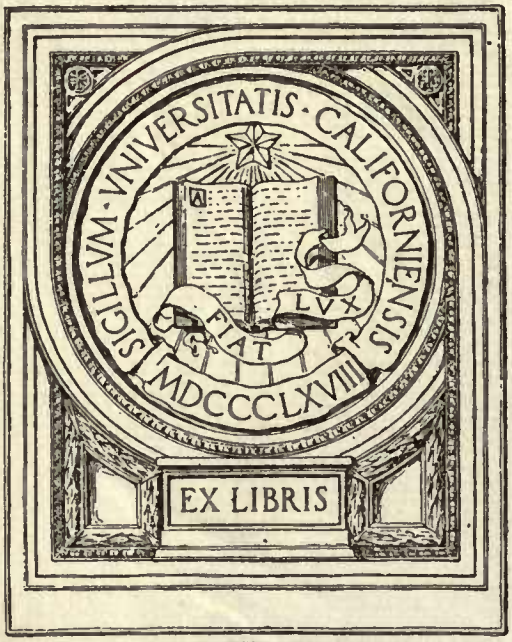

THE NATIONAL RESEARCH COUNCIL
Washington, D. C.

Clean Coal

THE EFFECT OF HIGH ASH

upon

Thermal Efficiency
Amount of Boiler Plant
Amount of Transportation Equipment

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THE NATIONAL RESEARCH COUNCIL
Washington, D. C.

ENGINEERING COMMITTEE
GANO DUNN, CHAIRMAN
43 EXCHANGE PLACE
NEW YORK

NATIONAL RESEARCH COUNCIL
ACTING AS THE
DEPARTMENT OF SCIENCE AND RESEARCH
OF THE
COUNCIL OF NATIONAL DEFENSE

WILLIAM F. DURAND, VICE CHAIRMAN
IN CHARGE OF WASHINGTON OFFICE
ROOM 327 MUNSEY BUILDING
WASHINGTON

December 13, 1917.

Thomas H. Watkins, Esquire,
Chairman, Committee on Clean Coal,
17 Battery Place, New York.

Dear Sir:

At the request of Mr. Frank S. Washburn and for the use of the National Coal Association through you, the Engineering Committee of the National Research Council hereby transmits a report with charts, prepared without charge by The J.G.White Engineering Corporation, on the effect of dirty or high ash versus clean coal upon thermal efficiency, amount of boiler plant, and railroad equipment required for transportation.

Trusting that this will be of use in this critical time, I am,

Very truly yours,

Gano Dunn
Chairman, Engineering Committee,
National Research Council.

GD OPS
Encl.

NATIONAL RESEARCH COUNCIL

ADVISER TO THE
DIVISION OF GEOLOGY AND GEOGRAPHY
OF THE
COUNCIL OF NATIONAL DEFENSE

Engineering Committee
Geo. Otis Smith, Chairman
Director U.S. Geological Survey
Washington, D.C.

Walcott H. Gibbs, Vice Chairman
Professor of Physical Chemistry
Harvard University
Cambridge, Mass.

December 15, 1917.

Thomas H. Watkins, Esquire,
Chairman, Committee on Clean Coal,
17 Battery Place, New York.

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Chairman, Engineering Committee,
National Research Council.

CD CPS
Encl.

THE J.G.WHITE ENGINEERING CORPORATION
ENGINEERS AND CONTRACTORS
43 EXCHANGE PLACE
NEW YORK

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CODES USED
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BENTLEY'S (MINING EDITION)
A.B.C. 5TH EDITION IMPROVED
LIEBER'S STANDARD

January 16th, 1918.

Mr. Gano Dunn, Chairman Engineering Committee,
National Research Council,
#43 Exchange Place,
New York City.

WASTE DUE TO EXCESSIVE ASH OR NON-COMBUSTIBLE IN COAL

Dear Sir:

The elimination as far as possible of slate and other ash-forming impurities in coal, before delivery to railroad cars, will prevent serious economic waste in its utilization and transportation.

It is very difficult to completely cover this subject in a short report, because of the widely varying uses to which coal is put, but since the major portion of the coal mined in this country is used for the generation of steam, the actual percentage being about 67% of the total coal mined, a discussion of this economic waste in the generation of steam will cover the most serious losses. The losses in other uses of coal will be similar, but of a different degree.

These wastes may be briefly summarized as follows:

1. Reduction in Heating Value of Coal Due to Presence of Ash. The presence of ash in coal not only reduces its heating value but as the percentage of ash increases, the percentage of combustible lost with the ash also increases, thus greatly reducing the boiler efficiency and hence lowering the economic value of the coal. See Chart No. 1.

