. Around Petersburg and northeast of Oakland the occurrence of the light-colored shale roof is not associated with a thinning of the coal—rather the reverse, as the thickest coal measured was under that kind of roof; but farther eastward, as at Washington, High Bank, and south of Algiers, the black shale disappears and the coal bed is much reduced in thickness. It suggests that following the laying down of the coal some stream entering the coal swamp from the east had brought out a quantity of mud, extending out irregularly on the newly deposited coal bed, this condition preceding the laying down of the normal black shale roof. This fact also suggests that the border of the swamp was not far to the east in this region, and that possibly this coal was not laid down as far to the eastward as some of the underlying coals, suggesting that the higher coals were laid down within more restricted outside limits.

Coal V is typically and finally developed all through the western half of Pike and Warrick counties. Coal Va appears above it, ranging from 40 to 50 feet above in northwestern Pike, to 5 to 20 feet above in central Pike County. It is not certain that these coals are at the same horizon. The Va coal of central Pike County is usually represented by less than 1 foot of coal, but in a few places, as south of Ayrshire and at Hartwell, this coal reaches a thickness of 3½ feet or more. The positions of coals VI and VII in this area are in much doubt. Most of the sections show only one workable coal above Coal V. In the hills west of the E. & I. R. R., from Petersburg to Littles, this single workable bed appears to be about 80 feet above Coal V. At Oakland the first coal above Coal V is 125 feet. At Fort Branch, Francisco, and a few other places, there appear to be two workable beds above Coal V coming close together, the lower being from 90 to 135 feet above Coal V, and the other 15 or 20 feet higher. Probably an average interval would be 100 feet and 20 feet more to the upper bed. In some of these drillings the distance between these two upper coal beds is much reduced, in one case near Oakland the two being separated only by 3 feet 7 inches, the two coals being apparently the same as the two
COALS V TO VII SOUTH FROM SULLIVAN COUNTY.

Two possible correlations may be made of these two coals, the first that they are coals VI and VII, the second that they are coal VI and the underlying coal previously mentioned, Coal VII, under that hypothesis, having thinned out. The fact that apparently these two coals can be traced southward to the Ohio River and then into Kentucky, where at different points, or in some cases at the same point, both of them are of good workable thickness, sometimes reaching even 6 or 8 feet, suggests that they belong at the horizons of coal VI and VII, rather than at the horizons of VI and the little underlying coal found below Coal VI in northern Knox County. One feature which renders this correlation uncertain is the fact that at several places under the lower of these two coals is found a limestone, no limestone appearing between the two. If this limestone is the same as the limestone underlying Coal VII from Vermilion County southward into northern Knox County, then it is evident the two coals must be considered as split benches of Coal VII, and Coal VI is entirely lacking. If it is not that limestone, and the lower coal is Coal VI, it is evident that this is a new limestone which appears below Coal VI only in this region. The fact that farther south two coals supposed to correspond with these two coals are found frequently in western Warrick County, and, as stated, in Kentucky, and that between these two coals in a majority of cases a limestone does occur, would suggest that the limestone found below the lower coal in this particular region is a local lens and does not tie in to the limestone under Coal VII farther north, or between the two coal beds farther south. Some difficulty has been experienced in determining the stratigraphic position of a pocket of thick coal lying just northeast of Oakland on the east side of the south fork of Patoka River. It is nearly, if not exactly, in the horizon of Coal V. Within this small area in the west part of Turkey Hill this coal shows a thickness of about 9 feet, usually broken up by one or more partings of clay or bone coal, and overlain by first a few inches of soft shale, and above that a sandstone. At Oakland, at Dongola, and at the old Carbon mine at Sophia P. O., Coal V has a fairly uniform thickness of about 4½ feet or less. These three points make a triangle enclosing the pocket of coal in question. Indeed, points much closer to the pocket in question may be selected at which Coal V shows a thickness of less than 5 feet, overlain with its typical black shale roof and limestone. Thus, at the first mine of the Peacock Coal Company, near the E. & I. R. R., Coal V has a thickness of about 4 feet, overlain with black shale,
the coal lying at a depth of about 40 feet. Again at the Enreka mine, east of Oakland and west of the south fork of Patoka River, Coal V is mined at a depth of 40 feet with a typical development and typical black shale roof. Again, in the southwest corner of Sec. 10, T. 2 S., R. 8 W., less than a mile east of Ingleton slope, Coal V has again its typical thickness. Thus at all of these points very close to this area Coal V appears to be developed with its typical thickness and roof.

Again, in the way of elevations, this pocket of thick coal appears to lie higher than the position of Coal V, as indicated by these other openings. At Oakland Coal V is about 340 feet above sea-level, at Sophia 420 feet, at Dongola 360 feet, or 40 feet below water level; at the Massey mine (Peacock Coal Company) the coal is about at river level or 400 feet above tide. The Massey mine is about half-way in a line from Sophia to Dongola. With the dip uniform between the two places, Coal V should have an elevation at Massey's of about 390 feet, or very close to the actual elevation of the coal at that place. At the road crossing near Massey apparently this same thick coal bed is just below water level, but with a rise to the south which should, if continued, carry it well up into the hills a short distance south of the river. Again, at the old Whitman shaft in the southwest corner of section 10, Coal V has an elevation of about 400 feet, with a dip to the southwestward which would rapidly carry it much lower. Apparently in contrast to this dip, the coal at the Ingleton mine, three-quarters of a mile to the northwest, has an elevation of about 420 feet, indicating a rise rather than a dip. On the other hand, however, the writer's notes indicate that from the Ingleton mine northward through section 9 this coal shows a strong rise to the north, giving the appearance of an anticlinal roll between the Ingleton mine and the Massey mine. The new shaft of the Peacock Coal Company, about three-fourths mile southeast of their old one, finds this thick coal in the hills about 15 or 20 feet above the bottoms. The only other possible correlation seems to the writer to be to assume that this thick coal is a thick pocket of Coal Va, which through this region in general is less than a foot thick, though in some places it thickens up to 3 feet or more. In view, however, of the dips suggested by the outcrops, which would seem to account for the discrepancy in the position in the hills of this coal, the writer has been inclined to interpret this coal as Coal V, though not without some question. The fact that Coal V frequently does have a gray shale roof in this region just eastward, reduces the argument against its being Coal
COALS V TO VII SOUTH FROM SULLIVAN COUNTY.

V on account of the roof. While the assumption that this thin coal has thickened up to 9 feet seems much less likely than that Coal V has thickened up, as Coal V is known to have a thickness of 6 to 8 feet at the Littles mine just a short distance north, and to run up to and over 6 feet in mines and drillings within 2 or 3 miles to the east.

Turning again to the coals and tracing them southward to the Ohio River, Coal V can be traced, without any further question, from Winslow to Evansville. As was before stated, it has been opened or stripped on nearly every 40 acres. The limestone above the coal is not as persistent as it is farther north, but it is often replaced by a calcareous clay full of fossils, which in places becomes a true limestone. This clay is known to the miners as "pen­nywinkle" (periwinkle) rock, from the gasterpod shells with which it abounds. It is often spoken of as "tumble" rock also, from its tendency to fall if the strata underlying it fall in a mine. The little coal, Coal Va, is seldom noticed through Warrick County or around Evansville. Most of the drilling in southern Warrick County and around Evansville shows only one coal of any thickness above Coal V. That coal comes from 90 to 100 feet above and is usually underlain by a limestone of some prominence, this limestone frequently having a thickness of 9 or 10 feet or more. At a large number of places in western Warrick County there appears to be a coal below this limestone. In some cases the two coals come quite close together, and in Greer Township apparently these two coals come within a few inches of each other and are worked as one thick bed, with a clay parting in the middle. In most of this district the upper coal is the more important and the lower coal is seldom seen, but is frequently reported as having been found within a few feet underneath the limestone.

It is of interest to note that very similar conditions exist in tracing the coals across the river into Kentucky, the coal worked at the People's mine at Henderson being evidently the same as Coal V at Evansville, not Coal VII, as interpreted in the 1898 report. The presence of limestone below the clay under that coal misled the writer at that time. A similar limestone proves to underlie the coal at Evansville, and in some of that district, usually not occurring as a rock ledge, but being found as long lenticular masses, or in some cases as short masses only a few feet in diameter, and a foot or less in thickness. The occurrence at Henderson is quite similar. Coal V as thus mined at Henderson has also been mined at many points to the eastward, as at Baskett, on Greene River, around
Owensboro, and elsewhere. Above this coal at all of these points is commonly found a coal seeming to correspond in position with Coal VII of Indiana, underlain with a limestone. In general, Coal VI underly ing the limestone is absent, but at many places, particularly west and south of Henderson, both coals are present. At Corydon the coal over the limestone reaches a thickness of 6 feet or more, as it does also at Smith Mills.

In the Madisonville district the No. V coal of Indiana is known as Coal 9, and coals Nos. VI and VII of Indiana as coals 11 and 12. In that district both 11 and 12 reach a workable thickness. In the Reinecke mine, west of Madisonville, the upper coal has a thickness of 4 feet 2 inches, the coal underneath the limestone a thickness of from 6 to 8 feet. The interval between the two coals is quite variable. At one point in that mine they are found 38 feet apart. At a distance of 4,200 feet to the south the No. 12 is down to within 3 feet of No. 11, suggesting a variability similar to that found in southern Indiana.

Some question has been entertained in Kentucky as to the correlation of the coals around Madisonville with those at Henderson. A comparison of the sections in southern Indiana with those around Henderson and Madisonville with those again found in southern Illinois has convinced the writer that Coal 9 at Madisonville is the same coal as mined at the People's shaft at Henderson, and is in turn the same as Coal V of Indiana; that coals 11 and 12 of the Madisonville district correspond to coals VI and VII, as here interpreted, in southern Indiana.

Coal III to Base of Coal V from Sullivan and Greene Counties Northward.—As indicated by the sections on Plate II, little difficulty is experienced in tracing coals IV and III northward from Sullivan County, notwithstanding that they were incorrectly traced in the 1898 report. With the knowledge now in hand that mistake could not have been made. Coal III as now known in western Greene County and under all of Sullivan County was then practically unknown, as were all of the coals below Coal VII in western Vigo County. Today hundreds of drillings have demonstrated that at nearly every point Coal V is underlain at a distance of about 200 feet by a coal that averages over 6 feet in thickness. This is true all over Sullivan County and the western edge of Greene County. The same drillings show that between Coal V and this 6-foot bed is another bed somewhat more variable in thickness ranging from 4 to 5 feet, and lying about 70 feet above the 6-foot bed. Tracing these drillings eastward, it is clear that the intermediate bed is
the bed so extensively mined from Linton to Jasonville and known as the Linton coal, and that the underlying bed is the coal that is mined around Midland and at many other points in the Linton-Jasonville district. This more recent drilling further shows that these two beds do not tie into the upper and lower Block coals of the Brazil district, for drillings at many points today demonstrate the presence of as high as seven or eight coals below the 6-foot coal, or Coal III, as it is now known. And, further, between Jasonville and Howesville a line of close drilling has made clear that the coal in the Howesville shaft is the same as the coal that in the drillings further westward comes about 200 feet below the 6-foot coal or Coal III. Further, the coal in the Howesville shaft, from its position, and on the testimony of a number of competent mining men and engineers who examined it, and who are thoroughly familiar with the Lower Block coal, appears to be certainly the equivalent of that coal.

Coal IV tends to run from 110 to 150 feet below Coal V all through Sullivan and western Greene counties, the average being about 130 feet. Between coals V and IV there is usually one thin coal, and often two. The lower of these, Coal IVa, is known as the rider of the Linton bed, and is always watched for by miners in shafting or drilling. It lies from 25 to 40 feet above Coal IV, and is usually overlain by a limestone, between which and the coal is black shale. Another limestone commonly occurs just below Coal V. The rest of the space is filled about equally with sandstone and shale. Sandstone usually occurs between Coal IV and IVa, often making the roof of Coal IV.

The interval from Coal III to Coal IV in Sullivan and Greene counties runs quite regularly from 60 to 75 feet. There is almost always one thin coal about half way between, which is often overlain by limestone, Coal IIIa, otherwise the rocks are shale and sandstone. It will thus be seen that in their stratigraphic relations there is considerable resemblance between coals IV and III in the fact that they do not differ greatly in thickness, that each tends to be split, that each has a shale or sandstone roof, that each is overlain at about the same distance by a thin coal, which in turn is overlain by black shale and limestone. These similarities have led to confusion at many points, and at many of the mines great uncertainty seems to exist as to whether the coal being worked is Coal III or Coal IV. After a study of hundreds of drill records now in hand, the writer is inclined to doubt if Coal III ever comes within 150 feet of Coal V in this region, and if Coal IV is ever
found more than 160 feet below Coal V. Exceptional cases, of course, are likely to be met with. There appear to the writer to be some other differences that may or may not be of value in distinguishing the two coals. Coal III of this district very generally has a thickness of over 6 feet, and while it sometimes runs much under that, on the whole it appears to hold that thickness quite persistently, tending to run up to 7 feet more often than it runs down to 5 feet. On the other hand, Coal IV seldom reaches a thickness of 6 feet, and in a great many cases will run under 5 feet, and not infrequently thins down to 3 feet or less, occasionally running out entirely. Again, while both coals tend to be split, it has appeared to the writer that Coal III has rather regular partings, there often being several of them, while in Coal IV there is usually only one parting, which is irregular, in many areas not showing at all or only as a smooth parting, while elsewhere this parting may thicken up and vary widely within short horizontal distances. While the roofs of the two coals have many points of resemblance, Coal IV probably has a sandstone roof much the more frequently. The floors of the two coals, however, tend to be quite different. The floor of Coal IV is usually sandstone or a hard sandy clay, while the floor of Coal III is usually clay, which is often soft, and in some mines farther north even shows a tendency to creep. Finally, the two coals seem to differ markedly in their chemical character, the analyses of Coal IV in nearly or quite all cases showing a lower percentage of sulphur, often less than 1 per cent, and seldom much more, while Coal III usually shows several percentages of sulphur or analysis, and in many cases shows an abundance of "sulphur" in visible form in the coal. This difference is usually reflected in the ash of the coals, Coal IV having a white or gray ash, while Coal III tends to have a red ash with clinkers.

Traced northward, coals III and IV seem to maintain much the same relation to each other and to Coal V that they have in Sullivan and Green counties, at least as far north as Clinton in Vermillion County, and Coxville in Parke County. Towards Clinton the interval from Coal V to Coal IV seems to decrease slightly, coming to average nearer 100 feet, and Coal IVa has a limestone under it more often than over it. Otherwise, the rocks are much the same as in Sullivan County. The interval from Coal IV to Coal III differs mainly in the fact that to the east Coal IIIa approaches very close to Coal III, while in most of Vigo County Coal IIIa usually keeps 30 or 40 feet above that coal. Around Stanton and Coxville it is often only 4 or 5 feet above, though usually the dis-
COALS V TO VII SOUTH FROM SULLIVAN COUNTY.

Tance is somewhat greater. In western Vigo the interval from Coal III to Coal IV increases somewhat over that interval farther south, in some cases reaching 80 feet.

From a few miles north of Coxs ville and Clinton northward the conditions change greatly. The outcrop of Coal V is deeply buried below the glacial drift to the north of Norton’s Creek, and it cannot be referred to as a key horizon. The interval from Coal III to Coal IIIa decreases so as to run regularly 6 feet or less, decreasing the interval from Coal III to IV correspondingly, and Coal III becomes irregular and finally runs out, being last seen south of Hillsdale and near the mouth of Rocky Run. On the west side of the Wabash from Clinton to Hillsdale there are so few outcrops that the correlation of the sections between the two points would be very difficult were it not that fairly abundant exposures exist along Raccoon Creek northward from Coxs ville. Two or three days were spent the past summer reviewing the evidence along Raccoon Creek of the thinning out of Coal III. The new evidence obtained only strengthened the conclusions reached before. Coal III continues sporadically to Mecca and beyond, separated from Coal IIIa only by a few feet of clay. Extensive quarries for clay product factories along Raccoon Creek and northward and across the river at Hillsdale and West Montezuma greatly increase the data to be obtained from the abundant natural outcrops, in many respects giving a better visible display of the strata than anywhere else in the coal field, as some of these quarries show 70 or 80 feet of perpendicular section. In striking contrast with this irregularity and thinning out of Coal III, Coal IIIa is remarkably persistent all the way from central Clay County to where it leaves the State in the Little Vermillion River district. Everywhere it ranges from 10 inches to 18 inches in thickness, seldom over that and seldom under it. Nearly always there is a thin parting above the middle. It is overlain by black, bituminous, sheety shale, and above that one, or often two, layers of ferruginous limestone and calcareous iron ore. While in Clay County one of these limestones often reaches 2 feet or over in thickness, over most of the district they have a persistent thickness of 3 or 4 inches each. One of these two layers often shows cone-in-cone structure, and is a shaly limestone, while the other is more often a calcareous, slightly fossiliferous iron ore, the outcrop being cut by regular joint planes, making it resemble a line of bricks stuck into the bank. Below the position of Coal III is a great body of shales that furnish the material for the brick and tile works. Coal IV is but little exposed in Parke
County, and the horizon of Coal III is not seen north of Montezuma. On the west side of the Wabash River Coal IV is exposed in the top of the bluff from Hillsdale to Little Vermillion River and up that river to the Horseshoe, everywhere running about 4 feet thick. Below it can be traced Coal IIIa, with the horizon of Coal III about 6 feet below, though no coal appears at that horizon. The clay between this horizon and Coal IIIa is a very refractory clay, and so has been mined at many points north of Hillsdale, and this in connection with the openings on Coal IV make the tracing easy. The interval from Coal III to IV varies north of Hillsdale, in some cases becoming less than 20 feet, though generally much more. In most of this district Coal IV, where exposed, is so near the top of the hill that little or none of the strata overlying it can be seen. On Little Vermillion River, however, at the Horseshoe, there appears another workable coal only a short distance above Coal IV. Much question exists as to what coal that is. The best solution seems to be that it is Coal IVa, which has at that point come nearer to Coal IV, and has at the same time thickened up. Another possible solution is that the upper coal is Coal V. Three sections are given on Plate II, taken from Illinois, from the region northwest of the Horseshoe on Vermillion River. In the first of these, two coals, considered to be the Grape Creek and the Danville, of the Danville district, are seen, having the normal distance between them of Coal IV and Coal V in central Indiana. The lower of the two coals at the Horseshoe of Little Vermillion River has been traced by Mr. DeWolf, of the Illinois Survey, with some question, into the Grape Creek coal of Illinois. The section in question is taken near Westville. Going northward, a number of drillings have been made and many mines exist on the two coals which show a steady decrease in the thickness between them, until in the region about Danville these two coals have come to within a few feet of each other, the distance often being less than 20 feet. The possibility, therefore, that the upper coal at the Horseshoe is Coal V has some facts in its favor. The roof of the upper coal there is not exposed, so that it cannot be told whether it has any resemblance to the roof of Coal V in Indiana. The correlation of the Grape Creek and Danville coals of Illinois with Coals IV and V of Indiana is not without some question. It is based primarily on the tracing by Mr. DeWolf, as just stated, and further upon the fact that at about the right distance below the lower of these two coals some other coals in Illinois are met with in drillings in about the position of the Minshall and No. II coals of Indiana, which, as it
happens, are the only important coals in Indiana at about that horizon in that part of the State.

The correlation made is only suggestive, and it is hoped will be given further study before the final comprehensive paper on the Eastern Interior Coal Field is issued.

**Coals Below Coal III North of Sullivan County.**—These coals are best known in the region of northeastern Vigo County and northern Clay County, where several of them have been extensively mined, and where a large amount of drilling has given a clear conception of their relations. In that region three of the coals are being mined. Above the three coals being mined drilling shows the presence of at least five other coals. The three coals mined are the three lowest, the uppermost of which occurs about 100 feet below the bottom of Coal III. It is overlain by a limestone that outcrops on Otter Creek west of Perth. Of the coals overlying this limestone the lowest one sometimes reaches a thickness of 3 or 4 feet, and has in a few cases been mined in connection with the next lower coal. Stratigraphic work by Mr. David White, of the U. S. Geological Survey, has led him to suggest that this coal, the first coal above the limestone, will be found to correlate with Coal II of Illinois, and it has, on that basis, been so designated in this report. Of the other coals between that and Coal III, two of them are frequently overlain by limestone, and sometimes a third. The first two coals underlying Coal III have variable roofs, but in many places each of them has a black shale roof overlain with a thin limestone. Another limestone occurs, sometimes as far as 75 feet below Coal III, and thus may be confused with the heavier limestone lying a little lower. The heavy limestone referred to outcrops at Minshall, and as the coal immediately underlying it has been called by the trade the Minshall coal, from its extensive mining at Minshall, this limestone will be referred to as the limestone at Minshall. The intervals of these coals from each other and to Coal III vary considerably. The Minshall coal may range from 70 feet to well over 100 feet, as it lies in basins in which the thickest coal is in the center of the basin and at the greatest distance below Coal III, while toward the edges of the basin the coal is found much closer to Coal III, and also much thinner. It is therefore easily confused with the overlying coals when only found in outcrop, even though the distance below Coal III may be obtainable at that point. Below the Minshall come the two Block coals of Brazil, known as the Upper and Lower Block coals. The Minshall coal in that region has frequently been referred to as rider Block coal. These three
coals in the 1898 report were designated as coals III, IV and V. The Minshall coal, with its overlying limestone, having been confused with the Alum Cave coal with its limestone, correspondingly the Upper Block coal was supposed to correlate with the Linton coal (Coal IV) of this report, while the Lower Block coal was thought to correspond with the coal below the Linton coal, and therefore designated as Coal III. The Minshall coal in all the district northward from this was designated as Coal V in the old report. As that designation has been more widely used for the Alum Cave coal some 300 feet higher, and is so used in this report, it cannot be used for this coal, and therefore the trade term of Minshall has been adopted. In like manner the designations III and IV having been used for coals of that number in Sullivan and Greene counties, cannot be used here and, as it happens, those numbers have been little used in the field in designating the Block coals, the old names of Upper and Lower Block will therefore produce no confusion. The distance from the Minshall coal to the Upper Block coal will average here about 30 feet, and from the Upper Block to the Lower Block coal a similar amount. These intervals vary greatly. In a few cases the Upper Block coal has what is called a “whitetop” roof, which is found to be the under-clay of the Minshall coal, and in such cases the Minshall coal is found to have come within a few feet of the Upper Block coal. In general, however, the intervals tend fairly constantly to hold to the figures given. All of these coals occur in basins of limited extent, in which the coals may be thick in the center, ranging up to 4 or 5 feet and thinning out to a few inches on the edges of the basins. No limestone has been noted in this region below the limestone which outcrops at Minshall. As a rule, no coal appears between the Minshall and the Upper Block or between the Upper Block and the Lower Block, though a coal does appear in those intervals in a very few cases. Coming southward, the Upper and Lower Block coals can be readily traced to the south line of Clay County. The Rider Block coal has not been mined and is not as readily traceable. Apparently, the relations continue much the same as those between Brazil and northeastern Vigo County. They can also be traced clearly into southern Parke County. Beyond that openings become scattered and comparatively little drilling has been done, so that from that point northward correlations are based almost entirely on the assumption that the rather heavy limestone that is found abundantly all through Parke, Fountain, and the southeastern edge of Warren County is at the same horizon, and
that it corresponds to the limestone at Minshall. In view of the fact that other limestones are noted in the sections in northern Clay County, the possibility of error in making the limestone the basis for correlation is admittedly large. However, the other limestones referred to wherever seen are usually not more than 1 or 2 feet thick, while the limestone at Minshall, though irregular, frequently is 10 or 15 feet, or even more, in thickness. Going northward from southern Parke County, at a great many points the limestone is found underlain closely by a coal of workable thickness, and this has been correlated as the Minshall coal. It has been worked at Minshall, and it is now believed that the coal worked at Mecca in the shaft is at this horizon. There are found at Mecca two coals, frequently separated by a limestone, the lower of which is being worked, but in some cases the upper coal comes so close to the lower coal that both can be worked together. The Minshall coal is again typically exposed between Minshall and Sand Creek, at which points a few exposures are seen of the underlying Upper Block coal. That coal, however, appears to be very pocketly, and no trace is found there of Coal III. Continued northward, very few stratigraphic sections are found except those along Sugar Creek or its branches, which involve mainly the Mansfield sandstone, believed to underlie the Lower Block coal. The exposures are almost entirely of coal openings, and where the coals are not drifted upon or stripped, they are usually reached by very shallow shafts. It has not been possible to correlate the coals at all points in the north part of the field because at many points no limestone is found overlying the coal, and it is not always certain whether the absence of the limestone can be interpreted as meaning that this is not the Minshall coal, or that the limestone has run out at this point, as the limestone is known to run out at many points on the Minshall coal. At many places in southern Fountain County what is taken to be the upper Block coal, lying 20 or 30 feet below the limestone at Minshall, reaches a workable thickness. Apparently, no workable coal underlies that, suggesting that Coal III was not deposited in this district. Coal IV appears to be found as far north as Veedersburgh, and most of the sections in that region do not show any limestone. The limestone, with its underlying coal, is found at Yeddo, and across the river in Warren County, where it appears to be the lowest workable coal. In that region one or two of the coals above the Minshall coal reach a thickness of 2½ feet to over 3 feet in places. This higher workable coal was designated Coal VI in the old report, though it is recognized now
that it does not correspond to the coal designated Coal VI in southern Parke County, now called Coal III. It was in this coal that Mr. White found the fossils that led him to correlate it with Coal 2 of Illinois. Northwest of Covington it appears to lie about 30 feet above the Minshall coal. West of Indiana Mineral Springs sections indicate that not only is the Minshall coal workable underly­ing its limestone, but two of the overlying coals reach a workable thickness, the first one correlated as Coal II, running from 15 to 20 feet above the Minshall coal, and the other as much higher. The Minshall coal in this district appears to be the lowest coal deposited, Coal IV having run out. Below the Minshall coal here is a body of black shale, apparently lying unconformably on a mass of sandstone correlated as the Mansfield sandstone.

Coals Below Coal V from Greene County Southward.—The fact, as demonstrated the past summer, that coals IV and III of western Greene County do not correspond with the Upper and Lower Block coals, as had been assumed in the 1898 report, has resulted in throwing into confusion all of the correlations of the coals southward from Greene County. In the early days of the Survey, under Mr. Cox, it was quite largely assumed that there were only a few coals. At many points a coal was found overlain by a limestone and was usually designated as Coal K. In most of Daviess County, for example, it was assumed that there were no coals between Coal K and the lowest coal of the coal measures. Coal K was supposed to correspond with Coal V of Sullivan County. In the 1898 report it was recognized that there was more than one coal overlain by a limestone. However, later work on the Ditney quadrangle in Pike and Warrick counties in 1900 showed that there were more coals overlain by limestone than were recognized in that report, and the writer now has the feeling that future detailed work will demonstrate the existence of at least one more limestone than was found in the Ditney folio work. For example, in Sullivan and Greene counties the thin coal between Coal V and Coal IV is usually overlain with a limestone. Again, the thin coal between Coal IV and Coal III is often or commonly overlain with limestone; still lower, below Coal III, as typically exposed in Vigo County and northern Clay County, there are at least three limestones, of which the lowest or third is most prominent.

During the past summer no attempt was made to go over the area in which the underlying coals outcrop to the east of the crop of Coal V, as it was felt that to do so would occupy many months of time and vastly more money than had been provided for in the
COALS BELOW V SOUTH OF GREENE COUNTY.

plans for the resurvey. Considerable time, however, has been given in the office to the attempt to readjust, out of existing knowledge, the relations of those coals in the light of the better information now held of the general stratigraphic column. Some additional time was given to the subject in Daviess County, sufficient to demonstrate the presence of at least three of the limestones mentioned. The field work for the Ditney folio in Pike and Warrick counties had previously demonstrated the existence of three limestones in that area. The possibility of there being still a lower limestone is pointed toward by certain facts as given beyond.

Coals III and IV and their intermediate thin coals, IIIa and IVa, can usually be recognized in drillings that pass through Coal V, on the assumption that these four coals are present and only these four coals. In many of the sections the second and fourth coals below Coal V are somewhat thicker than the others, and the first and third coals are overlain by limestones, to that extent resembling the typical section and giving some confidence in their identification.

In some of the drillings in Pike County many of the records show that the first coal below Coal V, while resembling Coal IV in its distance from Coal V and its thickness, is found to be overlain by a limestone. One or two drillings, however, show the limestone coming 10 or 15 feet above the coal, with a thin coal just under, so that it is considered that in the other cases the strata between the limestone and the main coal, including the thin rider coal, have pinched out. In going southward, the correlation of Coal III, especially in these drillings, becomes more and more uncertain.

In a general way the interval from Coal V to Coal IV remains about 100 feet, running over rather than under, and the coal is generally overlain by a light-colored shale or sandstone, except in part of Pike County, as described in the last paragraph. The position of Coal III becomes very uncertain, as will be evident from an examination of Plate II. The thick coal of the northern counties has disappeared. Whether it has thinned out, split up, or feathered out cannot be determined until much more drilling has been done. At present it looks as though Coal III had split and finally run out altogether before reaching the Ohio River. The amount of drilling within the outcrop of Coal V that reaches below Coal III is as yet so small that no attempt at correlation can be made.

The eastern outcrop of Coal V can be traced without difficulty
because of the great number of openings made upon its edge. Largely because of the presence of this thick and easily-mined coal, the smaller underlying coals which outcrop farther east have been but little opened or developed. Then, too, there has been lacking the incentive to drilling and other exploration, so that our knowledge of the lower coals which outcrop east of the edge of Coal V is obtained almost entirely from the occasional weathered exposures in the roads or the scattered neighborhood banks. Within the drift area extending south into northern Pike County there are few outcrops of rocks in the roads or stream banks, and relatively few neighborhood mines. Toward the edge of the mantle of glacial deposits in southern Daviess County the rocks are more frequently exposed.

Attempts to trace and correlate the coals have been based on resemblances, particularly of the roof of the coals and on their relative elevations. For example, just east of the crop of Coal V the first coal met with is usually a thin coal overlain with a black sheety shale and limestone. Usually near it is a bed of thicker coal overlain by light shale or sandstone. If the easternmost crop of Coal V is in the top of a high ridge, as often occurs in Pike and Warrick counties, these two coals will often be found down the slope of the hill and about 100 feet below Coal V. If their elevation can be determined it may be assumed that in a mile farther east these two coals will often be found at an elevation 20 to 40 feet higher, and twice as much two miles farther east, and so on proportionally. If, then, two similar coals be found to the eastward of those first found and at such an elevation as to indicate a rise to the east at some such rate as suggested, it is assumed that they are the same coals unless other facts point to the contrary. These coals will be considered the equivalent of coals IV and IVa. In tracing them eastward two similar coals are usually found. In some cases they can be clearly seen to be two lower coals, as the first two coals outcrop above them in the hill. More often a comparison of the elevations shows that to bring the first coals from where they were first found to the position of the newly-found coals will require a much lower dip than the normal, or an actual dip to the east, and on this basis they are therefore correlated as lower coals.

To take a concrete case: Coal V is just caught in the crest of the hill 1½ miles northwest of Selvin and at an elevation of 600 feet above sea-level, according to the U. S. Geological Survey topographic map. One-half mile or less to the east, and 100 feet lower,
or at 500 feet above sea-level, is a 3-foot coal, with an 18-inch coal overlain by black shale and limestone, coming only 6 feet above it. A mile farther to the east, down the same branch, is a similar 3-foot coal, overlain at about 6 feet by an 18-inch bed of coal having a similar roof to the rider of the coal first found. At first sight the two 3-foot coals are the same bed. The U. S. Geological Survey topographic map shows, however, that though apparently at the same elevation, the coals at the east are at an elevation of 470 feet above tide, or 30 feet lower than the coals at the foot of the hill to the west. Adding a dip of as low as 20 feet and it is evident that the coals are apparently, stratigraphically at least, 50 feet apart, a relation that is confirmed by the outcrops at Selvin, where both sets of coals are found, the first set in the top of the hill just west of town, and the other in the foot of the hill northeast and south of town. In the same area 3 miles east of the point where the second group of coals was first noted, there is an outcrop of a coal overlain by a black shale and limestone. The topographic map shows that it is at an elevation of 430 feet above tide, or 40 feet lower instead of 60 to 80 feet higher, as it should be were it the same coal as those found northeast of Selvin. This point is 2 miles south of Holland, and the coal there has been called the Holland coal. Three miles farther east and 1½ miles west of Ferdinand station are openings on another coal, also overlain by black shale and limestone, but the topographic map shows these coals to come at an elevation of 520 feet above tide, or 80 feet higher than the coal south of Holland, and if the dip be assumed to be normal, it is evident that they are probably the same coal as the Holland coal, a conclusion that is strengthened in this case by the presence of many intermediate outcrops on that coal. Two or three miles still farther east, around St. Henry, are reported many fragments of limestone which cannot be higher than 520 feet above tide. Are they from the limestone over the Holland coal? If so, there is no dip in this district, or possibly a dip to the east. Two miles still farther east is a coal under a limestone at about 540 feet above tide, and 4 miles beyond that, or 3 miles beyond Ferdinand, is a coal and limestone at about 640 feet above tide. Are all of these outcrops on the Holland coal and limestone? The elevations given are not very reliable, as they are made from Mr. Price's notes for the 1898 report, and adjusted as nearly as possible to the St. Meinrad topographic sheet. On the assumption that the normal dips prevail in this district, the limestone found around Ferdinand and St. Henry is a lower limestone than the one over the Holland coal. It
is true, there are known a very few cases of a very low eastward rise, or even a dip to the eastward, extending for several miles, as west of Montgomery, in Daviess County, but in the great majority of cases where the data is sufficient to render the correlation of any coal certain in an east and west line for many miles, it is found that there is a more or less uniform dip to the west, usually ranging from 20 to 40 feet to the mile. Therefore, when data to the contrary is lacking such a dip has been assumed and correlations have been made accordingly. In most of Dubois, all of Daviess, Martin and Greene counties no topographic maps exist, so that in those counties the relative elevations have been roughly estimated from the observed relations to drainage, checked as well as might be with barometric elevations, but the determinations in those counties, due to this fact and to the fact that the data are much more scattering, have not been as satisfactory as farther south where the topographic maps have been available. In the case of eastern Greene and Martin counties, the rugged character of the topography of the high hills gives a better opportunity for correlating the coals, as coals can frequently be found, one above the other, in such a way as to demonstrate their relationships. Even here, however, the great abundance of sandstones of generally similar character, but coming apparently within different intervals, and the abundance of thin coals, has rendered uncertain many of the correlations.

In Greene County the broad drift-filled valleys and accompanying prairies on either side of White River render correlations difficult. The drillings and test shaft near Howesville indicate the relation of the Block coals to coals III and IV, and drillings along the western edge of the county give the relation of coals III and IV to Coal V. The relations of coals V, IV and III have already been described in the typical section. In the 1898 report it was assumed that coals III and IV extended eastward to the bluffs of White River on the assumption that they correlated with the Upper and Lower Block coals of Clay County. With the present understanding of their stratigraphic position it would appear that they outcrop within or close to the eastern border of Range 7 West. Many shallow wells have been sunk in the upland in several directions from Switz City. None of these wells report a coal corresponding in thickness with Coal III, as developed in northwestern Greene County, and from the elevations it is assumed that the coals reported belong below that coal. Coals of workable thickness occur near Switz City and to the westward, and have been worked to
COALS BELOW V SOUTH OF GREENE COUNTY.

some extent. As drillings seem to show two workable coals below the one worked at the Lundy shaft, it is suggested that that surface bed is probably the equivalent of the rider Block coal or Minshall coal. West of its area of outcrop, to the center of Township 6 West, shallow wells should catch the thin coals between Coal III and the Minshall coal. Near the Lundy shaft the distance from the Minshall coal to the Upper Block coal ranges from 11 to 41 feet, and from the Upper to the Lower Block coal from 23 to 42 feet.

The block coals outcrop in the river bluffs west of White River. As a rule only one coal was found at any point, so that the relations of the two coals that were assumed to be present could not be definitely made out. East of White River the Lower Block coal is caught by the hill tops, and in the southwestern corner of the county the general rise of the land away from the river just makes up for the rise of the coal, so that the hill tops are made up of the rocks above the Lower Block coal almost as far east as Owensboro. Below the Lower Block coal is the massive sandstone correlated as the Mansfield, and below that one or two thin, not workable, coals. Still below the latter, and usually not far distant, are found outcrops of the Lower Carboniferous limestones with their characteristic Pentremites.

In Daviess and Martin counties there is a long break between the coals west of White River and the coals in the eastern part of the county, except in the latitude of the B. & O. S-W. R. R. The river bottoms produce broad prairies, broken only by sand hills through a wide belt on either side of the river. At Washington hills set in carrying Coal V almost to the east side of Range 7 West. Around Washington the dips are quite diverse. South of town the dip is to the southeast as far as the old Sulphur Spring mine, where Coal V is at an elevation of 467 feet above tide. Going northeastward, the coal rises at a rate of nearly 40 feet per mile, and at the Price drift east of town, near the railroad, it is 71 feet higher than at the Sulphur Spring mine, and at the old Raymond slope 91 feet higher, or at an elevation of 558 feet above tide. Ninety feet below the coal at Washington is a coal overlain with black shale and correlated as Coal IVa. At the Raymond drift this thin bed would have an elevation of about 468 feet. Were the same rise to continue to the east it would have an elevation of about 668 feet at Montgomery. A study of all the facts has led to the conclusion that instead the dip decreases or is reversed going eastward, and that this same thin coal outcrops in the railroad cut just west of the depot at Montgomery at about 510 feet. At the old
No. 1 mine just west of Montgomery it is found at an elevation of 484 feet or lower. Mining on the underlying coal has demonstrated that from the No. 4 mine near Black Oak switch, 2 miles west of the No. 1 mine, there is an eastward dip of 15 feet, and drillings suggest that this condition continues to the westward, so that the first two coals at Montgomery will tie into the first two coals below Coal V at Washington, though the evidence is not conclusive.

Where a large area has a broad monoclinal structure it is generally the rule that a flattening or reversal of this structure is followed in adjoining areas by steep dips that in some measure even up the general dip. So at Montgomery we have visible evidence of a rapid rise to the east, succeeding a long flat bench west of town, which brings up to daylight the rider coal (Coal IVa) near the depot. About 30 feet under this rider coal is the worked coal at Montgomery, which is, in accordance with the facts just given, thought to be the representative of Coal IV. It will be called here the Montgomery coal. It is believed that the rapid rise observable near the depot will bring this coal to the surface a short distance east of Montgomery, and that the surface coal at Cannelburg is a lower coal, possibly corresponding to Coal III. It will be called the Star coal, from having been mined at the Star mine, just east of the Mutual mine, southeast of Cannelburg. Its relation to the Montgomery coal is not clearly established. It was formerly thought to be the same as the Montgomery coal. To make it such, however, would require another bench in the structure or a low dip to the east between Montgomery and Cannelburg, which supposition is opposed by the apparent dips a short distance to the north and south.

About 60 feet below the surface bed at Cannelburg is the Cannelburg Cannel coal. On the basis of the correlation already made this is assumed to be in about the same position as the Minshall coal of the northern counties, and possibly to be the representative of that coal. Drillings have shown two or three beds between the Cannel bed and the surface bed. It is suggested that the Cannel coal is the equivalent of the black shale ordinarily found overlying the Minshall coal, which in this area accumulated as a fairly pure carboniferous deposit, analyses showing as high as 23 per cent of ash. What is supposed to be the same coal is seen in the cut of the Indiana Southern Railroad near Burns City, where the Cannel coal can be seen grading up into a gray shale. East of Cannelton little is known of the coals, but it is believed that the rise to
the east would make this coal possibly the equivalent of the surface bed at Loogootee. It is also believed that this coal may be the equivalent of the coal on Sugar Creek, overlain by black shale and limestone. Below this in the shaft at Alfredsville are found three coals that are believed to be about the equivalent of the Block coals of Clay County. This shaft coal at Alfredsville is again correlated with the workable coal in the ridge between Boggs Creek and Indian Creek in northern Martin County, and in Sampson Hill southeast of Shoals. It is called the Sampson Hill coal. In Martin County below that coal is a massive sandstone outcropping, notably around Shoals, and making the "Jug Rock" and the "Pinnacle," where it is over 100 feet thick. Below this sandstone is a coal that reaches a workable thickness near Shoals, and may be called the Shoals coal. Outcrops of the Lower Carboniferous limestone, full of its typical fossils, are found from 6 to 20 feet below this coal at Shoals.

North of the B. & O. S-W. R. R. it is assumed that the coal mined around Epsom is the equivalent of the Montgomery coal; that the coal mined in the branch halfway between Epsom and Raglesville is the equivalent of the Star coal, being the surface coal met with in wells all along the western edge of Range 5 West. The Raglesville coal is thought to correspond to the Cannelburg coal. Two coals at different levels around Bramble P. O., in northwestern Martin County, are correlated with the Block coals, and with the coals in the ridge east of Boggs Creek, in the hills southwest and southeast of Shoals, at Rusk P. O., and the hills southeast of that, extending into Orange County.

In southern Daviess and northern Pike and Dubois counties the exposures in the river hills indicate correlations as follows: It is now assumed that the coal at the Carlisle bank, northwest of High Rock, is Coal V instead of Coal IV, as has previously been thought. Seventy-five feet below it, in the river, is the limestone over Coal IVa. The rise to the east brings this up so that the underlying Coal IV outcrops above drainage east of High Bank and north of Long Branch P. O.; also on the Daviess County side just at drainage on the stream a mile west of Hudsonville. At Hudsonville the rise brings this coal well up into the hills. Stratigraphically below this a few feet, and assumed to make the "Rock Eddy" west of Hudsonville, appears a chert and limestone believed to come over Coal IIIa. This chert and limestone appear in force on the west bank of Mud Creek east of Hudsonville and southeast of Glendale. Some 15 feet below it in the latter locality is a split coal bed. East of
Hudsonville it can be seen to overlie a massive coarse-grained sandstone which appears in the east bank, and which is recognized as of the same character as the sandstone of High Rock. Though not seen in this district, it is believed that the horizon of the thin coal belongs close under the flint, while the split bed referred to belongs a few feet lower, the latter possibly being the equivalent of Coal III, and the former, as stated, of Coal IIIa.

The chert and the two underlying coals are found in the top of the ridge over the High Rock, which at that point is a massive sandstone 65 feet thick. Below the High Rock and in the valley of Sugar Creek, some four coals have been found. The uppermost of these underlies a black shale and limestone and chert. As previously stated, as a long range correlation it seems to occupy the position of the Cannelburg coal, or possibly of the Minshall coal. This coal has not been recognized east of Sugar Creek in Daviess and Martin counties, but in Dubois County it has been mined at many points just south of the river from Beach Creek, where it has an elevation of 430 feet, eastward past Portersville and Haysville, until it is in the crest of the ridge around Kellersville at an elevation of about 650 feet. It may be designated the Haysville coal in that region. The underlying coals come to outcrop and have been opened in a few places around Mount Pleasant, Whitfield P. O. and west of White River.