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NEW YORK
J.G.WHITE MANAGEMENT CORPORATION
NEW YORK
J.G.WHITE AND COMPANY, LIMITED
LONDON

January 16th, 1918.

Mr. Dana Dunn, Chairman Engineering Committee,
National Research Council,
643 Exchange Place,
New York City.

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2. Increase in Coal Consumption for a Given Power. The reduction in boiler efficiency greatly increases the amount of coal that must be purchased to produce a given amount of work. This is a direct financial loss, since the consumer is not only paying for unnecessary ash, but is losing good fuel which is carried off through the boiler grates with the excessive ash. See Chart No. 2.

3. Influence of High Ash on Boiler Capacity. The presence of excess ash seriously reduces the boiler capacity, because sufficient coal cannot be burned on the grates to do the necessary work. This is possibly the effect which is felt most seriously by the consumer, because he finds it impossible to get sufficient steam from his boilers to do the work demanded of them and is compelled either to reduce his output, or purchase additional boiler capacity. See Chart No. 3.

4. Increase in Transportation Equipment due to High Ash. About 85% of all the coal mined in this country is carried by the railroads, hence unnecessary ash means an unnecessary task given to the railroads. Each per cent of avoidable ash adds to the work of the railroads about 5,000,000 tons of unnecessary freight per annum. Some shipments of coal contain eighteen or twenty per cent. non-combustible. Such coal requires 65% more cars and locomotives than a reasonably clean coal of say 10% ash. See Chart No. 4.

REDUCTION IN HEATING VALUE DUE TO THE PRESENCE OF ASH.

The heating value per pound of combustible (i.e. ash and moisture-free coal) of all coals approximates 15,000 B. t. u. There are some variations from this figure, but as a general average it is about correct. The

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New York City.

Reduction in Heat values due to presence of Ash in coal.