Coal V outcrops in the top of a high ridge south of Survant in east-central Pike County. One hundred feet lower, beside the railroad at Survant, is the outcrop of Coal IV, or the Survant coal, as it was called in the Ditney folio. Above it at other points in this district is found a thin bed overlain with black shale and limestone that corresponds with Coal IVa. In the Ditney folio it was called the Houchin Creek bed. At Velpen the Survant coal is the surface bed. About 20 feet below it is the 18-inch bed overlain by black shaley shale and limestone, known as the Velpen coal. Just east of Velpen there is a coal at this level overlain with black shale. A few yards to the east another coal can be seen coming down over the first coal, until the interval between the two coals consists only of 6 inches of clay and ½ inch of black shale. These coals are about 20 feet higher than the Velpen coal just west of Velpen, or in about the position the Velpen coal would have with the normal rise. At several points within 3 miles to the south there occurs at practically the same elevation two coals, or a double coal, usually showing 1 foot of clay between the two benches. In the 1898 report it was assumed that the Survant coal had come down to the Velpen
coal, and that the double coal found at many points southeast of Velpen represented the two beds, in that report called coals IV and IIIb. This view seemed to be greatly strengthened by the fact that at one of these points near the center of Section 22, in Township 2 South, Range 6 West, the two coals are 4½ feet apart, and between them comes a bed of limestone 7 inches thick; and many other facts could be cited along the same line.

In the Ditney folio a different view was taken. The Velpen coal is typically exposed at Pikeville. In the hills south of the bridge north of Pikeville supposedly this same coal is exposed, underlain by a thick, massive sandstone reaching down to river level. As no coal appeared within a few feet between the Velpen coal and the top of the sandstone, it was assumed that the next coal below the Velpen coal must underlie the sandstone. Southeast of Pikeville the split or double bed already referred to occurs high in the hills overlying a large thickness of sandstone, but high dips to the northwest show at several points, and such a dip was assumed as would carry this coal below the sandstone underneath the Velpen coal at the bridge, since no such coal as this appeared in the clearly exposed section at that point. On this assumption this split coal must underlie the Velpen coal by at least 80 feet. While many points appear to sustain that position, a review of the facts in the office, in the light of what was seen near Hudsonville the past summer, has led the writer to the belief that this split bed, called the Rock Creek coal in the Ditney folio, comes not very far from the horizon of the Velpen bed, and that the thick sandstone under it is the same as the sandstone which outcrops below the Velpen bed at the Jonesboro bridge, and possibly the same as the massive sandstone at High Rock in Daviess County. Just what its relation is to that bed is uncertain. Near Selvin an 18-inch coal, correlated as the Velpen coal, is underlain at a distance of only 6 feet by a 3-foot bed, and the writer is inclined to consider this Rock Creek coal as the equivalent of the 3-foot bed of Pokeberry Creek, northeast of Selvin, and the same as the coal in the bed of Mud Creek beside the road southeast of Glendale in Daviess County, and again, the representative of Coal III, and tentatively he has so treated it. The facts, of which one or two cases have been given, tending to show that this split bed is only the Velpen and Survant coals brought close together, make it desirable to withhold definite decision until the field can be further examined.

Below the massive sandstone in the banks of Rock Creek and the adjacent part of Patoka River is found a limestone and a coal.
This limestone and coal are found to be the same as those outcropping around Holland, from which point it has been called the Holland coal. From its stratigraphic position as determined in the way just stated, and from the fact that this coal is frequently of a workable thickness, they are believed to occupy the position of the coal and limestone around Haysville and on Sugar Creek in Daviess County, and possibly to be the equivalent of the coal and limestone at Minshall.

East of Holland, as described in a previous paragraph, a coal overlain with a limestone is found at a point 3 or more miles east of Ferdinand. While not conclusive, the evidence points to this being a lower limestone and coal than the Holland coal. Two miles southeast of Ferdinand this limestone has an elevation of about 590 feet above tide. Two miles farther southeast, and at an elevation of 420 feet, is an outcrop of a 4-foot coal bed that is thought to be the same as the coal long mined at Cannelton, and therefore called the Cannelton coal. Whether this difference of elevation can be relied upon as giving a measure of the interval between the two coals is doubtful, but as they are about in the strike from each other, and as this point offers a good opportunity for the measurement of this particular interval, this difference of elevation of 170 feet has been assumed to be the correct interval.

Unfortunately, the question of whether this limestone east of Ferdinand is the limestone over the Holland coal or a lower limestone, leaves an uncertainty in the relation of the Cannelton coal to the Holland and higher coals. That one or more limestones occur below the limestone over the Holland coal seems certain from a study of the elevations at which limestones occur southeast of Dale, Buffaloville and Newtonville, but the possibility is suggested that these lower limestones may be the equivalents of the limestones found at Troy at 100 feet and at 74 feet above the Cannelton coal. On the whole, the writer is inclined to assume those to be still lower limestones.

Further evidence on the relation of the Cannelton coal to the Holland coal is gotten from the relative positions of the coal and limestone in the south part of Spencer County. In the southeast corner of Spencer County the Cannelton coal is practically at low-water level in the Ohio River. It is reported to outcrop in section 12, northeast of Maxville in the bed of Anderson River, or at an elevation, according to the topographic map, of about 360 feet. The hill northeast, or nearly north of Maxville, by the map has an elevation of 580 feet. A limestone is reported to come about 20
feet below the top of the hill, or at about 560 feet, approximately 200 feet above the Cannelton coal. In a hill west of Maxville, in Section 9, occurs a limestone which may be the same limestone, but here it has an elevation of below 500 feet. Still farther west, in section 19 of the same township, is a limestone at 440 feet. In section 24 of Township 6 South, Range 5 West, presumably the same limestone is at 420 feet. Near Big Sandy Creek in Section 27 of the same township is a shaft going down to a coal of workable thickness, which is overlain by a black sheety shale, no mention being made of a limestone. This coal has an elevation of 380 feet. The presence of the black sheety shale suggests that it may be normally overlain with a limestone, and that this limestone may be the same that has been mentioned outcropping at several points between this place and Anderson River. Forty feet above the coal in the shaft, and not far above Big Sandy Creek, is an outcrop of limestone at about 420 feet. Two and one-half miles to the north the limestone over the Holland coal outcrops at about 460 feet. Notwithstanding this difference of elevation, it has been thought possible that this limestone above the creek level at about 420 feet is the same as the limestone over the Holland coal. In that case the limestone which outcrops in the hilltops around Maxville lies 40 feet below the limestone over the Holland coal, and the Cannelton coal about 170 to 200 feet still lower, say 180 feet. That would make the Cannelton coal about 220 feet below the Holland coal. With the figures now in hand that seems to be the nearest that can be gotten as to the interval between the two. It must be admitted that many difficulties are met with in attempting to apply this to the maps. Thus, for example, northwest of Maxville a coal is worked apparently a short distance below the limestone in the top of the hill that Mr. Price speaks of as the same as the coal in the top of the hill at Troy, but according to the section which he gives, which corroborates Mr. Kindle's section at the same point, the top of the hill is only a little over 100 feet above the Cannelton coal, and therefore not high enough to catch the coal near the top of the hill northeast of Maxville. The section in question was not run with barometer, and the intervals and thickness of the sandstones and other rocks may therefore be much underestimated. In that case the limestone near the top of the section would correspond with the limestone in the top of the hill at Maxville. Assuming Mr. Price's and Mr. Kindle's section at Troy to be correct, the 14-foot sandy limestone near the top of their sections has an elevation of about 455 feet, while, as previously stated, the limestone in the
top of the hill near Maxville has an elevation of about 560 feet. The assumption has therefore been made on the stratigraphic plate that the limestone at the top of the section at Troy lies below the limestone in the top of the hill northeast of Maxville. Mr. Cox's section at Troy made the limestone nearly 300 feet above the coal, so that while this interpretation is given to it, it is suspected that an accurate measurement might show the limestone at the top of the section at Troy to correspond to the limestone at the top of the hill near Maxville.

In the attempt to actually trace the several coals from point to point considerable difficulty has been met with. Coal IV or the Survant coal has been traced with some degree of confidence from Survant and Velpen southward, where it is usually found only within 2 or 3 miles to the east of the crop of Coal V, as shown in detail in the Velpen folio. The rocks surrounding Coal V appear to have been of such a nature as to have protected the hills, so that the eastern outcrop of Coal V in Pike and Warrick counties is frequently in the crest of a high hill, near the foot of which outcrops Coal IV. In some cases outcrops of Coal IV are found in the valleys to the west of the easternmost outcrop of Coal V, and the dip appears to carry the former over the hills to the eastward within a short distance, as stated. The difficulties in determining the exact stratigraphic position of the Rock Creek coal have been stated, and these, added to the scarcity of outcrops of that coal, render its tracing very uncertain. The Holland coal fares much better on account of its workability at many points. It can be quite clearly traced from Holland southwestward past Dale, to Lincoln City, to west of Buffaloville, and to west and south of Newtonville. Around Duff, Huntingburg and Jasper the correlation of the limestones, and necessarily of the coals, has been in doubt. At Huntingburg a limestone outcrop in the road about on a level with the town. Chert covers the top of Standpipe Hill to the west, the two limestones being from 60 to 70 feet apart. It is uncertain, however, whether the chert on the hill belongs at the horizon of the Velpen coal or the Holland coal. This region is outside of that covered by the topographic maps of the U. S. Geological Survey, and elevations are dependent on barometric readings from railroad elevations.
Chapter IV.

THE COAL BEDS.

Number of Coal Beds.—In Fig. 1 are given the coal beds occurring in Indiana, showing their relation, position, their distance apart, and their average thickness. The sections in Plate II give an idea how constant the coals are in their occurrence, their distance apart, and their thickness. From the figure it will be seen that there are at least 25 distinct coal beds in the State. Nearly all of these reach a thickness of 2 feet or more in some places. Nine of them are persistently minable over considerable areas, though only one, Coal V, appears to be persistently minable over nearly the whole area within which it outcrops. The upper five of these nine beds are of the raking or “bituminous” variety, occurring as broad sheets. The lower four coals occur in basins, and while of good minable thickness in the basin, are not workable over much of the field. Of the minor coals, several local beds reach a workable thickness, and in the distant future may add to the State’s output. In addition to the coals shown, most of which are fairly regular, coal is occasionally found at still other horizons, so that, all told, coal is found to occur at at least thirty-four horizons.

Thickness of Coal Beds.—From the figures given on Plate III it is evident that the “bituminous” coals being mined average in the mines from 4 to 6 feet thick. Coals III, V and VI reach an average of 6 feet over large areas. Coals IV and VII will run from 3½ to 4 feet, though the former maintains a thickness around 5 feet over a large area in the Linton district. The block coals of the Brazil groups average about 3 feet in the mines, frequently reaching four feet, and occasionally 5 feet in the middle of the basins, and thinning to a few inches on the edges. Taking these beds as a whole, they will probably average well under 2 feet. As already stated, coals III and VI, while very thick over large areas, are entirely lacking over other large areas.

Extent of Coal Beds in Indiana.—The coal measure rocks of the Carboniferous period have always been recognized as possibly the extreme expression of variations in physical surface conditions both horizontally and vertically. Thus, as contrasted with most rock formations, where a single rock ledge may have a thickness of hundreds of thousands of feet and cover thousands of square miles,
FIG. 1.
with great uniformity, it is not uncommon to find in a vertical space of 100 feet in the coal measures five or six coal beds, as many clay beds underly ing each of them, possibly several thin beds of limestone, and a score or more of distinct beds of shale and sandstone. So, too, the tendency of massive sandstone to grade over into shales, and vice versa, in a horizontal space of a few yards, is well known to everyone at all acquainted with the coal fields. And yet through all of this, seeming and real, variation there runs a remarkable horizontal persistency. The writer's assumption in the 1898 report that certain coal beds of the Indiana field could be traced the entire length of that field has been strongly questioned by many outside geologists. An examination of the abundant drill records copied last summer not only confirms the writer's previous ideas in that line, but shows a greater regularity than he had suspected. While in certain cases the thinning away of coals is confirmed, in other cases it appears that the assumption that certain coals changed in going from one region to another was the result of incorrect correlations, and that when correctly tied together the coal beds in question maintain the same character from one area to the other. Recent work in Illinois and Kentucky, taken in conjunction with the work in Indiana, suggests, for example, that Coal V may be found to have been deposited as a fairly uniform sheet of coal over most or all of the area within its outcrop, or over an area of 25,000 square miles or more. What this means is better realized when it is remembered that the great Pittsburg coal bed, about the persistency of which so much has been said, probably covers less than 6,000 square miles. More than that, many of the accompanying rock members are but little, if any, less persistent. Thus, through Indiana Coal V has nearly everywhere above it a limestone. In the Ohio River district this limestone is usually wanting, but in its place occurs a calcareous clay, full of the same fossils as occur in the limestone to the north, and which is there known by the miners as the "pennywinkle" (periwinkle) rock, referring to the gastropods found in it. So, too, of the black shale that occurs between the coal and the limestone, with its iron sulphide concretions (hard heads) that commonly project down into the coal. Even more remarkable is the persistence of thin bands of clay or shale in the coal bed itself; often such a band, with a thickness of \( \frac{1}{4} \) inch, can be traced over hundreds of square miles. Even in the block coal field of Clay County, where the coals occur in hundreds of small basins, the coal thinning out between the basins to a mere film of a few inches, there is still a constant repetition of the same characters in the benches and partings from basin
to basin. On a small scale it is as where an old cornfield in the
spring has been dotted over with pools of water. The water of any
one pool is of variable depth and irregular extent, yet all exist
at the same time, under the same atmospheric conditions at least.
The coal measures developed, therefore, under two sets of condi-
tions, the one tending to produce widespread horizontal uniformity,
while the other tended to produce horizontal irregularity. What
these conditions were, it is not necessary to discuss here.

The study of the stratigraphy shows a slight, though not uni-
form gain in ascending through the series for the forces making
toward uniformity. It is not entirely certain that the seeming
lack of uniformity in the lower coals and associated rocks is not
due to our lack of data. The lower coals are certainly more irreg-
ular in thickness than the upper coals, due to their occurrence in
basins, but when we have considerable knowledge of the coals in
the basins, the persistency is found to exist, as previously noted.
Naturally the section of the coal where fully developed in the
center of the basin differs greatly from the section of the same coal
on the edge of the same basin, or even part way up the side of the
same basin. Obviously, then, under the conditions that existed
throughout the eastern edge of the field south of Clay County,
where data are confined to scattered outcrops or small country
banks a few square yards in extent, cutting the coal at various
points in the basin between its center and its edge, the same coal
presents a great variety of aspects at its different exposures, and as
the exposures are usually widely scattered, often several miles
apart, and as the rocks accompanying the coals often differ be-
 tween the center and edge of the basin, and as the interval to other coals
varies much in the same way, the correlation and tracing of coals
in that region becomes a matter of much uncertainty.

In general it seems to be true that the coals are much more per-
sistent than any of the other rocks, unless it be the clays which
underlie the upper coals. With the lower coals the clay, which
may exist in the center of the basin under the coal, may run out
over the "hill" or divide from one basin to another; but with the
upper coals it is often true the clay will persist when it is known
that the coal has run out. That this clay under a given coal rep-
resents a definite deposit or accumulation, is often evident from its
chemical or physical characters or from the contained fossils. Thus,
David White has thought that in the clay under the Minshall coal
at the Chicago Clay Company's plant at Brazil, he had found the
same clay that is extensively worked along the Mississippi River, on
the west side of the Illinois field all the way from Rock Island to St. Louis.

While it is true that some of the coals, as Coal V, are remarkably persistent within the field of our knowledge, the evidence is equally clear that other coals of large local thickness, as coals VI and III, certainly die out and are absent over large areas. In some cases this disappearance seems to be complete over a large area, as in the case of Coal VI around Terre Haute and to the north; in other cases, as with Coal III north of Coxville, the coal though generally absent over large areas, may frequently be found in local pockets of very limited extent, reaching about or quite the old thickness. While in some cases these coals, where lacking in this way, may have been eroded before the deposition of the succeeding rocks, in most cases they appear not to have been deposited. The breaking down from the area of large thickness to that in which it is absent is apt to be gradual, and the coal shows much irregularity over the broad belt between the two areas. While it appears to be generally true that the thick coal beds are the more persistent, this is not always true. Thus, Coal IIIa can be traced continuously northward through Clay and Vigo counties, overlying by but a short distance Coal III, which there has a thickness of from 5 to 8 feet. North of Coxville Coal VI becomes irregular and dies out, but close above it continues Coal IIIa, the coal being seen in every case where its horizon is exposed. In the shales above it occur two limestone layers, often so ferruginous as to be more nearly an iron ore layer. These layers, though only 3 or 4 inches thick, can be traced all through southern Parke County and eastern Vermillion County. Next to the coals and the under-coals the limestones are the most persistent rocks of the coal measures. As previously stated, the shales and sandstones replace each other within very short horizontal distances. In some cases this is due to a grading of one into the other; in other cases there is evidently an old surface between the two. In such cases the shale, usually underlying and having been eroded, has been superimposed by sandstone.

The Coal Chart.—On Pl. III is given a comprehensive view of the workable coal beds of the State. It should be noted that the measurements as they are given cannot in all cases be taken as average measurements. This is more nearly true of the upper coals than of the lower coals. Most of the measurements given have been made in mines by members of the survey. It should be remembered, however, that in a large number of cases the mines have been located as the result of drilling, which has often been
very extensive, and have been located usually in the center of basins where the coal is the thickest. This becomes very apparent to any one reading the old report in comparing the sections given in Clay County, for example, with those given in Dubois and Spencer counties. In the latter two counties there are very few commercial mines, and the relatively small number of country banks, measurements made along road sections, and elsewhere, show a great number of coals with a thickness of anywhere from 2 inches to 8 or 10 inches. The first impression gained might be that the coals of that region were very much thinner than the coals of Clay County. Granting that there may be some advantage on the side of Clay County coals, the probability is that the advantage is nothing like as great as would be indicated by those sections, for the major part of the sections in Clay County are taken from mine and shaft sections in the center of the basins, which have been pretty accurately located by preliminary drillings. Again, in the case, for example, of the Lower Block coal, the figures drawn on Pl. III have usually taken the coal near the center of the basin in order to include the underlying bone coal and its accompanying bed of good coal, for the sake of their stratigraphic value. Had there been no mining in Clay County and had the amount of drilling been only a small fraction of what it actually is, we might have gotten somewhat the same idea of the thicknesses of the coals as we now have of the coals of Dubois and Spencer counties, for the examination of a large number of those drillings shows many cases where the coals known to be of good workable thickness a short distance away have a thickness of only a few inches, evidently the drilling having gone through that coal on the broad divides between the separate basins. It may be that in Dubois and Spencer counties the basins are more restricted and the divides between them where the coal is very thin may be broader. In the plate mentioned the number of sections given is so few that naturally selection has been made from the measurements made in coal openings where the coal showed the highest thickness, on the assumption that future development will probably show scattered basins in the center of which the coals will have the thickness given, the measurements given in all cases being actually made by members of the Survey. In the case of the upper coals, which do not lie in restricted basins, with a marked difference in thickness in each mine, the measurements given as a rule are an average of the mine in which they are taken. There are many places at which the smaller coals coming between these principal coals that are figured, reach a thickness of 3 feet, or occasionally
even a greater thickness, but these unusual thicknesses are probably in very limited basins, and for the general purposes of this report have not been figured. In the description of the different coals the section of Sullivan County, western Greene, and southern Clay County, will be taken as the type locality of the coals described from that location northward and then southward.