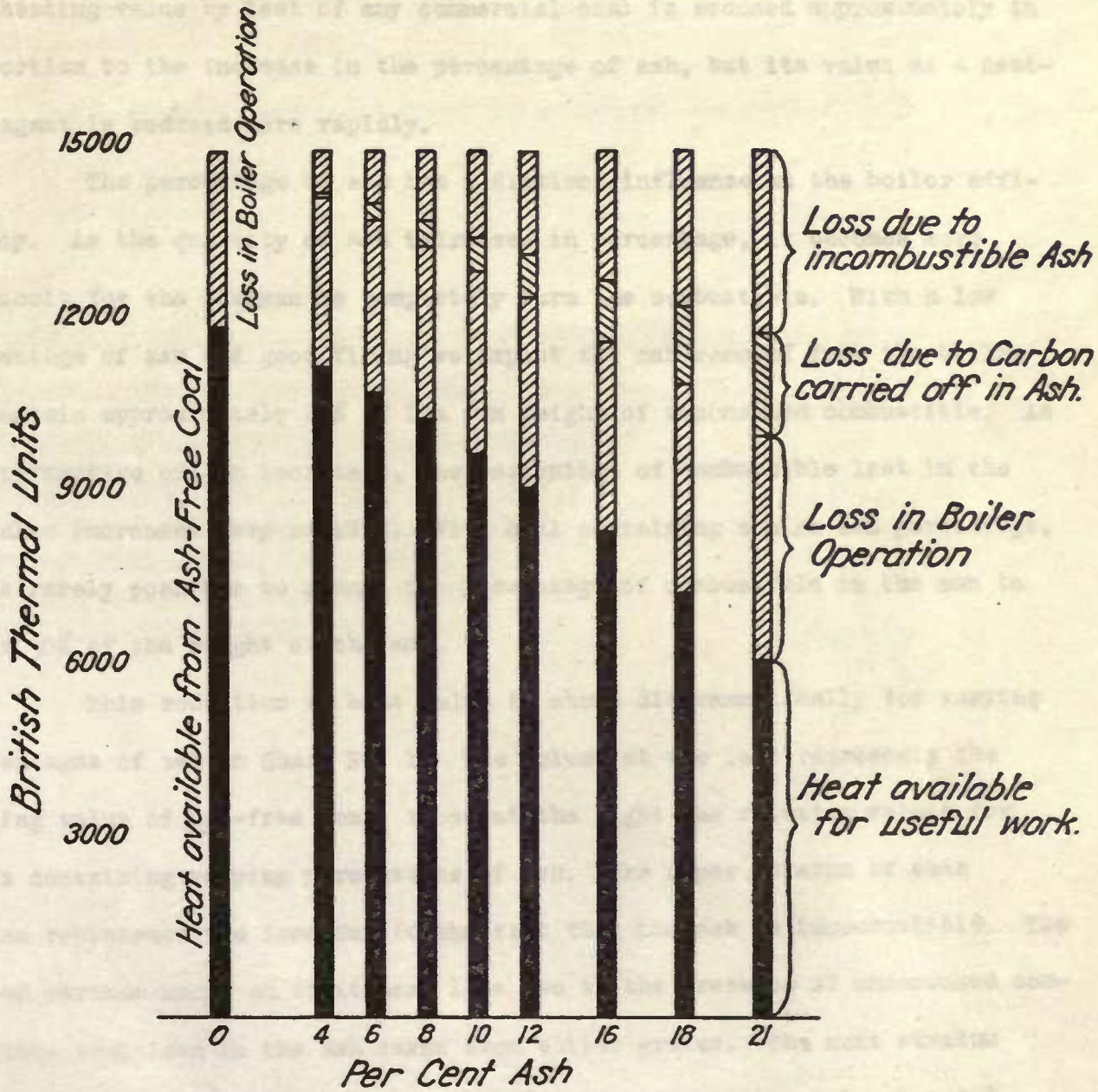

CHART Nº 1

The J. G. White Engineering Corporation
New York City

Reduction in Heat values due to
presence of Ash in coal.

CHART No. 1

variation in the heating value of coal is consequently largely due to the varying percentage of the ash, -- the effect of moisture being less important except in a few cases of unusual moisture content. If we could obtain an ash-free coal, we should expect a heating value of about 15,000 B. t. u. per pound. The heating value by test of any commercial coal is reduced approximately in proportion to the increase in the percentage of ash, but its value as a heating agent is reduced more rapidly.

The percentage of ash has a distinct influence on the boiler efficiency. As the quantity of ash increases in percentage, it becomes more difficult for the fireman to completely burn the combustible. With a low percentage of ash and good firing we expect the ash removed from the boiler to contain approximately 25% of its own weight of unconsumed combustible. As the percentage of ash increases, the percentage of combustible lost in the ash also increases very rapidly. With coal containing a high ash percentage, it is rarely possible to reduce the percentage of combustible in the ash to under 50% of the weight of the ash.

This reduction in heat value is shown diagrammatically for varying percentages of ash in Chart No. 1. The column at the left represents the heating value of ash-free coal, those at the right the relative values for coals containing varying percentages of ash. The upper stratum of each column represents the loss due to the fact that the ash is incombustible. The second stratum shows an additional loss due to the presence of unconsumed combustible contained in the ash taken from boiler grates. The next stratum represents the loss due to the fact that steam boilers cannot be operated at 100% efficiency. The lowest stratum, therefore, represents the relative

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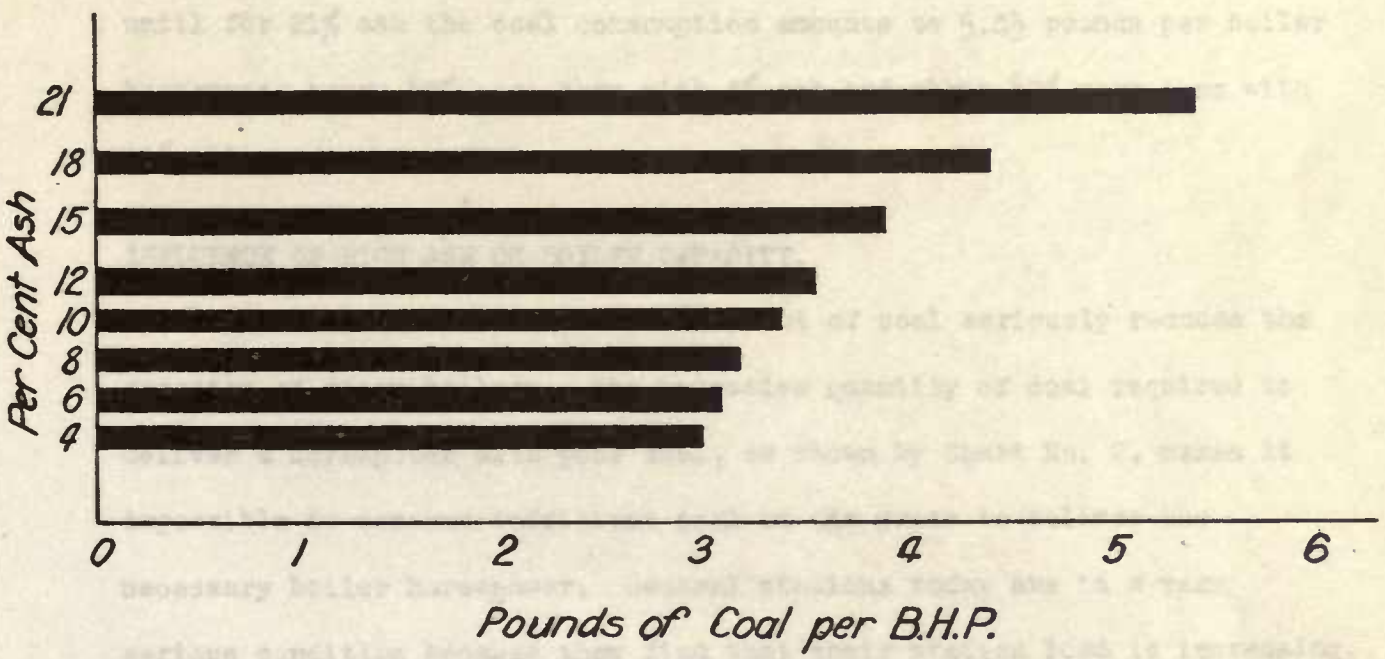