Coal VII.—Coal VII in Sullivan County is usually of a workable thickness, varying from 3 feet up to 6 feet. It has been little mined as it tends to have a "roly" roof, which cuts the coal down quite seriously, so that a mine which may show 6 feet of coal in many places, may not average over 3 feet. As the rolls are often of sandstone the driving of entries is rendered difficult, and this fact probably more than any other, in view of the easier working of the lower coals, has led to its being passed by in commercial operations. The coal is usually described as a somewhat soft coal for shipping, but a coal very free from sulphur. In this county it is almost always a solid coal. Stratigraphically it is usually characterized by the presence of a limestone which may run from 2 or 3 up to 10 feet or more in thickness lying but a few feet below it, sometimes coming immediately below the fire clay, and in other cases separated from the fire clay by only a few feet of clay or sandstone. The roof of the coal is either shale or sandstone. One characteristic of the roof where sandstone is the occurrence of stringers of coal which rise from the top of the coal bed over a lens of the sandstone roof and form a line of separation which tends to allow the dropping of that sandstone lens, to that extent making it a dangerous roof. The coal shows probably a little thickening from the south end of the county toward the north, some of the thickest sections being measured along the north edge of the county near Busseron Creek and around Farmersburg. The coal has been mined commercially around Farmersburg partly because of its good quality and thickness and partly because Coal VI at this point has proven to be very irregular and tending to run out. From the north line of Sullivan County to Terre Haute there are only a few openings upon what is considered to be this coal. It was probably this coal that was mined at Pimento and that outcrops on Honey Creek near the northeast corner of Linton township and the southeast corner of Honey Creek township. It has been extensively mined west of Terre Haute, where it occurs about at river level, having been mined by shafts in the bluffs from a point southwest of Terre Haute to St. Marys mine, about 3 miles northwest of West Terre Haute. Near the north edge of Sugar Creek township it
rises to the level of the bottoms, where it has been stripped west of the river road. It outcrops frequently along Coal Creek and again on Brouiletts Creek in southwestern Vermillion County. The coal shows quite a change from the outcrops in northern Sullivan County or on Honey Creek in going to West Terre Haute. From West Terre Haute northward to where the coal leaves the State in southwestern Vermillion County, it tends to show a solid bed from 4 to 5 feet in thickness, overlain by from 1 to 2 feet of bone coal, which consists of thin layers of coal in black shale. The coal still has under it a limestone similar to that occurring in Sullivan County, though in this region it nearly always underlies the fire clay. In most of the openings the bone coal makes the roof. Over the bone coal is usually a considerable body of shale very suitable for the manufacture of clay products. Similar shale appears over the coal on Honey Creek. This coal around West Terre Haute has been called by the mine operators Coal VI, on account of its being the first coal of any consequence above Coal V. Under the head of "Stratigraphy" the evidence has been given which leads the writer to consider that Coal VI has run out in this region, and that this coal is the equivalent of Coal VII of Sullivan County. Returning to Sullivan County and tracing the coal to the southward, it can be clearly traced into Knox County and for several miles south of Bicknell. In this region it shows a thickness of from 1 foot to 5 feet. Many sections show it overlain by a large thickness of sandstone, often as high as 80 feet or more, the sandstone in some cases coming down onto the coal, in others being separated by a small thickness of shale. The limestone underlying the coal in this region is less persistent, but appears sporadically in many of the drillings and shaft sections. The coal is a solid coal, as in Sullivan County, and there can be little question of its identity in this region. Passing southward from Bicknell to Wheatland a condition is found somewhat similar to that met with in going northward from the north edge of Sullivan County to West Terre Haute. At Wheatland Coal V is found, with its characteristic roof, while above it there is no coal of importance for a distance of 130 feet, or the interval at which the No. VII coal occurs in Sullivan County and to the northward, and also in the drillings southward from Bicknell. Around Wheatland, however, the coal instead of being solid, as it is to the northward, shows a strip of bony coal near the bottom, a point of resemblance to the No. VI coal at Bicknell and to the north. This fact and the fact that there is no coal below it of importance corresponding to the No. VI, has led to some question as to whether
the coal formerly worked at Wheatland and still being worked from outcrop from the river bluff to the northeast is not the Coal VI rather than Coal VII. Above this coal there is usually a sandstone, and some of the drillings and mines around Wheatland give a thickness of up to 80 feet, a point of resemblance to the conditions existing around Bicknell. At the exposure on the river bank northeast of Wheatland, at a distance of 24 feet below the coal being worked at one point is a coal which is thought might occupy the position of Coal VI. At one point it shows a thickness of about 2 feet, but thins out to 0 at a distance of 100 feet to the north. From Wheatland to the east fork of White River at the south line of the county apparently only one coal has been met with above the position of Coal V. This shows a thickness of 5 feet at Monroe City, and of 4 feet along Pond Creek. It apparently corresponds with the upper coal at Sand Hill, across the river in Pike County. From that point southward coal ranging from 4 to 5 feet in thickness is met with west of the old canal, the coal usually being solid, but southwest of Rumble showing a section similar to that at Wheatland in that there is a bottom bench a few inches thick of good coal, then a bench of bony. This coal shows a limestone below it at several places, such limestone seeming to correlate with the limestone below Coal VII in Sullivan County. In the central part of Gibson County drillings and mining show the existence of two coals above Coal V, of which the lower is more frequently the thicker coal. These coals will run from 15 to 20 feet apart. A somewhat similar condition seems to exist at Vincennes, where there are two coals in about the position of VI and VII, ranging from 13 to 18 feet apart. The upper coal there has been mined and shows characteristics of roof and of coal similar to the Coal VII in Sullivan County. The lower coal does not markedly resemble Coal VI in Sullivan County, but has been assumed to belong at that horizon. The lower coal in central Gibson County in like manner has no special resemblance to the coal called Coal VI in Sullivan County, but appears to come at that stratigraphic position. The upper coal is variable in thickness, ranging from 4 feet downward. In a mine west of Oakland it can be seen to thin out entirely in a mine. At Dongola it shows as two benches, separated by 12 inches of clay. Passing southward into Warrick County, Coal VII appears to continue as a bed, with an average of about 3 feet, becoming thinner south of Chandler, and at Newburg having a thickness of only 18 inches. Through this district there lies but a short distance below it another coal bed ranging from 1 foot to 3 feet in thickness. In
some cases this lower bed is 6 or 8 feet or more below the 3-foot bed assumed to be Coal VII. In other cases the lower bed comes close up to the upper bed, the two being separated by only a few inches of shale or clay. This condition is first met with in southern Gibson County in some drillings near Somerville, in which the two coals are less than 4 feet apart. A comparison with drillings in the neighborhood would seem to indicate that the lower coal was the coal being worked at Fort Branch and Francisco, where it is assumed to be Coal VI. At Lynnville the two coals range from 6 feet to as many inches apart. At Buckskin the two coals are reported in the Buckskin mine to be about 3 feet apart, the interval being largely bony coal, the upper bench having a thickness of 41 inches, and the lower bench having a thickness of from 2 feet to 3 feet. In Greer Township the two coals come together, making what appears to be a single bed, including 6 feet of coal in two benches, separated by 4 or 5 inches of shale. Around Millersburg and southward nearly to Chandler the upper coal has a thickness of about 3 feet, usually divided into three benches, and usually underlain by a limestone. In some cases the limestone lies immediately below the coal, and in others it is separated by a little shale or clay, or both. In several sections below the limestone is noted, or was reported, a coal bed from 2 to 3 feet in thickness. Apparently this is the same coal that is being mined at Fort Branch, or Coal VI. In the south part of the county and around Evansville the lower coal bed appears to have run out. The upper bed, Coal VII, ranges from a foot to 3 feet in thickness. In southern Warrick County and around Evansville the limestone which underlies this bed, coming usually close below the fire clay, is quite prominent, frequently having a thickness of 9 or 10 feet, as shown in outcrop just east of Newburg.

In 1907 the writer, with Mr. Frank W. DeWolf, of the Illinois Survey, visited a number of mines in western Kentucky in the hope of obtaining data which would help to tie the coal measures of southern Indiana across to those of southern Illinois. The evidence that the coal long worked at the People’s mine at Henderson was the same as Coal V seemed to be conclusive. At many points about 100 feet or more above Coal V was found a limestone that appeared to correspond with the limestone underlying Coal VII in Indiana. Above and below this limestone at a number of points were found coals, sometimes thin and sometimes of a good workable thickness. This limestone and accompanying coals was noted at a large number of mines in the Henderson district from Henderson eastward as
far as Owensboro. In that district, however, the coals around the limestone appeared to be thin. Going westward from Henderson, however, at Corydon the coal above the limestone has a thickness of over 6 feet, the coal below the limestone being in two benches and thin. At Waverly the coal below the limestone is the thicker, the coal above the limestone being in two benches and thin. At Morganfield, again, it is the coal below the limestone that is thick, the coal above being thin. In the Madisonville field it appeared in some cases to be the coal above the limestone that was thick, in others the coal below the limestone. In the Reinecke mine, west of Madisonville, the two coals are reported to be from 3 feet to 38 feet apart. The upper coal has a thickness of 4 feet 2 inches; the lower coal has a thickness of 6 feet at the eastward, where it occurs under the limestone, and of from 6\(\frac{1}{2}\) to 8 feet on the west side of the mine, where the roof is shale. Similar conditions are given in the reports of the Geological Survey of Kentucky for Ohio and other counties. In that State the lower of these two coals has been designated Coal 11, and the upper Coal 12. If our correlation is correct, it would therefore appear that Coal 12 of Kentucky is the equivalent of Coal VII of Indiana, and that Coal 11 of Kentucky is the equivalent of Coal VI of Indiana.

**Coal VI.**—In Sullivan County Coal VI has a thickness of from 6 to 8 feet, and holds this thickness with great uniformity. Of this amount there is commonly a bottom bench of from 10 to 14 inches that is bony and usually left for a floor in the commercial mines, reducing by that much the thickness of commercial coal. This coal in this county gives a most remarkable example of the persistence of thin partings and of the coal benches in character and thickness. In nearly every mine in the county two thin light-gray partings appear on the middle of the entries from 4 to 6 inches apart, so that any one taken into a mine on this coal blindfolded could recognize the bed the moment the blindfold was taken from his eyes. These partings are of shale and usually range about one-half inch in thickness. They make it necessary to do a good deal of hand picking in order to make the coal as shipped to market clean. Most of this shale can be gotten out in mining the coal, as it separates readily from the coal benches. Frequently, however, it is necessary that the coal be picked over as it is screened in order to fully eliminate this shale. The roof is usually a shale, overlain at a small interval by a sandstone. The sandstone appears to come nearer the coal at the north than in the central part of the county, where the shale may have a thickness of 15 to 20 feet. This shale
makes a poor roof, especially in warm weather, and this fact has tended to discourage mining on this bed probably more than any other. It is hoped that some day experiments may be carried on which may suggest a manner of treatment which will render this roof more stable and will greatly facilitate mining on this bed.

Though involving greater initial cost, it is probable that the following plan might result in a large economy in the total cost of operating a mine on this coal bed: this is, to drive entries to the boundaries of the property, leaving the top bench of coal for a roof, and taking up enough bottom to give headway, and then to mine the coal back toward the shaft, taking the coal clean as mining retreated, either by a modification of the common room and pillar method, or a regular long wall system, or some combination of the two, such as is being used so successfully in many fields.

At the north edge of Sullivan County, around Farmersburg, this bed becomes very irregular, some of the drillings there failing to find it at all, while several attempts to mine it have had to be abandoned, as the coal would run out or would run down to a few inches in many of the entries. Apparently this coal has not been found at all northward from this point, though it is probable that some workable coal at this horizon will be found to exist in southern Vigo County, as it is unusual for a bed maintaining such a uniform and good thickness as this bed does in Sullivan County to pinch out along such a narrow band. Going southward from Sullivan County the coal maintains its character as far as Bicknell, showing the typical partings and bottom bony bench at Edwardsport and also at Bicknell. Drilling at Bruceville indicates a tendency to split up into a number of benches. Again, at Vincennes the lower of the two coals, as previously described, is variable in its thickness and condition, sometimes appearing as a nearly solid coal, in other cases being split into two or more benches, separated by several feet of clay and shale or other rock.

At stated in a preceding paragraph, in the southeastern part of Knox County this coal appears to be of very variable thickness or to be wanting, and apparently this condition holds southward to the Patoka River. It is suspected, however, that future extensive drilling may develop large basins or pockets of this coal of considerable thickness, and it may prove to gain in regularity and workability westward from the outcrop in western Knox County. In central Gibson County it becomes of workable thickness, and is commercially mined at Francisco and Fort Branch, showing a thickness of 4 feet at both of these points, and probably much
workable coal at this horizon will be developed by drilling in this county. Continuing southward into Warrick County, this coal is believed to become thin, and the interval from it to Coal VII to decrease, until, as described under Coal VII, it is represented only by a thin bench from a foot to 3 feet in thickness lying close under Coal VII, in some cases so close that the two coals can be mined as a single bed. This coal appears to be absent in southern Warrick County and southern Vanderburg County, also in the Henderson district of Kentucky. The existence of thick coals at many points in Kentucky at this horizon suggests that the future will prove up much workable coal in territory where present information does not show its presence at all.

Coal V.—As stated several times previously, Coal V is beyond doubt the most important coal bed in Indiana, and if correctly correlated with the coals of Kentucky and Illinois, it is probably the most important bed in those fields. If this correlation is correct it becomes one of the most important beds in the United States. In a general way, it is usually a solid bed, overlain in almost all cases by a black shale that splits readily into great sheets and is characterized by marine open sea fossils, such as nautilus, orthocera and similar forms, and by the presence in this shale of concretions of pyrite or "sulphur" which very commonly tend, at the point of meeting of the coal and roof, to project downward into the top of the coal. In some mines these are extremely abundant, occasionally so much so that the whole roof has the appearance of a boiling surface of water inverted and vastly enlarged, while in other cases there is just one here and there, separated sometimes by scores of feet. In some cases they are small, a foot or so in diameter; in other cases they have a diameter of 8 or 10 feet, and in some cases project down into the coal 3 or 4 feet or more. There are a few places, notably in Pike County, and on the eastern outcrop, at Washington, in Daviess County, where the black shale roof is replaced by a gray shale, or sometimes by a sandstone. In some of the mines of Pike County this gray shale roof appears as a lens between the coal and the black shale the latter rising over the lens of gray shale, which evidently preceded it in deposition. In other cases the black shale disappears, as around Washington, and in some cases the coal is immediately overlain by sandstone. This occurs over very limited areas in the region mentioned, and usually only toward the eastern outcrop. Over this black shale is almost universally a limestone, frequently in two benches, this limestone often having a thickness of 4 to 6 feet or more. Toward the Ohio
River this limestone is only found occasionally, but in its place is a clay layer, filled with the same fossils, and apparently the equivalent of the limestone, the quantity of lime being decreased, and the quantity of clay being increased. Coal V has almost everywhere in the State a rider, usually occurring above the limestone, and sometimes a second bed appears. In many parts of the State this rider is 20 or 30 feet above the coal, but in other places it comes close to it, notably in Vermillion County and in Pike County. In Pike County the rider sometimes thickens up to 2½ to 3 feet, or even more, and in one or two cases an attempt has been made to mine it in connection with the underlying coal. Coal V itself is apt to be characterized by partings of "sulphur" (pyrite). These usually do not occur at any particular horizon, a measurement at one part of the mine showing "sulphur" partings at different horizons from those taken at any other part of the mine. The coal, however, appears to make a strong steam coal and to give general satisfaction for that purpose. There is naturally quite a difference in the quality of the coal in different places, particularly as regards the sulphur content. The floor of the coal is usually fire clay, though there is a bone under it in a few places. In Sullivan County this coal will probably average 6 feet or more in thickness. It is exposed in the creek bed at Alum Cave, with a thickness of 8 feet, and is reported to show a thickness of up to about 11 feet in places in the mines at that point. In the northwest corner of Greene County, around Jasonville, appears one of the few points at which this coal is reported to run out. Here wells strike the limestone, but fail to find any coal underlying it. Again near Lewis the coal appears to be variable in thickness, several openings showing a thickness of only 2 or 3 feet, and drilling in that region brings out the same fact. Drillings east of Farmersburg also fail to find it. Going northward through Vigo County, a number of openings have been made in Pierson and Riley townships, and between Riley and Terre Haute. Most of these openings show coal having a thickness of from 5 to 6 feet, with all the characteristic features of coal and roof. Crossing the Wabash, it is well developed and extensively mined around West Terre Haute and to the northward as far as Clinton, where it is the surface bed, both at Clinton and Lyford. In most of that region it shows a thickness of 5 feet or more. It can be traced with certainty, with the data in hand, only as far as the Torrey mine north of Clinton. The writer, however, has been inclined to assign the coal at Dana to this horizon, with, however, some doubt. At that point it is
less than 4 feet in thickness. Going southward from Sullivan County, the coal maintains its excellent thickness in eastern Knox County, and is now extensively mined, particularly around Bicknell, and drilling has shown that it maintains this excellent development southward from Bicknell at least as far as Wheatland, where it is just beginning to be developed. It maintains this thickness also east of the river and west of Washington in Daviess County, but to the eastward and on the south of Washington the roof changes from a black shale to a gray shale or to a sandstone, and the coal decreases from a thickness of 6 or 7 feet to a thickness of 3½ feet or less. At the old Murray mine on White River southwest from Washington, the coal had its characteristic thickness and roof. Around Petersburg this coal is developed with a magnificent thickness, showing 8 to 10 feet in the mines of this district. On Mud Creek it is exposed in the creek bank with a thickness of 9 feet. While in most of the mines it has its characteristic roof of black shale and limestone, in some cases it is overlain by gray shale. In view of the fact that at Washington the appearance of a gray shale roof is accompanied by a great decrease in the thickness of the coal, it is of interest to note that in the Smith mine northeast of Petersburg the coal has a gray shale roof, but shows a thickness of over 10 feet, showing that the gray shale roof is not necessarily accompanied with a decreased thickness of the coal. Eastward from Petersburg, on White River, near High Bank, and occurring about 75 feet above the river, are some openings on the 3½-foot coal overlain by a gray shale that have always been considered to be of a coal at a lower horizon. The writer is now inclined to think that this is the eastern edge of the No. V coal, corresponding in thickness and in roof with the same coal as developed at the No. 4 mine at Washington, or as developed in the outlier south of Flat Creek, in Jefferson Township of Pike County. At the Wooley mine in Petersburg this coal shows a parting of up to 6 inches, and some of the drillings around Petersburg indicate a separation of the two benches, amounting in some cases to several feet. Southward from Petersburg to Patoka River the coal maintains its thickness as far as Little's Station. Going eastward from that towards Winslow and White Oak it tends to decrease somewhat in thickness, the average in that district being between 4 and 5 feet, and in some cases the roof changes from a black shale and limestone to a gray shale overlain with sandstone.

South of Patoka River, and just east of the south fork, is a
coal believed to be at the horizon of Coal V that differs so in its characteristics and in its local position that it has been the subject of much dispute, many thinking it to be the representative of Coal VI. The coal has a thickness of 6 or 8 feet, and is divided by one or more partings. A careful study of the conditions, in connection with the excellent topographic map of that region, has led the writer to believe that his first correlation as Coal V is correct. All around this region, except at Little's Station, both at Oakland, Dongola, Ayrshire, Arthur and to the southward of Oakland, Coal V has a thickness usually of only about 4 feet. Again in a shaft in the southwest corner of Section 10 it also has a thickness of 4 feet. At Princeton this coal shows a thickness of 6½ feet. In the central part of Pike County the coal tends to run somewhat thinner, averaging probably between 4 and 5 feet. In that section the little rider coal, which is usually less than 1 foot in thickness, tends to come within 6 or 8 feet of the top of Coal V. Southward in Warrick County the coal continues to have its characteristic roof, though often wanting the limestone, and varies in thickness from 4 to 8 or 9 feet, the former figure being the more common. Over a small area near Folsomville the coal splits into two benches, and this splitting can be readily traced from one opening to another until it reaches a maximum separation of 3 feet 6 inches, beyond which the two benches come together. East of Booneville and in some of the territory to the northeast of that the coal shows a thickness of 7 feet or more. South of west of Booneville, however, the coal becomes very regularly about 4 feet thick, continuing in this condition to the Ohio River, and across the Ohio in the Henderson-Owensboro district, where it is known as Coal 9.

**Coal IV.**—Coal IV finds its typical development in the district around Linton, where it averages about 5 feet, running up occasionally to 6 feet or over. Where solid it usually shows a smooth parting in the middle. It tends to split into two benches which may become several feet apart. The figures in the plate are almost entirely measurements made in the mines. A study of the drillings, however, seems to show that over the coal field as a whole this bed is quite often split and unworkable. At Linton such a splitting takes place just south and west of town, the split following a northwest and southeast line running through the centers of sections 21 and 27. In some of the mines the coal has been followed westward until the split becomes as much as 2 feet in thickness, and drillings still farther west are reported to show the separation to become as much as 13 to 17 feet. In like manner in
other cases in Vigo, Sullivan, Vermillion and Parke counties, drillings show this coal "to go to pieces" locally. Through western Greene County and eastern Sullivan County this bed runs from 3 feet 6 inches to 5 feet in average thickness. The roof is either a shale or sandstone. The floor is usually sandstone or very hard, sandy clay.

Going northward from Linton, this coal maintains its thickness in places, though on the whole probably it will average somewhat thinner. At many points it is split into two benches. In south-western Parke County it is workable at nearly every point seen, though thin, usually running 3 feet or under. From Hillsdale northward the coal runs from 4 to 5 feet to the region of the Little Vermillion River. In much of this territory it is so close to the surface as to have a very poor roof at the outcrop. The westward dip, however, should carry it low enough to obviate that difficulty a short distance farther west.

South of Linton this coal seems to have a workable thickness over large areas in Daviess County, usually running 3 feet or more. It usually has one small parting. Around Washington it appears to be thin, while one drilling in Knox County reported a thickness of nearly 7 feet. At Vincennes it is thin. In western Pike County many drillings report this coal to have a thickness of 4 feet or over. On the outcrop in eastern Pike County it usually is about 3 feet thick. In Warrick County the coal is more variable, and probably will not average over 2 1/2 feet thick, though sometimes running over 3 feet. It will probably more often run down to 2 feet or less as the Ohio River is approached. At Evansville it is too badly broken up to be workable.

Coal III.—Coal III has its typical development in northeastern Vigo County at Coal Bluff and Seelyville. It has a large development from Coxville on the north to Linton on the south, apparently maintaining this thickness from the extreme eastern edge of its outcrop at Turner and south of Clay City as far westward as drilling has been carried. Considering the way it runs out to the north and possibly to the south, it is suggested that it may have been laid down in an east and west basin, and may maintain this large thickness farther in an east and west direction than it does in a north and south direction. In practically all cases where the coal was actually examined it shows one or more partings or binders. In some cases these are regular for some distance; in others they vary from one mine to the next. Thus, over a large area in northeastern Vigo County and southwestern Parke County there is a
thin bed of sulphur or pyrite running regularly through the coal from 12 to 18 inches from the top. In some cases there is a sulphur bed near the bottom. This sulphur or pyrite band is so regular and clean at Rosedale that it has been freed from the coal in a rattler and sold for the manufacture of sulphuric acid. In most places in Vigo, Clay and Parke counties this coal has at least three partings, which will range from 1 inch to 2 feet thick, the latter, however, being very exceptional. Usually the partings do not exceed 6 inches. There is often one or more thin streaks of bony coal in the bed. The roof of this coal is usually shale, though often sandstone comes down, in which case it is apt to cut out the top of the coal. Crossing Raccoon Creek from Coxville, an overlying sandstone comes down on top of the coal. Evidently the coal had been planed off until at one point a channel has been cut to an unknown depth below the coal and filled with the same sandstone.

North of Coxville the coal rapidly thins out. This thinning out is evidently not due to the coal having been eroded away, but to its not having been deposited. At Coxville the coal has a thickness of about 6½ feet, with a clay parting near the middle. Going northward, the lower bench thins out, so that a few miles to the north it is represented only by a few inches of coal and then is gone altogether. Then the upper bench thins down. This thinning is apt to be irregular, however, the coal at one point showing a thickness of 2 feet, and in 100 yards being entirely gone. Coal in this horizon was last seen in going northward at the mouth of Rocky Run and a little to the southwest of Hillsdale. That the cutting out of Coal III is not due to erosion of later date is shown further by the presence of Coal IIIa, only a few feet above it, not only where Coal III is thick, but also where Coal III is thin or lacking. As before stated, this little 18-inch rider can be clearly traced from central Clay County to the mouth of Jonathan Creek on Little Vermillion River.

South of Vigo County this coal appears to hold its thickness as far south as a line from Sullivan to Linton, and possibly farther. A number of commercial mines have been opened on it in northeastern Sullivan and northwestern Greene counties. When visited in 1908, nearly all of these were closed. The fact that most of the mines on Coal IV were open when visited, while nearly every mine on Coal III in the district was not running, does not argue well for the workability of Coal III. The sections given of Coal III in this district are mainly from drillings, and the fact that no part-
ings are shown in several of them is not conclusive evidence that no partings exist.

While it is reasonably certain that Coal III, as described from Coxville to central Sullivan County, is a more or less nearly continuous bed, no such claim can be made for the coals described as Coal III south of Sullivan County. Very few drillings within the outcrop of Coal V go farther down than to Coal IV, and those that do fail to find any thick bed corresponding with Coal III of the northern counties. As described under "Stratigraphy" there is not infrequently found a short distance below Coal IV a coal that by reason of its thickness and character and the character of its roof, resembles Coal IIIa of the more northern counties, and below this, often only a few feet, is found a bed that may represent Coal III.

In much of Daviess County the exact correlation of most of the beds is more or less conjectural. The bed we have chosen to call Coal III has a thickness of about 2 feet just west of Raglesville. Farther south, at the Gookee bank, it is 2½ feet thick. At Cannelton, where it is the surface bed, it has a thickness of from 2 to 4 feet in some of the mines and in others is split up into three benches. South of Cannelton the Star coal, as it has been called in this region, shows a thickness of from 2½ to 3½ feet at a number of points until it comes out on the top of the ridge above the High Rock. Usually it has at least one parting, which may vary from 1 to 3 inches in thickness.

From the neighborhood of Velpen southward the Rock Creek coal, which has been taken as the representative of Coal III, is a split coal, often showing as two benches, with a thickness of about 1 foot each, separated by from 6 inches to 18 inches of clay. In other cases it appears to be a solid bed 2 to 3 feet thick or more. In some of these cases it is closely overlain by an 18-inch rider, the Velpen coal. That, as previously stated, resembles Coal IIIa of the northern counties. This condition is shown in the Day and Byers sections. From Gentryville southward nothing of workable thickness was found at this horizon. A few of the drillings to the west show coals of workable thickness, in some cases showing up to 3½ feet. Most of such sections, however, fail to find workable coal at this horizon.

Minshall Coal and Coal II.—In the north end of the coal field it is found that the workable coal at almost all points is overlain by a black shale and limestone. It has been thought possible that these thick coals with that roof were all at the same horizon. In the
1898 report this coal was thought to be at the same horizon as the thick coal with a similar roof from Sullivan County to the Ohio River, so it was called Coal V. It is quite clear now that it comes stratigraphically about 300 feet below Coal V of Sullivan County. As this coal occurs in basins in the same way that the block coals do, the thicknesses given are from measurements taken in the basins and indicate in most cases more nearly the maximum than the minimum of thickness. From the sections given, which might have been multiplied many times, it is evident that this coal is of a good workable thickness at many points in Warren, Fountain and Parke counties. Four feet is a common thickness in the basins, and 6 feet is reached occasionally, as at Mecca. Where it has been explored by drilling, its basins appear to lie in west of north and east of south directions, having a good length and maintaining a good thickness in that direction, and thinning rapidly toward the edges of the basins in an east and west direction. The roof frequently is a black shale, but not necessarily a sheety shale, and often is a gray shale. The history of these beds from the laying down of the coal to the laying down of the limestone apparently has been quite different from that of those following the laying down of Coal V. In some cases the limestone comes down and makes the roof. There is frequently bone coal associated with this coal, and in many cases in Daviess County and farther south the presence of bone coal or of Cannel coal has been made much of, as an evidence of the correlation of those coals with the Minshall coal of Parke County. In a number of cases the first coal above the Minshall coal, which usually is 10 to 20 feet or more above, comes down close to the lower coal, the limestone and other intermediate strata having pinched out, and the underclay of the upper coal makes the roof of the lower bed. In several such cases the "white top" roof of the lower bed has fallen in, and it has been found that the overlying bed was thick enough at that point to work, and some work has been done upon it. This upper bed, which has been designated Coal II, is often of workable thickness in its own right. In Warren County this coal has a thickness of from 2½ to 3½ feet. It is usually cut into benches by partings. This coal was called Coal VI in a former report and thought to correlate with what is now called Coal III. It would appear to reach a workable thickness locally at many points in the northern counties, though the fact that it is so close above the Minshall coal, which is usually thicker, and will usually be worked first, may render much of it unminable.
The limestone which overlies the Minshall coal is quite variable, often changing from a thickness of 10 or 20 feet to nothing in comparatively few rods. In places the roof of this coal changes from a black shale to limestone or even sandstone, as on Sand Creek.

Minshall coal is commercially worked at Mecca, Sand Creek, Minshall, Fontanet and north of Williamstown, and has been worked at other places. South of the Vandalia Railroad it is less conspicuous, the limestone is more frequently absent, and the coal as a rule appears to be thinner. It is thought that it may have been this coal that was worked at the old Markland shaft near Clay City. Neither of these coals are conspicuous across Greene County. It is correlated as the surface coal mined west of Switz City, where it runs from 2½ to 3 feet in thickness. The coal is characterized by having a black shale roof. About Newbury is a coal from 2 to 3 feet thick that has been correlated as the Minshall coal. It also has a black shale roof and shale floor. The Raglesville coal has been assumed to be at this horizon, as has also the cannel coal at Cannelton. At Raglesville the coal is almost always associated with bone coal, coming at the top, the middle, the bottom, as the case may be. The good coal will usually yield a total thickness of about 3 feet, though in some cases the bone coal encroaches upon the good coal until the bed is not workable. Near Burns City what is thought to be the same bed has only 1 foot or so of good cannel coal at the bottom, and from that grades imperceptibly up into a bone coal, and on up into gray shale. At Cannelton this bed consists of from 1 to 2 feet of bituminous coal overlain by from 2 to 4 feet of cannel coal. The fact that the cannel coal has been successfully and continuously mined here for a great many years is sufficient evidence that the coal is of high enough grade to meet the demands of the market.

In the southeastern part of Daviess County, on Sugar Creek, is found a coal closely overlain by limestone, which is placed at this horizon. The coal runs from 2 to 3 feet in thickness without partings. The roof varies from shale to clay, limestone and sandstone within short distances. South of White River apparently the same coal that is found on Sugar Creek has been opened at a large number of places in northern Dubois County. At most of these places it has a thickness of from 3 feet to 3½ feet. At Jasper is a coal of workable thickness, overlain by limestone that may come at this horizon, though it is not quite certain that it does not come at a somewhat lower horizon. From this point southward this coal has
been called the Holland coal, and reaches a workable thickness at a number of points around Holland, Lincoln City, Buffaloville and Newtonville. At most of these points the coal is without partings, but in a few of them shows a single parting, ranging in some cases up to 2 feet, though in most cases only an inch or two. At Jasper there is a workable coal which comes a short distance above the coal overlain by limestone. If the limestone coal is the Holland coal, corresponding approximately to the Minshall coal in position, then the overlying workable coal belongs at the horizon of Coal II. In that region it has a thickness of from 2 1/2 feet to 4 1/2 feet. It is usually a solid coal with either a shale or sandstone roof. If the limestone coal comes at the lower horizon, then the coal just described probably corresponds more nearly with the stratigraphic position of the Upper Block coal.

*Upper Block Coal.*—The Upper Block coal appears to be absent in the north end of the State. If the coal on Coal Creek in western Fountain County is correctly correlated, then it appears there in considerable force, having a thickness in places of 6 feet, usually with a small parting. It appears to also be workable near Veedersburg, and near the south edge of Fountain County. It is seen on Sand Creek, where it locally reaches a workable thickness. Its type development, however, is in Clay and southern Parke counties, extending from only a few miles north of the Clay County line practically all the way through Clay County. It is this coal that has largely been responsible for the reputation of the Indiana Block coal, though the Lower Block coal is reputed to often show a little higher quality, but as the Lower Block coal is somewhat thinner, most of the mining in the past has been upon the upper bed. The coal will have in that district an average thickness of but little over 3 feet, though it often reaches a thickness of 5 feet in the center of a basin. Coal occurs strictly in basins, which may range in area from a few acres up to many square miles. Between the basins it thins down to a few inches. It is all through this district characterized by a bench mining, a little below the middle usually, which consists of about 2 inches of hard, brittle coal that before the use of powder was generally used to mine in. The roof is either shale or sandstone. The Upper Block coal is distinguished from the Lower Block among other things by the fact that the jointing, from which it takes its "block" name, is more open at the top than at the bottom. In many of the mines the jointing or slips, as they are called by the miners, are not pronounced below the bench mining. The Upper Block coal maintains a thickness of 4
feet in the basins over most of the southern part of Clay County, especially east of Clay City and that portion of Owen County immediately east of that.

It is supposed to be the Upper Block coal that outcrops in the bluffs west of White River, where it runs from 2 to 3½ feet thick, usually solid, though sometimes split up. The roof is shale or sandstone and the floor fire-clay. Through Daviess and Martin counties the coal assigned arbitrarily to this horizon is a thin coal only 2 to 2½ feet in thickness, with a sandstone roof, outcropping along the western edge of Martin County. In southeastern Daviess County three coals occur below the Sugar Creek coal, which lies under the limestone. It is quite likely that none of these coals correlate exactly with the coals of the Brazil district, or that if they do, the lowest coal here may be the representative of the Lower Block coal of Brazil, the next coal above, the Upper Block coal of Brazil and the coal under the limestone, the Minshall coal, as previously assumed, or, again, it may be that the coal at the bottom of the shaft at Alfordsville is the same as the Sampson Hill coal in eastern Martin County. As there is some possibility that the Sampson Hill coal is at a lower horizon than the Alfordsville coal, the latter will be discussed under the head of Upper Block coal, and the Sampson Hill coal under Lower Block coal. The Alfordsville shaft coal is found at several points in southeastern Daviess County. It runs from 3 to 4 feet in thickness, usually solid, but sometimes with a little bony coal below the good coal.

In Dubois County a coal running from 3 to 4 feet thick, with a shale or sandstone roof, is found at several points southwest of Jasper and in the northwestern part of T. 2 S., R. 5 W.

Farther south, in Spencer County, the first coal below the limestone coal at many points shows a thickness of from 2 to 3 feet, or even more. This is always a solid coal, with a shale or sandstone roof. At most points it is hardly thick enough to be workable under present conditions. Purely on the basis of the interval, the 5-foot coal being mined at the Keystone mine at Henderson, Ky., is supposed to come about at this horizon.

Lower Block Coal.—This coal does not seem to be present in the northern part of the coal field. A coal found at several points in Fountain County may belong at this horizon, as at Veedersburg, and at a few other points even farther north. If at this point the coal has been correctly correlated, the Lower Block coal has a thickness of 4 feet or over. In the Sugar Creek region of Parke County many coals are found which it has not been possible to
correlate, and it is more than probable that some of the easternmost of these belong at the horizon of the Lower Block coal.

As typically developed, however, the Lower Block coal can first be definitely recognized only in southern Parke County. From there it can be traced without difficulty to the south edge of Clay County, or possibly over into Greene County. It presents certain peculiarities that distinguish it at once from the Upper Block or other coals. The coal has an average thickness of 3 feet in the basins, as far as mined, running up to 5 feet as a maximum. Of this thickness the uppermost 6 inches to 10 inches is a bituminous coal; the rest is a block coal. The block slips of the Lower Block coal are more open at the bottom than at the top, seldom, if ever, entering the little bituminous bench at the top, in contrast to the Upper Block coal, where the slips are more open at the top. Below this coal in the center of the basins is commonly found a bench of bone coal, which may run from 0 up to 2½ feet in thickness, and below that still is a bench of soft coal running from 0 up to 2 feet in thickness. In some cases the bone coal comes immediately below the main bench of good coal. In most cases, however, the benches of bone and the thin good coal are separated from the coal being mined by from 6 inches to 2 feet of clay. In some cases the little bottom bench of good coal is absent. These two underlying benches are found only in the basins and tend to run out as soon as the coal goes to the rise in going from one basin to another.

This coal tends to hold its thickness into southern Clay County, but in going eastward into Owen County increases in thickness, until at many points around Lancaster it is 6 feet thick. Whether this greater thickness is due to the bone coal having turned into good coal to the eastward or not, is not known. South of Clay County the Lower Block coal is known to have a good thickness at Howesville, where it is up to 4 feet or more over quite a district. East of White River its thickness is from 2½ to 5 feet, though it probably will not average above 3 feet. The writer does not know whether any of the characteristic features which it shows in Clay County persist into this Greene County area.

In Martin County, under this head, will be described the coal east of Boggs Creek, as far south of White River, and east of White River south of the B. & O. S-W. R. R. The coal occupies only a small area in the long ridge between Boggs Creek and Indian Creek. It very frequently has one or more benches of bone coal, sometimes at the bottom, but nearly as often at the top. It shows a thickness
of 3 feet at many points, but it is doubtful if it will average that thick through the ridge. South of Shoals there is an area of it in Sampson Hill, where it is known as the Sampson Hill coal. It shows a thickness of 3 feet or over at many of these openings. At many points there is associated with it a bench of bony coal, which in some cases may so encroach on the good coal as to render the whole bed unworkable. South from Sampson Hill it is found in a few hills, where it shows a thickness ranging from 2 feet to nearly 5 feet. In these cases it is a solid coal, with a shale or sandstone roof.

In Dubois County the coal mined in the shaft at Huntingburg has been correlated as at this horizon. The correlation is purely suggestive and mainly made for the purposes of discussion. At Huntingburg this coal has a thickness of 4½ feet, with a shale roof and a shale floor. A coal supposed to be at the same horizon has been opened at several points north of Huntingburg, also up the rise to the east. The coal at most of these places has a thickness of from 3 to 4 feet. In Spencer and Perry counties this coal was correlated as the first coal above the Cannelton coal. In that district as a rule it is quite thin, having a thickness of usually not more than from 6 inches to 2 feet. Its correlation with the Huntingburg shaft coal is far from certain.

_Cannelton-Shoals Coal._—All along the eastern edge of the coal field below the massive sandstone that has been called the Mansfield sandstone, is commonly found a thin coal bed. In going southward it seems quite possible that this sandstone increases in thickness, or what is more likely, that older underlying sandstones set in, so that by the time Martin County is reached the first sandstone above the lower Carboniferous limestones is a somewhat older sandstone than the sandstones north of Brazil. It has therefore been questioned whether the Shoals coal will not ultimately be found to belong to an older and lower horizon. The lowest coal at Shoals, coming there usually but a few feet above the lower Carboniferous limestone, with its characteristic fossils, reaches a workable thickness at several points. Its maximum is probably less than 4 feet, though it has a thickness of 3 feet at several places. It was at one time mined commercially near Shoals. This coal usually has associated with it quite a little bone coal, coming sometimes at the bottom, sometimes at the top and occasionally in the middle. The roof is shale often, though sometimes it is composed of a mass of conglomerate sandstone, which here has a thickness of from 50 to 70 feet or more.
This coal has arbitrarily been assumed to belong about at the horizon of the Cannelton coal, though its exact correlations have yet to be demonstrated.

The Cannelton coal is typically developed at Cannelton on the Ohio River. Here it has a thickness of from $3\frac{1}{2}$ feet or possibly 4 feet down to 0. The basin character of the coal is very clearly seen at Cannelton, as the coal has been mined here for three-quarters of a century and can be seen running out to 0 in the entries. This coal usually has under it a bench of bone coal or in places it may have one or more benches of cannel coal. In places all of these can be seen to run out. Going toward Troy, over a small area the coal is split into two benches by a parting of clay, which may become as much as a foot thick. At Troy it has again a good thickness, though broken up with two partings. It is found at several points along Anderson River as far north as St. Meinrad, and at these points shows a thickness of from 2 to 4 feet. Sometimes it is solid; more often it has one or two partings. The roof is usually shale.
CHAPTER V.

DISTRIBUTION OF COAL IN INDIANA BY COUNTIES.

Warren County.—It must be remembered that nearly all of the counties lying in the Indiana coal field have been more or less deeply covered in drift. This is more particularly true of the area north of the Vandalia Railroad, running from Indianapolis to Terre Haute. Apparently the deposits also increase in thickness in going northward, so that Warren County is more deeply overlain than Fountain County, and Fountain County more so than Parke. South of the Vandalia Railroad the deposits are thinner and more nearly of a uniform thickness down to the line marking the edge of the ice lobe. It therefore follows, as a matter of fact, that the underlying coal measure deposits are less and less exposed going northward, until in Warren County they are hardly exposed at all, except along the valley of the Wabash River and the lower courses of some of the streams.

As nearly as can be worked out, under these conditions, Warren County is underlain by Division II and the Minshall coal and the Mansfield sandstone. This last part of the Coal Measures outcrops east of Pine Creek and along Wabash River from Williamsport nearly down to Covington. As shown on the map, it occupies about half of the portion of the county east of Pine Creek. As nearly as can be worked out, it lies between two nonconformities, lying unconformably on the lower Carboniferous below and being overlain unconformably by the block coals of Brazil. The rocks underlying this division consist of the lower part of the lower Carboniferous, or Knobstone formation of the Indiana reports, probably equivalent to the Waverly of Ohio. As the limestones of the upper part of the lower Carboniferous are not found in this section, somewhat greater difficulty is experienced in differentiating the sandstone of Division I from the underlying sandstones. Underlying the Mansfield sandstone at a few points there is found from a few inches to a foot of coal, nowhere workable, however, and probably never to be found of workable thickness. The block coals of Brazil are represented in this county apparently only by the Minshall coal. This was designated Coal V in the old report. This is found at a number of places west of Wabash River from Williamsport southwestward to opposite Covington. It is characteristically developed, with its overlying black shale and-
limestone, and at many points shows a workable thickness of from 3 to 4 feet—sometimes a little more. It will doubtless prove to be in limited basins, much as it is known to occur southward, so that while it theoretically should underlie all of the county west of its outcrop, except where it may have been removed by pre-glacial erosion, still its basin character will probably mean that not more than one-fourth of that area ever contained coal of workable thickness, as now interpreted. Overlying this coal by usually only a few feet is Coal II. It was designated in the old report Coal VI, but is now known not to correlate with what was called Coal VI of Parke County, and to lie, of course, much lower below the Coal VI of Sullivan County. This coal has a thickness of 3 or 3½ feet in many parts of the area, and will occupy about the same territory as the Minshall coal. It is, however, somewhat thinner, and in many sections is more or less broken up by partings, so that it probably will not have the future value that the Minshall coal will show in this county. From the character of the outcrops too little is known of the dip in this county to warrant the assertion that any of the higher workable coals may be found under the mantle of glacial deposits in the western edge of the county. Should future development show that there is a dip corresponding somewhat nearly with the normal dip farther south, Coal II and possibly Coal IV may be found underlying the portion of the county near the State line. It is quite probable that the thin coals overlying Coal II in Division II are present in places in the western part of the county, and in some cases may be of workable thickness. With the present lack of development it is little more than guesswork to judge of the coal resources of the area away from the outcrop.

Fountain County.—Fountain County, lying southeastward from Warren County, across Wabash River, presents much the same conditions as are found in the preceding county, except that the drift is probably not as thick, and somewhat better exposures have been made of the coals. Practically the same divisions and coals exist in Fountain County as in Warren, except that it seems that at least one of the block coals is known to set in before the south edge of the county is reached, and it may underlie nearly or quite all of the county. The basal sandstone of Division I outcrops over a belt from 2 to 10 miles wide in the eastern half of the county, while the coals of the Brazil division and Division II, cover nearly all of the western half of the county. There are a few outcrops of the coal underlying the sandstone of Division I in this county, though none of them appear to show coal of workable thickness.
COALS OF FOUNTAIN COUNTY.