CHART Nº2.

The J. G. White Engineering Corporation
New York City.

Pounds of Coal consumed to produce One Boiler H.P.

Pounds of Coal per B.H.P.

CHART No 2.

commercial values of coal containing varying percentages of ash.

INCREASE OF COAL CONSUMPTION FOR A GIVEN POWER.

On the basis of Chart No. 1, Chart No. 2 has been plotted. This shows the pounds of coal required to produce one boiler horsepower with coal of varying percentages of ash with careful operation. It will be noted that for the best coal with 4% ash, there is required approximately 3 pounds of coal per boiler horsepower hour, and that with 10% ash, less than 3-1/2 lbs. is required. Beyond this point the increase is very rapid until for 21% ash the coal consumption amounts to 5.45 pounds per boiler horsepower hour; 80% more than with 4% ash and about 60% more than with 10% ash.

INFLUENCE OF HIGH ASH ON BOILER CAPACITY.

The increase in the ash content of coal seriously reduces the capacity of steam boilers. The excessive quantity of coal required to deliver a horsepower with poor coal, as shown by Chart No. 2, makes it impossible to consume sufficient coal on the grate to deliver the necessary boiler horsepower. Central stations today are in a very serious condition because they find that their station load is increasing, but that the quality of coal has very much decreased, necessitating the operation of a larger number of boilers. They find that whereas their boiler houses, two or three years ago, were of sufficient size to handle all ordinary increase in power demands, now, because of the poor quality of coal, they find it difficult to provide the steam necessary to carry the station load. Up to within the past two years it was considered good

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New York City.

Number of 500 H.P. Boilers required to generate 300,000 pounds steam per Hour.