Some openings have been made upon these coals to test their thickness and character, and in a few cases a little digging has been done, but as far as known nothing of workable thickness has yet been developed. In the Brazil division the Minshall coal and probably the upper Block coal reached, in many places, an excellent thickness, and have been mined commercially, and on a small scale, and in a number of places. A selected series of sections of the Minshall coal are well shown on Plate III, also of the Upper Block coal. The latter coal appears to be of workable thickness around Veedersburg and to the northward on Sugar Mill Creek, southwest of Wallace, near the county line, around Snoddy’s Mills and Coal Creek P. O., and around Silverwood. The Minshall coal shows a good thickness around Yeddo, at Silverwood, and on Silver Island to the westward, and locally around Snoddy’s Mills, as well as at other places scattered over the county. The correlation of the coals in this county is not above question, but is based on the assumption that the lowermost coal overlain with the limestone and black shale belongs in all cases in the horizon of the Minshall coal. Such a limestone underlain by a coal is met with at many points in the county, and its correlation is based simply on the assumption that there is only one limestone at about this position. Other thin limestones are known to occur over some of the higher coals of Division 2 in this county, as elsewhere, but the coals underlying them are usually quite thin and the limestones are usually a foot or less in thickness. The coals in this county doubtless all lie in limited basins, as the same coals do elsewhere, those basins probably having longer axes in a north and south direction. It will therefore require a large amount of close drilling to determine the areas of workable coal, not only on account of the basin character of the coals as originally deposited, but also because of their removal by the pre-glacial erosion, or because of their lack of roof where not removed. With the interpretation of the structure as made, the dip across this county is very slight. Not enough accurate determinations are at hand to show the amount of dip, but simply judging from the appearance of supposedly the same coals at nearly the same position with reference to drainage, the dip must be but a few feet to the mile. Probably detailed paleontologic studies will be required to determine accurately whether these coals have been correctly tied together. It would seem that the county ought in the future to be found to possess a large amount of workable coal, as the coals where known often present thicknesses of 5 or 6 feet.
Parke County.—Entering Parke County, which lies south of Fountain, much more is known of the coals, which are exposed at a much larger number of points, and have been commercially developed in many basins. The northern half of the county continues the conditions found in Fountain County, with a narrow border of sandstone along the eastern edge of the county, extending over into Montgomery County, which sandstone is underlain at a few points by thin coal, seldom over a foot thick. West of that belt, along Sugar Creek and Sugar Mill Creek, are many outcroppings of coal, which have been correlated with great difficulty or not at all. In a few cases coal overlain with limestone has been assumed to be the Minshall coal, or the Coal V of the old report. Along Sugar Mill Creek, west of Grange Corners, a coal correlated as the Upper Block coal has a good minable thickness. South of this, along Sugar Creek, are a large number of openings on coals, ranging from 1 to 3 and occasionally 4 feet in thickness, but these coals appear to be pockety and to show little resemblance from one point to another. In a general way they would appear to be at the horizon of the Upper Block coal. Possibly some of them are at the horizon of the Lower Block coal, and toward the west coal overlain with limestone is assumed to be at the horizon of the Minshall coal. Coal II doubtless outcrops in this northwestern part of the county, but its definite recognition has been doubtful. South of the Indianapolis, Decatur & Western Railroad conditions are such that the coals are better known, and in the southwestern part of the county for the first time it becomes possible to trace the coals with a high degree of accuracy. In this part of the county the lower sandstone of Division I appears to have a low dip and to outcrop across a broad belt ten or more miles wide.

In Washington Township is found the Sand Creek mining district, where the Minshall coal, overlain by its limestone, has long been worked. This coal lies a short distance above drainage on Sand Creek, but will underlie the level of most of the township. The Upper Block coal is noted at a few points in this district, lying in marked basins, the interval from that coal up to the Minshall coal varying rapidly within a few feet. The Minshall coal in this district has a thickness of from 3 to 4½ feet, the limestone in some cases making the roof, in other cases the roof being of shale, overlain with sandstone. Coal IV has a thickness of about 1 foot as a maximum, thinning out to 0 within short distances. It is overlain by shale. The two coals are here about 18 feet apart. Somewhat similar conditions exist in Adams Township, the Minshall coal be-
COALS OF PARKE COUNTY. 121

ing workable on Sand Creek in sections 3 and 4, and along Williams Creek, east and southeast from Rockville, where this coal has a thickness of from 2½ to over 4½ feet. One of the block coals outcrops in the eastern part of the township, especially on Strongers Branch in sections 35 and 36. Raccoon Township is the type locality for the Minshall coal. The upper Minshall coal is above drainage near the old Minshall mines, while the lower Minshall is only a short distance below drainage. The limestone between the two coals outcrops in the stream bottom. In the S. E. ¼ of this township and in the S. W. ¼ of Jackson Township are extensively mined the Minshall and the two block coals, the coals at this point being only an extension of the Brazil Block coal field. Mining here is principally upon the Upper and Lower Block coals. In the southwest corner of Jackson Township the two coals occur in small basins, each having a thickness of 5 feet or more in the center of the basins, and thinning rapidly toward the edge. They are above the level of Otter Creek in sections 31 and 32, but descend below drainage in going westward into Raccoon Township. They are extensively mined by shafts in the region of Caseyville, the shafts frequently finding all three coals.

In the southwest part of the county, in Florida and Wabash townships, Coal III has been extensively worked, occurring above drainage level on either side of Raccoon Creek. It has its regular large development around Rosedale and Coxville, but northward from that point decreases in thickness, so that on the line between Florida and Wabash it usually is not more than 3 feet thick and becomes variable in its development, sometimes being 3 or 4 feet thick at one point and disappearing entirely 100 feet away. It appears locally at points from this northward to Rocky Run, near the mouth of which it was seen to vary from 4½ feet to 0 in the space of 50 feet. At most points in this interval no coal appeared at this horizon. The position of the coal can be readily traced because of the relation to the little rider coal and a number of persistent strata that overlie the rider. The southwestward dip carries it below drainage rapidly, so that it probably passes below the Wabash River in the southwest corner of Wabash Township, and is some distance below in western Florida Township, where it has been extensively worked at Lyford. Coal IV has been opened at a few points in Florida Township and in the south edge of Wabash Township. At most points, however, it is a rather thin coal and has not been mined on extensively. It is below drainage on the western side of Florida Township. Coal V occupies a small area in the
western half of Florida Township, outerropping well above drain-
age at Lyford.

Vermillion County.—Little is known of the coals of the north-
ern end of Vermillion County. Some coals outcrop around Perrys-
ville, and a few coals have been met with in drillings at points west
of that. Coming southward, the first coal of any importance ap-
ppears to be on Coal Branch of Big Vermillion, near Cromerville.
Here what is now considered to be the Minshall coal has a consid-
erable development, being, however, badly split up with partings,
but as the individual benches in several cases are 3 feet or more
in thickness it may be considered a workable coal. Limestone ap-
ppears a short distance above it, and largely on that basis it has been
referred to the horizon of the Minshall coal. It is just above drain-
age on Coal Creek, and appears again at the Hanging Rock of Ver-
million River, and again a short distance above Eugene, where it
has been worked on both sides of the river, but shows a much smaller
thickness. In most of this district it has a main parting, ranging
from 10 inches to 4 feet, while the upper bench also usually shows
a thin parting of an inch or less. What is taken to be the same
coal is mined southwest of Cayuga at the clay plant at a depth of
about 80 feet. It is then carried below drainage and does not ap-
ppear again in the county except as it is met with in drillings around
Hillsdale and a few other points. On the Little Vermillion River,
at the Horseshoe, there appear two coals, the lower of which has
been assumed to be Coal IV and the upper IVa, both being of
workable thickness. Coming down Little Vermillion River to the
mouth of Jonathan Creek a coal rises above drainage that is be-
lieved to be the rider of Coal III. These three coals are found
at many points along the bluff on the Wabash River south of New-
port, Coal IV being of a workable thickness through most of that
district, and having been opened upon at many points. Coal IVa
was not noted in this section. The fire clay below the rider of Coal
III coming between it and the horizon of Coal III, near West
Montezuma becomes very refractory and has been extensively quar-
rried and mined in that region. South of Hillsdale traces of Coal
III begin to appear, in some places several feet of coal showing.
West of Hillsdale Coal V is believed to have entered the State,
and to have been reached by a shaft at Dana and Illiana. The coals
are practically all hidden from Hillsdale to Norton Creek. Here
Coal V outcrops a short distance above creek level and has been
drifted upon. Coal III has also been found about 175 feet lower.
Around Clinton Coal V outcrops above the level of the bottoms and
Coal measures outcrop only in the western part of these counties, the outcrop in the main consisting of the Mansfield sandstone. Under this sandstone thin coals are found at many places, usually, however, less than a foot in thickness. The Lower Block coal is caught by some of the higher ridges and points in Putnam County south of Putnamville, and northeast of the mouth of Mill Creek, also around West Union and west of Eel River in the southwest part of the county.

In Owen County a large area of the block coals occur in Lafayette, Marion and Jefferson townships. The block coals in these townships, however, are usually quite close to the surface and will not be workable in many places for lack of roof. They are usually found only in the uplands, though approaching drainage along the western edge of the county. These coals show a good development around Lancaster or Patricksburg, around Woodside, where they have been extensively mined, and to a less extent around Coal City. While underlying considerable areas around the western edge of the county, in going eastward they occur nearer and nearer the tops of the hills until finally they occupy only the narrow crests of the ridges or divides, in most cases occupying too small areas to pay for commercial working.

Clay County.—The block coals are at or below drainage through all the eastern part of Clay County, while along the western edge of the county Coal III will be found, and in a few places Coal IV, while in the southwest corner Coal V outcrops. The block coals are extensively developed in Van Buren, Jackson, Sugar Ridge and Harrison townships. As a rule, in this district they occur in very small basins and at depths of usually less than 100 feet. The coal in this area has now been very nearly worked out. In some cases the Upper Block coal was worked out many years ago. The Lower Block coal being somewhat thinner and harder, was left and has been worked out at a more recent date. It had at one time been supposed that in going westward to below the outcrop of Coal III the block coals would not be found of workable thickness. Later evidence leads to the conclusion that the block coals will be found in basins under much of the outcrop of Coal III. How far to the westward into Vigo County they will be found in workable basins cannot be stated at this time, though the evidence exists that such
basins may be found in places under all of Vigo County. In most of the townships first mentioned the Minshall coal is of relatively little importance and has been mined at only a few points. Going westward, the Minshall coal gains in importance, and is now being mined north of Williamstown, and in a small way at several other places. Coal III just reaches to the western edge of the county at the northwest, in Dick Johnson Township. South of that it covers the major portion of Posey, Perry, Harrison and Lewis townships, in the last two townships occurring only west of Eel River, except for an outlier in the hills south of Clay City. Over most of this region it is quite close to the surface, generally being found at less than 100 feet in depth. It is, however, finely developed, showing a fairly regular thickness of 6 feet or more, though almost always somewhat broken up by partings. In some cases these partings will detract seriously from its workability. The roof is usually a clay shale overlain by an interval of from a few feet to 15 or 20 feet of sandstone. This sandstone frequently comes down, making the roof, and cutting more or less into the coal. Coal IV probably occupies a narrow area in the western part of Posey and Perry counties, in the southwest corner of Harrison, and most of Lewis Township west of Eel River. To the northward it appears to have only a nominal thickness, more often under 3 feet than over, but in the southwest corner of the region it begins to attain the fine thickness which it has all through the Linton district to the southward.

**Vigo County.**—Vigo County is believed to be entirely underlain by the block coals, at a moderate depth on the eastern edge, at a considerable depth on the western edge. They have all been demonstrated to be of workable thickness and character near Fontanet, where both the Minshall and Lower Block coals are being worked, and it is presumed that future prospecting will develop much workable coal at these horizons. Coal III underlies practically the whole of the county, except a small area near Foleyville. It is just about at drainage level in the northeast corner of the county, but will be below drainage everywhere else. Coal IV is not found in the northeast corner of the county, but occurs at drainage level around Grant and Seelyville, and probably is not far from drainage level in the southeast corner of the county. It is being mined commercially southwest from Seelyville and northwest of Terre Haute. Drillings seem to have demonstrated that while this bed is quite persistent, it is apt to be split with partings, so that the areas within which it is workable will be more or less limited. It will
probably appear, however, that it will be found to present a workable thickness under a large share of the county. Coal V is above the hilltops all through the northeastern part of the county, but comes down to drainage level at Durkee's Ferry, in the region east of Terre Haute, around Riley and the headwaters of Splunge Creek, and around Lewis P. O. From this line it is below drainage to the westward. It should underlie all of the county west of the Wabash River and west of a line drawn from Terre Haute to Lewis. What its condition may be in the southwestern part of the county has not yet been determined. From a general knowledge of its persistence it may be predicted, however, to maintain a good workable thickness over nearly all of that territory. It is thin around Lewis and probably will not be workable in some of that district.

Coal VII outcrops above drainage west of the Wabash River as far as Terre Haute. It outcrops at numerous points on Coal Creek, reaching the level of the bottoms near the north edge of Sugar Creek Township, and reaches about the level of the river at Terre Haute. It will, however, underlie all of the region west of a line from Terre Haute to Farmersburg, and extend an irregular distance to the eastward of that line, outcropping in the headwaters of Honey Creek and Busseron Creek. All of the coals in the county will be at a considerable depth in the southwest part.

Greene County.—All of the coals outcrop in Greene County, Coal VII, however, barely overlapping the western edge of the county near Dugger, and possibly at one or two points south of that. East of the west fork of White River the block coals and the coals below the Mansfield sandstone are nearly everywhere above drainage. The Mansfield sandstone outcrops through nearly all of the ridges in the eastern half of the county, the rise of the ridges to the eastward from the river just about keeping pace with the rise of the rocks, so that the Mansfield sandstone forms the crest of most of the divides all through the eastern townships. The coals above the Mansfield sandstone outcrop in the tops of the ridges in Richland, Taylor, and western Jackson townships. They occupy, however, very narrow belts, except in parts of Taylor township. In Cass Township the dip has carried them below drainage. A broad belt runs through these townships, following White River, in which are broad prairies, deeply filled with alluvial matter dating from the Glacial period. This belt is pierced by a ridge running out from Swiss City toward Bloomfield and Plummer. The block coals are believed to outcrop around the base of the bluffs on the west side of White River, from which point the dip carries them rapidly.
below drainage to the westward. The limestone over the Minshall coal does not seem to be typically developed in this county, and that coal has not been very definitely recognized. The western townships, Wright, Stockton and Stafford, are almost entirely underlain by coals III and IV, Coal V underlying the major part of the west half of those townships, and Coal VI is found over a small area within the western margin of the county. The depth to coals III, IV and V in this county is usually small, generally not over 200 feet.

Sullivan County.—The block coals probably underlie Sullivan County at considerable depth, not outcropping at any point in the county, and it is possible that in the future they may yield a considerable volume of workable coal. The lowest coal outcropping in the county is probably Coal V, which is just at drainage level along the eastern edge of the county, from the northeast corner almost all over the district to the southeast corner. Coal VI outcrops a short distance to the west of that, in many cases the two coals outcropping within distances of half a mile or less. Coal VII is found west of Busseron Creek in Jackson Township, but to the south of that extends nearly to the eastern border of the county. Going westward, all of these coals dip rapidly, and along the E. & T. H. R. R. Coal VI is usually more than 200 feet deep, Coal VII being at a somewhat slighter depth, and the lower coals at still greater depths. It is believed that all of these coals are below drainage along the Wabash River on the west side of the county. A coal correlated as Coal VIII appears to have a workable thickness in some parts of the western half of the county, showing such a thickness at Merom, along Turmans Creek, and in a few of the drillings.

Martin County.—Only the lowest part of the coal measures occur in this county. The lowest coal, here called the Shoals coal, is above drainage through most of the eastern half of the county. A series of faults at and west of Shoals brings it above drainage at several points in the western part of the county. It is also above drainage through much of the upper valley of Boggs Creek, west of Huff Station and to the southward. In the old report it was thought to keep above drainage or at least not to go but little, if any, below drainage along the whole length of White River down to where it meets the Orange County line. The writer is now inclined, however, to consider the coal at Trippy’s, at Mount Pleasant, a somewhat higher coal. In like manner the coal at drainage level north of Bramble P. O. he is considering a higher coal. Above this coal several coals outcrop in the ridge between Boggs Creek and
Indian Creek. One of these coals outcrops at a number of points just at the top of the ridge. The coal that was described under the heading of the Lower Block coal occurs somewhat lower in the ridge. It underlies a small area southeast of Shoals in what is known as the Sampson Hill district; also a small area in the top of the ridge south of Lost River at Rusk P. O., and in the high ridge just south of that. West of Boggs Creek it is assumed that the dip will bring this coal down to drainage level along the western edge of the county. South of Loogootee it is assumed to be this coal that is found near Mount Pleasant and in the streams a little west of White River, in the southern half of T. 2 N., R. 4 W., and the northern half of T. 1 N., R. 4 W. It is thought that the Upper Block coal is the coal that is mined at many points along the southwestern edge of the county.

Daviess County.—As already described, it has been assumed that the coal along the eastern edge of Daviess County is, in a general way, about at the horizon of the Upper Block coal. This coal is found in the shaft at Alfordsville, and, it is assumed, passes below drainage of Prairie Creek east of Raglesville. It is assumed to be this coal that has been found at several points along Furse Creek in the northern part of Madison Township. At Raglesville the Raglesville coal, which has been assumed to come about at the position of the Minshall coal, is about 30 feet above Prairie Creek, east of town, but the dip to the southwest carries it down to drainage level a short distance southwest of town. It is assumed that it passes below drainage level, so that the coals that have been opened in Section 7 west of Raglesville belong at a higher horizon. They have been assumed to be the equivalent of Coal III. Were the dip to continue those coals in turn would be carried below the eastern outcrop of the coal mined around Epsom. That coal is high in the hills east of Epsom, but dips rapidly to the westward, and must pass below Prairie Creek a little west of south from Epsom. Through the center of the county it is thought that the coal in the shaft at Cannelburg may be the same as that outcropping on the upland around Loogootee. The surface bed at Cannelburg, it is assumed, passes below drainage in a short distance to the west, and that the Montgomery coal outcrops east of Montgomery. The Montgomery coal dips rapidly westward from its outcrop to just west of Montgomery and then rises slowly to the westward, probably to beyond Black Oak. Approaching Washington, there are some high hills that catch Coal V, and the dip east of town is sharp to the westward so that the coal rapidly passes below drainage, Coal
VII being just above White River at the west edge of the county.
In the south part of the county the Sugar Creek coal outcrops at
many points just above the level of Sugar Creek. This coal passes
below the level of White River, probably not far from High Rock.
On top of the High Rock is abundantly scattered the white flint
that is supposed to belong just above the equivalent of Coal IIIa.
This dips rapidly to the westward and is only a few feet above Mud
Creek, east of Hudsonville and Glendale. It probably makes the
"Rock Eddy" west of Hudsonville on White River. The Mont­
gomery coal is in the upland around Hudsonville and Glendale, but
passes down to drainage level in a mile or two to the westward.
Coal V is just at river level at the Murry mine on the west fork of
White River southwest of Washington.

Knox County.—All of the coals underlie nearly all of Knox
County. Coal V is just at river level at Edwardsport and Murry
Station. It is above river level at the mouth of the west fork of
White River, and on White River above Edwardsport. At Appraw
Ford, Coal VII is down to the level of low water of White River,
indicating a broad syncline from east to west in the center of
the county on the eastern edge. The northeast corner of the county
has the coals below Coal V outcropping, so that Coal V is wanting
in that part of the county. Coal VI outcrops, with an irregular
line, through the eastern half of R. 8 W. Coal VII outcrops a
short distance west of Coal VI. By the time the middle of R. 8 W.
is reached all of the workable coals are under cover. From there
westward the dip carries the coals down until at Vincennes Coal
VI is only 35 feet above tide, or at a depth of about 400 feet, and
the other coals will occupy correspondingly greater depths except
Coal VII, which is there 18 feet above Coal VI.

Orange and Crawford Counties.—The coal measures outcrop in
the western half or more of these counties, but are confined to the
ridge tops, except toward the western edge, when they get down
nearly to drainage level. Over most of the area covered by the coal
measures only the basal sandstone and its underlying coal is found.
Along the high ridge followed by the Southern Railroad from
Birdseye to east of Tazewell, and also on the crest of the high ridge
in the southwest corner of Crawford County, it is thought that the
Cannelton coal occurs.

Dubois County.—The bottom of the coal measures is above
derainage in the northeastern part of Dubois County, and above
Anderson River in the southeast corner. The Cannelton coal oc­
curs in the tops of the ridges in the eastern part of the county, but
is supposed to pass down to drainage level in the neighborhood of St. Anthony, on Flat Creek, and to the southwest of Kellersville on White River. The Huntingburg shaft coal comes into the hills around Bretzville and under the high ridge around Ferdinand, and reaches drainage level on Patoka River a little west of north of Huntingburg. It is 40 feet deep at Huntingburg, and outcrops at many points between there and Jasper. The coal just southeast of Jasper is placed at this horizon. In the high ridge around Ferdinand the coal overlain by a limestone is thought to be the coal below the Holland coal. It is supposed to be the same limestone that outcrops in a road cut just east of Huntingburg, and in the fields southeast of Jasper at a somewhat higher elevation than the coal there previously mentioned. The Holland coal is in the top of the ridge at Kellersburg, probably more than 200 feet above White River. Going westward to Haysville and Portersville, it gradually descends until it reaches drainage level on Beech Creek, west of Portersville. What is considered to be this coal outcrops high in the ridge north of Jasper, with the Upper Minshall coal outcropping above it. The exact position of this coal in the ridge north of Duff is still in question. There is a coal there overlain by a limestone and chert, but there is some doubt as to whether this is at the horizon of the Holland coal or at the horizon of the Velpen coal. The Holland coal is at drainage level west of Patoka River in Section 10 east of Velpen and along Rock Creek, southeast of Pikeville. It is above the level of Sugar Tree Fork, just west and southwest of Holland. From there it rises to the east until it has an elevation of 520 feet above tide west of Ferdinand Station. The Rock Creek coal is found in the tops of the ridges along the west edge of the county, south of Patoka River.

_Pike County._—The Holland coal is just about at river level on White River in the northeast corner of the county, on Patoka at the east-central edge of the county, and on Pokeberry Creek in the southeast corner of the county. The Rock Creek coal is in the hills and uplands along the eastern edge of the county. Going westward, this coal is carried rapidly downward, and a few miles from the eastern edge of the county the Survant coal is found in the hills, notably just north of Long Branch, in the upland around Velpen, southeast of Pikeville, and just west of Selvin. Coal V occurs in the tops of the ridges near the eastern edge of R. 7 W. It extends out into a long tongue of upland in the big bend of Flat Creek northwest of White Oak P. O. It is in the top of the ridge just south of Survant, around Stendal, and extending southward
almost to Selvin. It also outcrops near the top of the ridge northwest of High Bank. From these points the dip carries it downward to the west until it passes below river level north of Petersburg on White River, south of Littles, on Patoka River, east of Oakland on the south fork of Patoka. Coal VII is found in the hills near the top of the high ridge from Augusta southward and extending westward past Arthur P. O., also in the ridges in the southwest corner of the county. This coal occupies all of the upland in the northwest part of the county. It is above drainage at Dongola and west of Oakland.

Gibson County.—As just described, Coal V passes below drainage just at the eastern edge of Gibson County at the latitude of Oakland, and Coal VII is in the upland there. These coals dip rapidly downward until at Princeton Coal V has an elevation of about 20 feet above sea-level, and the dip carries it still lower to the west. At Fort Branch Coal VI has an elevation of 175 feet above sea-level, while at Francisco the same coal has an elevation of 270 feet above sea-level. In the western part of the county the dip allows the measures to descend until the highest coals of the State, the Parker, Friendsville and Aldrich, are found in the hills.

Perry County.—All but the eastern third of Perry County is underlain by coal measures except the stream valleys. The bottom of the coal measures usually reach drainage level by the middle of R. 3 W. East of that the hilltops catch the lower coal measures, and to a large extent the Cannelton coal. Going westward the dip carries the Cannelton coal down to river level along the Anderson River.

Spencer County.—As just stated, Coal II is at river level along Anderson River on the eastern border of the county. The Holland coal reaches drainage along the western edge of the northern part of the county, near Lincoln City and Holland. Coal II should therefore occupy all of the county. The Holland coal underlies probably the western part of the county from the middle of R. 5 W. westward. From the middle of that range eastward the hills contain the coals lying between the Holland coal and the Cannelton coal. Coal V is just caught in the top of the knobs west of Centerville and north of Rockport. It is above all of the other land in the southwestern part of the county. Coal IV is not far below drainage level in the southwest corner of the county, but is probably cut out over a large area in what is known as Pigeon Plain on the east side of Little Pigeon Creek. It should, however, be found
in all of the hill land or land that rises above the level of Pigeon Plain and the river bottoms. The Rock Creek coal will come between Coal IV and the Holland coal in this territory.

**Warrick County.**—The Holland coal is just above drainage in the northeastern part of the county, but passes below drainage west of Pokeberry Branch. The Rock Creek coal is caught in the hills east of Pokeberry Branch, and outerops above drainage in the hills west of Pokeberry Branch. Coal IV is caught in the ridges between Pokeberry Branch and Coles Creek, north of Tennyson. Coal V outerops in the tops of the ridges southwest of Folsomville and from Folsomville to Scalesville. From there it passes quickly below drainage, so that apparently it does not outerop on Big Creek, though a few outerops on Cypress Creek occur south of Boonville. The outerops of this coal in Warrick and Pike counties is shown in great detail in the Ditney folio of the U. S. Geological Survey. In Anderson Township it outerops only a short distance below Little Pigeon Creek, and passes below drainage a short distance from Yanketown. This coal underlies all of the western part of the county. Coal VII outerops in the ridge tops west of Scalesville and through the ridge west of Cypress Creek around Chandler; also in the crest of the ridge between Boonville and Yanketown. It is above high water at Newburg, but passes below drainage a short distance down the river. It is just about at drainage at Millersburg on Pigeon Creek, and above drainage on the eastern forks of that creek north and southwest of Chandler. It underlies the western edge of the county.

**Vanderburgh and Posey Counties.**—All of the coals are below drainage under these counties. Coal V is worked at many points around Evansville at a depth of about 260 feet, the coal being about 125 feet above sea level. All of the coals should be present under these counties, but drilling seems to indicate that many of the coals are thin, as compared with their development farther north. Thus, up to the present coals VII, V and a coal at about the position of the Upper Block coal appear to be all that can be counted upon. Of these Coal V seems to be the only one that is persistently workable. The lowermost coal mentioned has been opened by a shaft at Henderson. The diamond drilling at Mount Vernon reveals the presence of several workable coals, the highest being at a depth of 600 feet. The uppermost coals of the measures outerop to a small extent in the uplands of northwestern Posey County. They do not, however, appear to be workable there. They will be cut out over the broad band of river bottoms that encircle that county.
Chapter VI.

STRUCTURE OF THE INDIANA COAL FIELD.

The general statement has been made that the coal measures of Indiana dip to the south of west. On the large chart prepared by Mr. Lines the attempt has been made to give the amount and character of that dip by contour lines. There will be noticed a series of red lines running irregularly, but more or less nearly parallel, the length of the field in a south of east direction. These lines are numbered from 0 in the southwest corner of the field to 900 feet near the eastern edge of the field. The numbers refer to elevation above sea-level, and are applied to the position of the No. V coal or the position it would have had it not been carried away by erosion. The lines have been drawn by first placing onto a tracing of the map the elevation of Coal V at every point at which its elevation is known. In many other places the elevation of some other coal is known, and knowing very closely the distance of that other coal above or below Coal V, it was possible to compute the approximate elevation of Coal V.

These elevations have been obtained in a number of ways. In a large number of cases through the kindness of the various railways the elevation of the switch rail at the mine has been learned, and by subtracting from this the depth of the shaft the elevation of the coal has been obtained. These elevations are given on the chart in the list of mines. In the same way many of the mining companies have leveled to the top of their drillings, so that the elevation of the coal at a large number of points in undeveloped parts of the field could be obtained in this way. In the area of the Ditney folio the contour lines had already been drawn on Coal V, based on elevations obtained at every outcrop or stripping in that area. As the geology of that folio was studied after the preparation of the topographic map, it was possible to determine quite accurately the elevation of Coal V and of the other coals at practically every point where they are known in that area.

The U. S. Geological Survey has also prepared topographic maps of the Clay City quadrangle in Clay County, and of the St. Meinrad and Tell City quadrangles in Spencer, Dubois and Perry coun-
The first of these sheets was only surveyed in 1908 and has not yet been published. Within the area of these sheets, which give the elevation of the ground at all points, it has been possible to obtain the elevation of many of the coal outcrops quite accurately. In the case of the coals on these sheets in Spencer County, the elevations have often been only an approximation, as the writer is not personally familiar with the position of the coals in that county. Mr. Price, who did the work in that county, frequently described the position of the coals he saw, either referring to their distance from some section corner, or to their approximate elevation above an adjoining stream, so that, with the topographic map in hand, it has often been possible to estimate the actual elevation closely. In many other cases, by knowing the position of the coal relative to some neighboring large stream or river, it has been possible to estimate the elevation of the coal. The elevations of low-water on the rivers has been determined at many points, and assuming a regular gradient between any two such points, it is possible to obtain the elevation of the river at any intermediate point. In this way the elevation at the mouth of the larger streams can be obtained, and if the elevation can be obtained higher up that stream, where crossed by a railroad or a State road, the elevation of any point along the creek can be closely approximated. In these ways hundreds of elevations on Coal V were obtained or computed; then lines were run connecting all elevations of each even hundred feet, or so spaced on either side of other elevations given as to place such elevations their proper relative distance between the contour lines on the two sides of them.

Theoretically, from these lines the position of Coal V can be closely approximated at any point in the field. Thus, if the point in question is found to immediately underlie one of the red lines, Coal V is as many feet above sea-level as the figure on that red line. Should it be halfway between these two lines, its elevation will be theoretically 50 feet higher than the elevation indicated by the red line west of it. In the same way, if it is only a third of the distance from the western line its elevation will be theoretically 33 feet higher, and so on. Actually the elevations to be obtained are not as accurate as that. Within the area of the Ditney folio in Pike and Warrick counties it should be possible to obtain the elevation of Coal V from the contour lines to within 25 feet, and the same is probably true of eastern Sullivan County, western Greene County, northeastern Vigo County, and northwestern Clay County. Over the coal field as a whole, however, it is not ex-
pected that these contours will give the accurate elevation of the coal within a limit of error of 50 or 75 feet. They are intended primarily to show the general structure of the field in a broad way, and in doing that they also show approximate elevations of different coal beds within the limit of error mentioned. To obtain the elevation of any other coal bed than Coal V, turn to the stratigraphic chart and measure the distance from that particular coal down to or up to Coal V, and add or subtract from the elevation of Coal V accordingly as the coal in question lies above or below Coal V. No attempt will be given in the text to describe in detail the structure. Its character is shown on the map, as stated, and in addition a large number of elevations have been given on the map, and the accurate elevations of the coal at most of the working mines have been given on the chart. A note of caution should be given in regard to these elevations of the coal in that they are based on the assumption that the depth of the coal in the shaft is correct as given on the chart. In many cases the depth of the shaft has been reported differently by different people, or at different times. If the figures giving the depth of the shaft at any point prove to be incorrect, the elevation of the coal at that point should be corrected a corresponding amount.
Chapter VII.

The Amount of Coal in Indiana.

In view of the interest taken at present in the conservation of our natural resources, and the subsequent census of the country’s stock of mineral and other wealth, the question of how much coal there is in Indiana is of more than local interest. The present knowledge of the stratigraphy renders the figures given in the 1898 report inaccurate, greatly increasing them, and it is expected that future development may still further increase the amount of estimated coal reserves in the State beyond the figures given in this table, as these figures are thought to be more or less conservative.

It is at once recognized that the value of any figures must depend on how they have been obtained. In this case the attempt has been made to determine in each county the area underlain by each coal bed. That area in square miles has then been multiplied by the average thickness in feet of each coal bed, and again by the number of tons of coal in a bed 1 foot thick and one square mile in area. On the face of it that ought to be simple enough and to give quite definite results. However, the personal element in the interpretation of facts enters very largely. If a given bed is entirely above drainage in any county it may be possible not only to map it accurately, and so determine its area, but to find outcrops so placed as to show whether it runs out or thins in any direction. Under these circumstances it may be possible to estimate the tonnage within a very few per cent. Unfortunately, the conditions are seldom so simple. If it is above drainage it has slight cover, and under the conditions existing in most of the Indiana field, that means that it may have been cut out over indefinite areas by the preglacial drainage, and the evidences of such early erosion have been later covered up by the glacial deposits.

Again, the usual dip to the west is such that the coals do not remain above drainage many miles in an east and west direction, and as each bed passes below drainage mining and exploitation is upon the next higher bed, and little is known of the first bed farther to the west, where it underlies the next succeeding higher bed. This
lack of information is much less today than it was ten years ago, due to the large amount of drilling that has been done. Continuing westward, however, a point is usually reached beyond which drilling seldom reaches down more than to one of the overlying beds, and the continuance of the bed and its workability become conjectural. It is here that the question of probabilities enters. For example, in Sullivan County we have fairly definite knowledge of the coals down to Coal III over the eastern half of the county, and no small measure of the northwestern part of the county, but in the southwestern and western part of the county, covering nearly half of its area, the writer has no exact information. Shall we consider that because the coals have maintained their thickness and regularity over the known part of the county, therefore they probably do over the rest? Between the extremes of assuming that the coals in that case do run regularly over the rest of the county, and that it is not safe to assume anything beyond the area definitely and thoroughly known, is a medium course that assumes that the evidence is sufficient to warrant carrying the coals over at least part of the unknown territory, and making some allowance for the possibility that they do not go over all of it.

Thus, to take a concrete case, in Sullivan County, since that has been mentioned: Coal VI is known to be regular and generally workable over the eastern part of the county and part of its northwestern area. It appears, however, to run out at the north edge of the county, and to become irregular not far from the south edge of the county. Under these circumstances it may be questioned how far to the westward it is safe to assume its extension with a workable thickness. In the same way, Coal V, that at most points in the eastern part of the county shows an even thickness, is known to be absent east of Farmersburg, around Jasonville, and at other points. To assume its presence over all of the unexplored part of the county would therefore hardly be justified. Under these conditions the writer has probably erred on the side of conservatism.

Next in the case of thickness there is also much room for diversity of opinion. For example, any one going into a succession of mines on the block coals is apt to forget that practically each of those mines has been started only after drilling has developed the position and lay of the basin in which it occurs, and that probably what he sees in the mine is in the very heart of the basin, and not even an average of that part of the basin that has been or will be mined out. Again, in the upper coals, examination of a large num-
ber of drillings reveals many points at which one or more of these usually regular beds are absent or thin. So, too, regarding the sections seen in the mines—the mines that are open are the mines that have found the bed workable and continuing regularly. It is only when inquiry is made into the history of the closed or abandoned mines that it is realized that even the most regular of the beds have their weak places where, for some reason or other, they are not workable. It has, therefore, been the writer’s plan to assume that the observed thicknesses are more likely to be above than under the average thickness, then to assume that that average thickness persisted only over part of the area—the portion taken depending on the apparent regularity of the bed in question, and the data on hand ranging from a small portion of the area to all of it—and then to assume usually that the bed will underlie the rest of the area with a greatly reduced thickness.

The table giving a “Summary of Coals by Counties” follows:
### SUMMARY OF COAL BY COUNTIES

<table>
<thead>
<tr>
<th>COUNTY</th>
<th>Number of Beds Contained</th>
<th>Greatest Thickness Recorded</th>
<th>Maximum Total Thickness</th>
<th>Total Thickness Workable Coal (Max.)</th>
<th>Square Miles Underlain by Coal.</th>
<th>Square Miles Underlain by Workable Coal</th>
<th>Estimated Total Tonnage of Coal.</th>
<th>Estimated Total Tonnage Rendered or Unworkable Coal.</th>
<th>Estimated Total Tonnage of Workable Coal Left.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warren</td>
<td>4</td>
<td>Feet</td>
<td>Feet</td>
<td>Feet</td>
<td>Feet</td>
<td>Feet</td>
<td>Feet</td>
<td>Feet</td>
<td>Feet</td>
</tr>
<tr>
<td>Fountain</td>
<td>7</td>
<td>8</td>
<td>15</td>
<td>6</td>
<td>7</td>
<td>30</td>
<td>500,000,000</td>
<td>1,000,000,000</td>
<td>600,000,000</td>
</tr>
<tr>
<td>Putnam</td>
<td>5</td>
<td>7</td>
<td>35</td>
<td>24</td>
<td>19</td>
<td>250</td>
<td>400,000,000</td>
<td>400,000,000</td>
<td>400,000,000</td>
</tr>
<tr>
<td>Parke</td>
<td>8</td>
<td>12+</td>
<td>22+</td>
<td>22+</td>
<td>20</td>
<td>650</td>
<td>200,000,000</td>
<td>20,000,000</td>
<td>200,000,000</td>
</tr>
<tr>
<td>Vermilion</td>
<td>12</td>
<td>7+</td>
<td>23+</td>
<td>23+</td>
<td>20</td>
<td>750</td>
<td>200,000,000</td>
<td>200,000,000</td>
<td>200,000,000</td>
</tr>
<tr>
<td>Owen</td>
<td>2</td>
<td>1</td>
<td>10</td>
<td>10</td>
<td>8</td>
<td>305</td>
<td>600,000,000</td>
<td>600,000,000</td>
<td>600,000,000</td>
</tr>
<tr>
<td>Clay</td>
<td>16</td>
<td>9</td>
<td>27</td>
<td>27</td>
<td>20</td>
<td>250</td>
<td>600,000,000</td>
<td>600,000,000</td>
<td>600,000,000</td>
</tr>
<tr>
<td>Vigo</td>
<td>18+</td>
<td>7+</td>
<td>23</td>
<td>23</td>
<td>20</td>
<td>800</td>
<td>200,000,000</td>
<td>200,000,000</td>
<td>200,000,000</td>
</tr>
<tr>
<td>Greene</td>
<td>14</td>
<td>7</td>
<td>35</td>
<td>35</td>
<td>30</td>
<td>300</td>
<td>700,000,000</td>
<td>700,000,000</td>
<td>700,000,000</td>
</tr>
<tr>
<td>Sullivan</td>
<td>16+</td>
<td>2+</td>
<td>28+</td>
<td>28+</td>
<td>20</td>
<td>300</td>
<td>1,000,000,000</td>
<td>1,000,000,000</td>
<td>1,000,000,000</td>
</tr>
<tr>
<td>Martin</td>
<td>7</td>
<td>4</td>
<td>16</td>
<td>16</td>
<td>12</td>
<td>400</td>
<td>400,000,000</td>
<td>400,000,000</td>
<td>400,000,000</td>
</tr>
<tr>
<td>Davison</td>
<td>15</td>
<td>7</td>
<td>27</td>
<td>27</td>
<td>20</td>
<td>750</td>
<td>200,000,000</td>
<td>200,000,000</td>
<td>200,000,000</td>
</tr>
<tr>
<td>Knox</td>
<td>13+</td>
<td>9</td>
<td>20+</td>
<td>20+</td>
<td>18</td>
<td>500</td>
<td>2,000,000,000</td>
<td>2,000,000,000</td>
<td>2,000,000,000</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>50</td>
<td>200,000,000</td>
<td>200,000,000</td>
<td>200,000,000</td>
</tr>
<tr>
<td>Crawford</td>
<td>5</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td>350</td>
<td>1,000,000,000</td>
<td>1,000,000,000</td>
<td>1,000,000,000</td>
</tr>
<tr>
<td>Dubois</td>
<td>10+</td>
<td>5</td>
<td>17</td>
<td>17</td>
<td>15</td>
<td>300</td>
<td>400,000,000</td>
<td>400,000,000</td>
<td>400,000,000</td>
</tr>
<tr>
<td>Pike</td>
<td>15+</td>
<td>10+</td>
<td>20+</td>
<td>20+</td>
<td>18</td>
<td>420</td>
<td>1,000,000,000</td>
<td>1,000,000,000</td>
<td>1,000,000,000</td>
</tr>
<tr>
<td>Gibson</td>
<td>15+</td>
<td>7</td>
<td>13+</td>
<td>13+</td>
<td>11</td>
<td>440</td>
<td>800,000,000</td>
<td>800,000,000</td>
<td>800,000,000</td>
</tr>
<tr>
<td>Perry</td>
<td>10+</td>
<td>5</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td>90</td>
<td>2,000,000,000</td>
<td>2,000,000,000</td>
<td>2,000,000,000</td>
</tr>
<tr>
<td>Spencer</td>
<td>12+</td>
<td>9</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>500</td>
<td>1,000,000,000</td>
<td>1,000,000,000</td>
<td>1,000,000,000</td>
</tr>
<tr>
<td>Warrick</td>
<td>10+</td>
<td>4</td>
<td>16+</td>
<td>16+</td>
<td>12</td>
<td>360</td>
<td>3,000,000,000</td>
<td>3,000,000,000</td>
<td>3,000,000,000</td>
</tr>
<tr>
<td>Vanderburgh</td>
<td>12+</td>
<td>6</td>
<td>22+</td>
<td>22+</td>
<td>18</td>
<td>420</td>
<td>2,000,000,000</td>
<td>2,000,000,000</td>
<td>2,000,000,000</td>
</tr>
<tr>
<td>Posey</td>
<td>11+</td>
<td>10</td>
<td>34</td>
<td>34</td>
<td>26</td>
<td>200</td>
<td>650,000,000</td>
<td>650,000,000</td>
<td>650,000,000</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>31</strong></td>
<td><strong>10</strong></td>
<td><strong>2</strong></td>
<td><strong>2</strong></td>
<td><strong>6</strong></td>
<td><strong>3,051</strong></td>
<td><strong>16,840,000,000</strong></td>
<td><strong>16,840,000,000</strong></td>
<td><strong>16,840,000,000</strong></td>
</tr>
<tr>
<td><strong>Approximately</strong></td>
<td><strong>31</strong></td>
<td><strong>10</strong></td>
<td><strong>2</strong></td>
<td><strong>2</strong></td>
<td><strong>6</strong></td>
<td><strong>46,840,000,000</strong></td>
<td><strong>46,840,000,000</strong></td>
<td><strong>46,840,000,000</strong></td>
<td><strong>46,840,000,000</strong></td>
</tr>
</tbody>
</table>

*Obtained by adding together the maximum of all the beds.
In the table there is given in the first column the total number of beds found in each county. The plus (+) signs refer to the incompleteness of our knowledge of usually the lower part of the column. To get the total number of beds in the State it is necessary to count the higher beds, as found in the western counties, and add the lower beds, from their outcrops in the eastern counties. As before stated, the total appears to be in the neighborhood of thirty-four horizons at which coal has been laid down. Of these probably not more than twenty-five have any regularity or can be recognized over any large area. In the second column is given the greatest thickness of a single bed measured in each county. The greatest thickness in the State measured by the Survey is 10 feet 2 inches, though still larger thicknesses are reported. The next column gives the maximum thickness of coal found in each county, obtained by adding together the greatest extensive thickness observed of each bed, not necessarily the sum of the greatest individual measurements, but the sum of the best average thicknesses. Thus, with the workable beds the figure used is usually the average of at least one or more mines. In the table Greene County appears to have the greatest thickness. Our actual knowledge of Sullivan County reaches down only to Coal III, below which are still doubtless six or eight additional coals. The basis of the figures in Greene County may be given as an illustration of how the figures have been obtained. From the table the reader who is acquainted with the thicknesses of the coals in that county can then judge for himself as to the reliability of the thickness for the other counties.

### Thicknesses of Coal Beds in Greene County

<table>
<thead>
<tr>
<th>Coal</th>
<th>Beds Found</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>VII, as in the Smith mine, sec. 31, T3-R7</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>VIa</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>VI, as east of Dugger</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Va, as in a number of drillings</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>V, as in the Twin No. 4 mine, Vulcan mine, etc.</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>IVa, as in many drillings</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>IV, as in Vandalia mines Nos. 2 to 9</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>IIIa and IIIb, as in drillings</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>III, as at the Letsinger and Tower Hill mines</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>II, IIa, etc.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Mitchell coal, as at Switz City</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Upper Block coal, as at the Aydelotte slope</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Lower Block coal, as at Howesville and east of White River</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Sub-Mansfield coal, in eastern part of county</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>50</strong></td>
<td></td>
</tr>
</tbody>
</table>
In Sullivan County several drillings showed coals to a total of 35 feet, in depths of less than 500 feet, including coals III to VIII. In one such drilling, excluding all coals below 3 feet 10 inches as unworkable, 26 feet 3 inches of workable coal is shown. In this case particular mines have been cited where the larger coals have the average thickness given.

At the bottom of the column the total maximum thickness of the coal for the State is given as 100 feet. This was obtained by taking the thickest measured section at each of the beds in the type region of Sullivan and Greene counties, and adding to it still greater thickness from other regions and the thickness of the coals not found there. The following table shows how the thickness runs in Sullivan and Greene counties, and is used as a basis for this total figure:

**Maximum Thickness of Coals Measured in Sullivan and Greene Counties.**

<table>
<thead>
<tr>
<th>Coal</th>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coals above coal VIII, total</td>
<td>3</td>
<td>..</td>
</tr>
<tr>
<td>Coal VIII</td>
<td>4</td>
<td>..</td>
</tr>
<tr>
<td>Coal VII</td>
<td>6</td>
<td>..</td>
</tr>
<tr>
<td>Coal VI</td>
<td>8</td>
<td>..</td>
</tr>
<tr>
<td>Coal Vb</td>
<td>1</td>
<td>..</td>
</tr>
<tr>
<td>Coal Va</td>
<td>3</td>
<td>..</td>
</tr>
<tr>
<td>Coal V</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Coal IVb</td>
<td>2</td>
<td>..</td>
</tr>
<tr>
<td>Coal IVa</td>
<td>3</td>
<td>..</td>
</tr>
<tr>
<td>Coal IV</td>
<td>6</td>
<td>..</td>
</tr>
<tr>
<td>Coal IIIb</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Coal IIIa</td>
<td>3</td>
<td>..</td>
</tr>
<tr>
<td>Coal III</td>
<td>9</td>
<td>..</td>
</tr>
<tr>
<td>Coal II to bottom of III</td>
<td>8</td>
<td>..</td>
</tr>
<tr>
<td>Minshall coal</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Upper Block coal</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Lower Block coal</td>
<td>4</td>
<td>..</td>
</tr>
<tr>
<td>Sub-Mansfield coal</td>
<td>3</td>
<td>..</td>
</tr>
</tbody>
</table>

Total, about ................................ 80 ..

It will be at once recognized that the thicknesses given are not the maximum for those beds in the State. Thus, the block coals frequently reach 5 feet in the Brazil district; the Minshall coal reaches 6 feet in Parke County; Coal V reaches over 10 feet in Pike County. Further, in Gibson County are at least three coals giving a total measurement as a maximum of 7 feet that are not found in Sullivan County; and, again, in the southeast part of the
AMOUNT OF WORKABLE COAL IN INDIANA.

141 AMOUNT OF WORKABLE COAL IN INDIANA.

Coal field, as in Perry County, occur coals below any found in Greene County, so that it is believed that the total estimate of 100 feet is not far from correct, and were the figures accurately known this would probably be increased rather than diminished.

The next two columns give the areas underlain by coal or coal measures (C. M.) and by workable coal. These figures are probably conservative. They are simply copied from the estimates of the previous report. The estimated total tonnage is based on the computation for each county of the area and average thickness of each coal bed. Another way of getting at that figure would be to average the thickness of the coal in a large number of drillings and other obtainable sections, and to multiply that by the area of the county and tonnage per square mile per foot of thickness. The study of Sullivan County in this respect showed that drillings from Coal VIII to Coal III contained from 20 to 34 feet of coal, 30 feet being not far from the average. Assuming that the coals below Coal III will more than make up for any amount under that that a larger number of sections might show, if that average holds over the whole county of 440 square miles, and if it be assumed that every square mile of coal 1 foot thick contains 1,000,000 tons of coal, the county, on that basis, would contain 13,200,000,000 tons. It will therefore be seen that the figure of 10,000,000,000 tons obtained by the other method, while conservative, is probably not unnecessarily so.

The next to the last column is intended to show the amount of coal worked out or rendered unworkable. The total amount is estimated at double the amount of coal actually removed, the difference consisting not only of the loss in pillars, etc., but the crop coal and other portions passed by or lost through conditions of adverse possession and the damage to overlying coals. After completing this computation the writer found that Mr. Parker, of the Division of Mineral Resources, has computed the total output of Indiana at 159,440,390 tons, which agrees closely with the figures used in this table.

The last column gives the estimated actual tonnage recoverable under present mining conditions, assuming as workable coal all over 2½ feet thick, and that only 60 per cent is recoverable. Allowance is thus made for not only the actual loss in mining, but for the losses in the overlying beds, etc.

As a matter of fact, the total coal that will probably be recovered will lie somewhere between the figures of the last column and those of the third column from the last, for better methods of
mining are bound not only to increase the percentage of any bed that is recoverable, but to make possible the mining of beds now considered unminable. Recent advances have already pointed the way to some of the means that will be adopted. Some of these are as follows:

Better means of utilizing low-grade coals, making it possible to mine with profit bony or poor benches now left in the mines, as, for example, the bottom bench of Coal VI in Sullivan County. The Pittsburg fuel testing plant of the U. S. Geological Survey is at this writing successfully using the roof coal on the Pittsburg bed, commonly called bone coal, and considered to be too high in ash to mine profitably. In the same way, at the St. Louis testing plant, bone coals running up to 30 or 40 per cent ash were successfully used in the producer gas plant, and yielded as good results as high-grade coals in the steam engine.

Better Methods of Mining.—There are mines operating in Illinois and in other states where as high as 98 per cent of the coal owned is recovered. It is only a question of time when that will be true of all mines.

Better Machinery and Appliances Which Will Make it Profitable to Mine Thin Coals.—Where the price warrants coals well under 2 feet are successfully mined at many points today. Undoubtedly in the future new machinery will make it possible to mine these thin coals at a profit in Indiana. There are also many factors which are tending to raise the price of coal in the future, among which may be mentioned the fact that in the past mining has been upon the coal that could be obtained most easily, and therefore that future mining is almost bound to be more expensive, and the product more costly to the purchaser. Again, the agitation for greater safety for the miners is going to render mining more expensive, and again will in turn mean greater selling price. These factors will enable the mining men to turn to the thinner coals than are now considered workable.

Summing up the figures that have been given, the following approximate conditions appear to exist:

Proportion of total amount of coal removed, 1-140.
Proportion of workable coal removed, 1-80.
Average rate of removal for last sixty years, 3,333,333 tons a year.
Life of field if past average rate be maintained, 4,000 years.
Rate of removal in 1907, about 13½ million tons.
Life of field if present rate were maintained, 1,000 years.
Rate of increase during last few years, about 1,000,000 tons a year.
Life of field if present rate of increase were maintained, 150 years.
Production the 150th year, about 169 million tons.
Considering the factors already discussed, it is probable that the life of the Indiana coal field will be not less than double the figure given, or, say, 300 years, and probably it will be more.
The principal reasons for believing that the life of the field will be longer than the 150 years on the basis of present conditions being maintained may be briefly summarized as follows:
(1) Thinner beds will be worked than are now considered workable, so that much coal that is now included in the figures on total coal, but not in the column of workable coal, will be transferred to that column.
(2) Better mining methods will insure a larger percentage of recovery, and smaller losses to overlying beds and outside districts, so that instead of estimating the recovery at 50 or 60 per cent, it may rise to 80 or even to 90 or 95 per cent.
(3) Better methods of utilization will secure the same power or heat by the use of less coal.
(4) Other sources of power may meet part of the demand, such as water power, the sun's heat, wind and wave action, alcohol from vegetable matter, and other sources not yet recognized.
APPENDIX A.

RECENT ANALYSES OF INDIANA COAL.

In order not to burden the body of the report, and at the same time to make available the large amount of analytical work recently done on Indiana coals, this has been gathered together as an appendix where it can be readily referred to. The table includes many analyses made by the fuel-testing plant of the U. S. Geological Survey at St. Louis. These were made from mine samples and car samples. The former were made by cutting a strip the full thickness of the bed, and after throwing out such portions as are commonly rejected in mining, quartering the rest until a quart sample was obtained, when it was hermetically sealed and sent to the laboratory. The car samples were taken at the plant. The coal, after crushing, was elevated in a conveyor, and the sample was obtained by taking small shovelfuls at regular intervals from the conveyor buckets, mixing and quartering down to make a laboratory sample. They should therefore represent very closely the exact character of the coal and its delivery to the customer. There are also included a number of analyses made under the direction of the State Geological Survey. In most cases these were from properly sampled lots and are perfectly reliable. In a few cases they are from drillings or from samples sent in from interested parties. The methods of analyzing samples by the Technological Branch of the U. S. Geological Survey are fully described in the various bulletins issued by that branch.
Life of field if present rate were maintained, 1,000 years.
Rate of increase during last few years, about 1,000,000 tons a year.
Life of field if present rate of increase were maintained, 150 years.
Production the 150th year, about 169 million tons.
Considering the factors already discussed, it is probable that the life of the Indiana coal field will be not less than double the figure given, or, say, 300 years, and probably it will be more.
The principal reasons for believing that the life of the field will be longer than the 150 years on the basis of present conditions being maintained may be briefly summarized as follows:
(1) Thinner beds will be worked than are now considered workable, so that much coal that is now included in the figures on total coal, but not in the column of workable coal, will be transferred to that column.
(2) Better mining methods will insure a larger percentage of recovery, and smaller losses to overlying beds and outside districts, so that instead of estimating the recovery at 50 or 60 per cent, it may rise to 80 or even to 90 or 95 per cent.
(3) Better methods of utilization will secure the same power or heat by the use of less coal.
(4) Other sources of power may meet part of the demand, such as water power, the sun's heat, wind and wave action, alcohol from vegetable matter, and other sources not yet recognized.
APPENDIX B.

DESCRIPTIVE NOTES ON THE STRATIGRAPHIC CHART.

In Plate II the attempt is made to present, in a condensed form, a comprehensive view of the stratigraphy of the Indiana coal measures. By placing the sections close together somewhat the effect of a very broad generalized section is produced, while at the same time the local composition and variation is clearly indicated by the individual sections. In this way it is possible to get a comprehensive grasp of the relation of the coals to each other and to other rocks which it is hoped will enable the reader to himself apply to new local conditions in the field. The writer believes that such information is of much more value than a simple statement of supposed correlation, no matter how widely applied. The sections consist in some cases of single shaft, drill, or outcrop sections; more often they are combinations of two or all of these. In some cases a single section is the result of piecing together short sections obtained at different places; in others they are the result of averaging a number of sections covering the same interval. In some of these instances the result is the average of several scores of individual sections. To give the plate more local value additional notes are here added to the brief titles on the plate. The sections have been arranged from left to right in order from north to south, including a few sections from the Danville district of Illinois on the north at the left, and a few sections in the western Kentucky coal field on the south at the right. The scale of the sections is 80 feet to the mile, which is used as a convenient one in that an ordinary rule can readily determine the distance between any given members, as an eighth of an inch is equivalent to 10 feet.

Descriptions of Sections.—The numbers to follow apply to the several columns, beginning at the left. The letters, where used, apply to the individual sections in the several columns.

1. Danville, Ill. From a drilling near.
2. From a drilling at Pawnee, Ill.
3. From a drilling south of Westville, Ill.
4. A combination of exposures along Pine Creek and of sections at the mines on Fall Creek, west of Indiana Mineral Springs.
5. A combination of sections at several of the banks in Sections 3, 8 and 10 of 20 N., 9 W., lying a few miles northwest of Covington.
6. Section of outcrops in Section 38, 18 N., 9 W., on Coal Creek.
7. From outcrops on Silver Island, Section 34, 18 N., 9 W., a short distance west of Silverwood.
8. From outcrops and a drilling in the region of Hanging Rock and Coal Branch, northeast of Cayuga.
9. (A) From outcrops and drilling at the Horseshoe and below. (B) Section at Blacks, Section 22, 14 N., 5 W.
10. (A) From outcrops and drillings north and west of Hillsdale. (B) Section showing general relations on Sugar Creek.
11. (A) From mine shaft and drillings at Dana. (B) Section at the Parrot Mine, southwest of Hillsdale. (C) Outcrop on Sand Creek, northeast of Rockville. (D) Section at Reelsville, Section 21, 13 N., 4 W.
12. (A) Outcrop at Indiana Furnace, on Bruilett Creek, Section 33, 14 N., 10 W. (B) Drilling by the Brazil Block Coal Company south of Clinton, south edge of county. (C) Connected sections at Mecca, from exposures in the several ravines and shaft section. (D) Outcrop on Racoon Creek.
13. (A) Combined section from outcrops, shaft and drilling records, on Bruilett Creek. (B) Combined section of outcrops, shaft sections, and drilling at Coxville, for the upper part of the section, while the lower part is made up from outcrops and drillings at Minshall. The sections are tied together on the supposition that the drilling at Coxville reaches the Upper Minshall coal.
14. (A) Generalized section from a large number of drillings and shaft sections in the Clinton district. (B) Section of Superior No. 2 shaft at Caseyville, Section 35, 14 N., 7 W. (C) Outcrops at Cataract, Owen County, Section 2, 11 N., 4 W.
15. (A) An average section from a large number of drillings and shaft sections in Fayette Township of Vigo County. (B) An outcrop section from Buzzard Gulch, Owen County, Sec. 6, 10 N., 4 W.
16. (A) Section of the old Hartford shaft at Pimento. (B) Section of the Fleisher shaft, Section 7, 11 N., 8 W. (C)
An average section of a large number of shaft sections combined with outcrops and drillings in Nevins Township of Vigo County, and Dick Johnson Township of Clay County. (D) Section from Ritters Hill and Freedom in Spencer County, Section 20, 9 N., 4 W.

17. (A) An outcrop section from Sugar Creek in western Vigo County. (B) Outcrop and shaft sections at Riley, southeastern Vigo County. (C) Bore on the John Harris place, in southern Clay County, Section 20, 10 N., 7 W. (D) A combined section from the Brazil district, made up from shaft and drill records in the Stanton-Turner region, combined with shaft and drill records around Brazil, and outcrops on Croys Creek, east of Brazil.

18. (A) An average section from outcrops, shaft sections, and drillings in Sugar Creek Township in the West Terre Haute district. (B) Section of the old Center Point shaft at Center Point, Clay County. (C) An outcrop from Cemetery Hill, at Greencastle, Section 28, 14 N., 4 W.

19. (A) Section at the Dix Bank on Turman Creek, Section 26, 9 N., 10 W. (B) Outcrop and shaft section at Sanford Hill, Section 1, 10 N., 9 W. (C) Section of the shaft at Hymera. (D) A section of the shafts at Seelyville, and a drilling from the bottom of the old Seelyville shaft. (E) Outcrop on the Lansford place in Owen County, Section 24, 9 N., 5 W.

20. (A) Section of the Pioneer shaft at Curriesville. (B) Combined section of outcrops and drillings around Lewis and Clay City. At Clay City the section at Middlebury is not tied into the section at the Harrison mines to the east, an interval of unknown extent coming between the two sections. (C) Section on the H. T. Weathers place, Section 12, 12 N., 5 W.

21. (A) Generalized section of the Farmersville district and the north-central edge of Sullivan County. (B) Section at Needy Bank, Section 17, 9 N., 5 W.

22. (A) A section of the cliff at Merom, Sullivan County, combined with a shallow shaft at that point. (B) Part of a section of the Farnsworth shaft. (C) A generalized section of drillings around Jasonville and eastward to Howesville, including the Howesville shaft. (D) A section on Beech Creek, eastern Greene County, Section 14, 7 N., 5 W.
23. (A) Generalized section of a large amount of drilling in Fairbanks, Turman and Hamilton townships, Sullivan County. (B) Section of the old Coal City shaft, Section 11, 9 N., 6 W.

24. (A) Generalized section from drillings and shaft sections in the region about Sullivan. (B) A drilling on the edge of Switz City, Greene County. (C) An outcrop section at the Sexton place, Section 15, 6 N., 3 W.

25. (A) Section at the Barnes place on Turman Creek, Section 9, 8 N., 10 W. (B) Section made up from a large number of shaft sections and drillings in Cass Township, Sullivan County. (C) Drilling record from near the Lundy mine, southwest of Switz City, Greene County. (D) An outcrop section near the Monon tunnel, southeast corner of Greene County, Section 28, 6 N., 3 W.

26. (A) A section of the shaft at Carlisle. (B) A section combined from drillings at Lines, Section 4, 6 N., 6 W.

27. (A) Outcrop near the Narrows of Wabash River, Section 25, 9 N., 11 W. (B) Combined section of shafts and drillings at Edwardsport, Knox County. (C) Combined section at Raglesville, northeastern Daviess County.

28. (A) Combined from drillings about Bruceville and Bicknell. The upper part of the section is taken from the neighborhood of Bruceville, and the lower part from a large number of drillings about Bicknell. (B) Section of Sampson Hill, Martin County, southeast of Shoals.

29. (A) Section of a core drilling at Vincennes. (B) Generalized section of Orange County.

30. (A) Section at Mantei place, Donation 10, east of Vincennes. (B) Section of a drilling 3 miles south of Bicknell. (C) Section of a drilling at Chelsea, near the B. & O. S-W. R. R., between Washington and Montgomery.

31. (A) Section from the shaft at Wheatland and outcrops along the river northeast of that town. (B) Section of the shaft at Montgomery. (C) Section of the Mutual mine shaft at Cannelburg. (D) Section of the cliff north of Shoals.

32. (A) Section of Cox Hill, Section 8, 4 N., 8 W. (B) A drilling on the Williams place, Section 35, 2 N., 8 W. (C) Section of the shafts at Washington, combined with a deep core drilling near the C. & K. No. 4 mine.
33. (A) Section combined from exposures in the hill of shaft and boring at Bunker Hill, Knox County, Section 28, 3 N., 10 W. (B) A generalized section from outcrops about Petersburg and Sand Hill combined with an oil drilling at the Wooley mine. The coals in this drilling are not represented the full width of the section, to imply that the data in regard to them is not overreliable.

34. (A) Section at the Hoffman Bank, 1 mile south of Bruceville, on Donation 183. (B) Section from outcrops and drillings near Hosmer, Pike County. (C) Section on Mud Creek, one-half mile southeast of Glendale. (D) Section of the shaft at Alfordsville.

35. (A) A section at Patoka, in Gibson County. (B) A partial section at the Bird mine at Francisco. (C) A combined section from Dongola and the hill east of the south fork of Patoka River, east of Oakland. (D) Section at the Cross place, on Aikman Creek, Daviess County, Section 17, 2 S., 6 W. (E) Section at High Rock, in southeastern Daviess County, on White River, Section 18, 1 N., 5 W.

36. (A) Section from outcrops and boring at Hazelton, Gibson County, Donation 101. (B) Section derived from a number of borings in the Arcadia district. (C) Combined section from those obtained at several of the whetstone quarries in Orange County.

37. Generalized section of Gibson County, as given in the Patoka Folio of the U. S. Geological Survey, combined with the drillings for oil at Princeton. As at Petersburg, the coals in the lower part of this section are not carried across the section on account of the general unreliable character of coals reported from oil drillings.

38. (A) Section of the shaft at Fort Branch. (B) A section at Pikeville, extending north to Patoka River. (C) A section at Huntingburg, Dubois County, extending from the top of Standpipe Hill to the coal in the shaft. This section is not overreliable.

39. (A) Section at Somerville from outcrops in the hills at that point, combined with a drilling there. (B) Outcrop section on Rock Creek, southeast of Pikeville, combined with a section on the road west of the bridge across Patoka River, northeast of Duff.
40. (A) Section at Lynnville, made from sections of the hills to the north, combined with drilling at that point. (B) An outcrop section at St. Meinrad, Spencer County.

41. (A) Section at Millersburg, Warrick County. (B) Generalized section of eastern Pike County, as given in the Ditney folio of the U. S. Geological Survey. (C) ——. (D) Section of Little Deer Creek, Sections 12 and 13, 6 S., 3 W.

42. (A) Section at Babytown, northwest of Evansville. (B) Section from outcrops and a drilling at Scalesville. This section is of interest in showing the unreliability of reported thicknesses of coal as given in the record of drillings for oil and gas. A drilling near Scalesville had reported 6 feet of coal at a depth of 25 feet; 11 feet of coal, with a sandstone roof, at 100 feet; 7 feet of Cannel coal, with a black shale roof, at 130 feet; 4 feet of coal, with a limestone roof, at 250 feet, the record stating that they had “dry-holed through all veins except first.” The section shown was obtained from a diamond core drilling put down close to this oil well drilling to test the accuracy of the report made for that. (C) Section of a well in Holland, Dubois County. (D) Section at the Reed Bank, Perry County, Section 26, 6 S., 3 W.

43. (A) Section from outcroppings and a shaft at Priests Bluff, Section 19, 7 S., 11 W. (B) Section from drillings and outcrops at Boonville. (C) Section from the shaft and outcrops at the Lloyd mine on Big Sandy Creek, in southern Spencer County. (D) Section of the hill east of Troy, Perry County.

44. (A) Section of the shafts at Chandler. (B) Section of a drilling in the top of the hill west of Jasper. (C) Section of Gage Hill, southwest of Maxville, Spencer County.

45. (A) Section made by combining outcrops with shaft section and a drilling at Newburg, Warrick County. (B) A generalized section of Cannelton, Perry County.

46. Generalized section of the Evansville-Henderson district, derived from shaft sections and drill records.

47. From a detailed diamond core drilling at Mount Vernon, Posey County.

48. Section obtained by Mr. F. W. DeWolf and the writer at Corydon, Ky.

49. Section obtained in the same way at Madisonville, Ky.