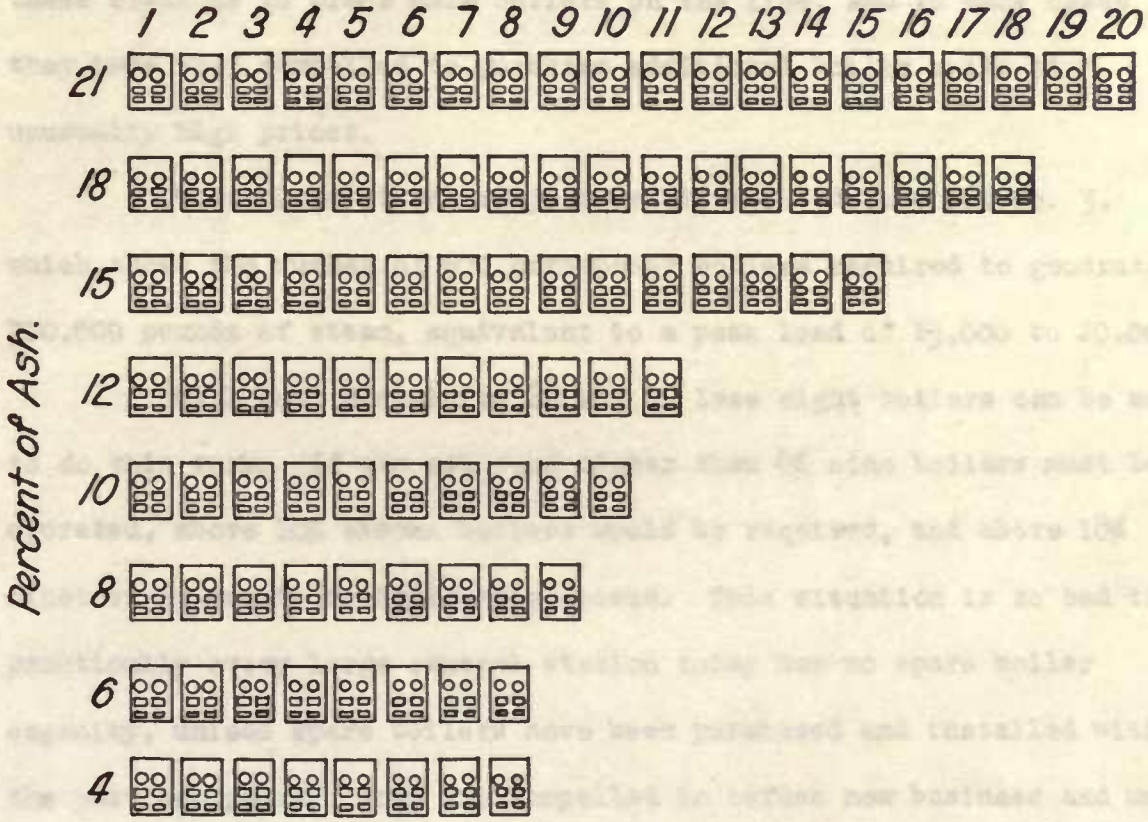

CHART No. 3.

The J. G White Engineering Corporation.
New York City.

Number of 500 H.P. Boilers required to generate 300,000 pounds steam per Hour.

CHART No 3.

practice to operate central station boilers at 200% to 250% of their rated capacity during peak periods. In the same stations it is now difficult to operate the boilers at more than 150% to 160% of their rating, and sometimes at even less. It is, therefore, necessary for these stations to place more boilers on the line, and in many cases they have been compelled to purchase additional boiler units at unusually high prices.

This phase of the subject is illustrated on Chart No. 3, which shows the number of 500 horsepower boilers required to generate 300,000 pounds of steam, equivalent to a peak load of 15,000 to 20,000 k.w.

With coal containing 6% ash or less eight boilers can be made to do this work. If the ash runs higher than 6% nine boilers must be operated, above 10% eleven boilers would be required, and above 18% nineteen or twenty boilers are required. This situation is so bad that practically every large central station today has no spare boiler capacity, unless spare boilers have been purchased and installed within the past two years. They are compelled to refuse new business and must often keep boilers in service that should be undergoing cleaning and furnace repairs.

The effect upon industrial plants is similar to that experienced by the central stations, but in a different degree. Industrial plants do not operate their boilers at the high ratings experienced in central station practice, but they do not as a rule carry so large a percentage of spare boiler equipment as do the central stations. They, therefore,

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find it necessary to operate their entire boiler equipment, or curtail production, and their boilers are kept in service for longer periods than is good practice. It is impossible to take the boilers out of service long enough to properly clean them from scale and to properly repair baffles and brick work in the furnaces. The consequence is that the boiler efficiency is seriously reduced until they are in such poor condition that they must be shut down for cleaning, at the expense of production. With reasonably clean coal this situation would not exist.

INCREASE IN TRANSPORTATION EQUIPMENT DUE TO HIGH ASH.

There is a difference between preventible and non-preventible non-combustible in coal. The non-preventible ash is so thoroughly incorporated with the structure of the coal that it cannot be separated mechanically. This minimum ash content differs in each mine.

By preventible ash is meant the slate and other impurities which can be separated by careful preparation. This minimum ash varies from as low as 2% in some cases to as high as 33% in other cases. The average for the country is probably about 9% or 10%. The percentage of ash in the coal from various States, together with the output for the year 1915 is given in Table I. Over half the coal mined shows an ash analysis of 9% or better. The percentage for the country if averaged in proportion to each State's production is about 9.9%. We may, therefore, consider 10% as a fair average for clean coal for the entire country.

TABLE I

TONS OF COAL MINED IN 1915 AND THE PER CENT. OF ASH IN THE COAL FROM THE PRINCIPAL COAL PRODUCING STATES

	Coal mined per annum. Tons (2000 lbs.)	Average per cent. of unavoidable ash
Pennsylvania	158,000,000	9%
West Virginia	77,000,000	7%
Illinois	59,000,000	13%
Ohio	22,500,000	10%
Kentucky	21,400,000	9%
Indiana	17,000,000	11%
Alabama	15,000,000	12%
Colorado	8,600,000	16%
Virginia	8,100,000	8%
Iowa	7,600,000	13%
Kansas	6,800,000	13%
Wyoming	6,500,000	6%
Tennessee	5,700,000	15%
Other States	29,500,000	12%
	AVERAGE FOR THE COUNTRY	9.9%

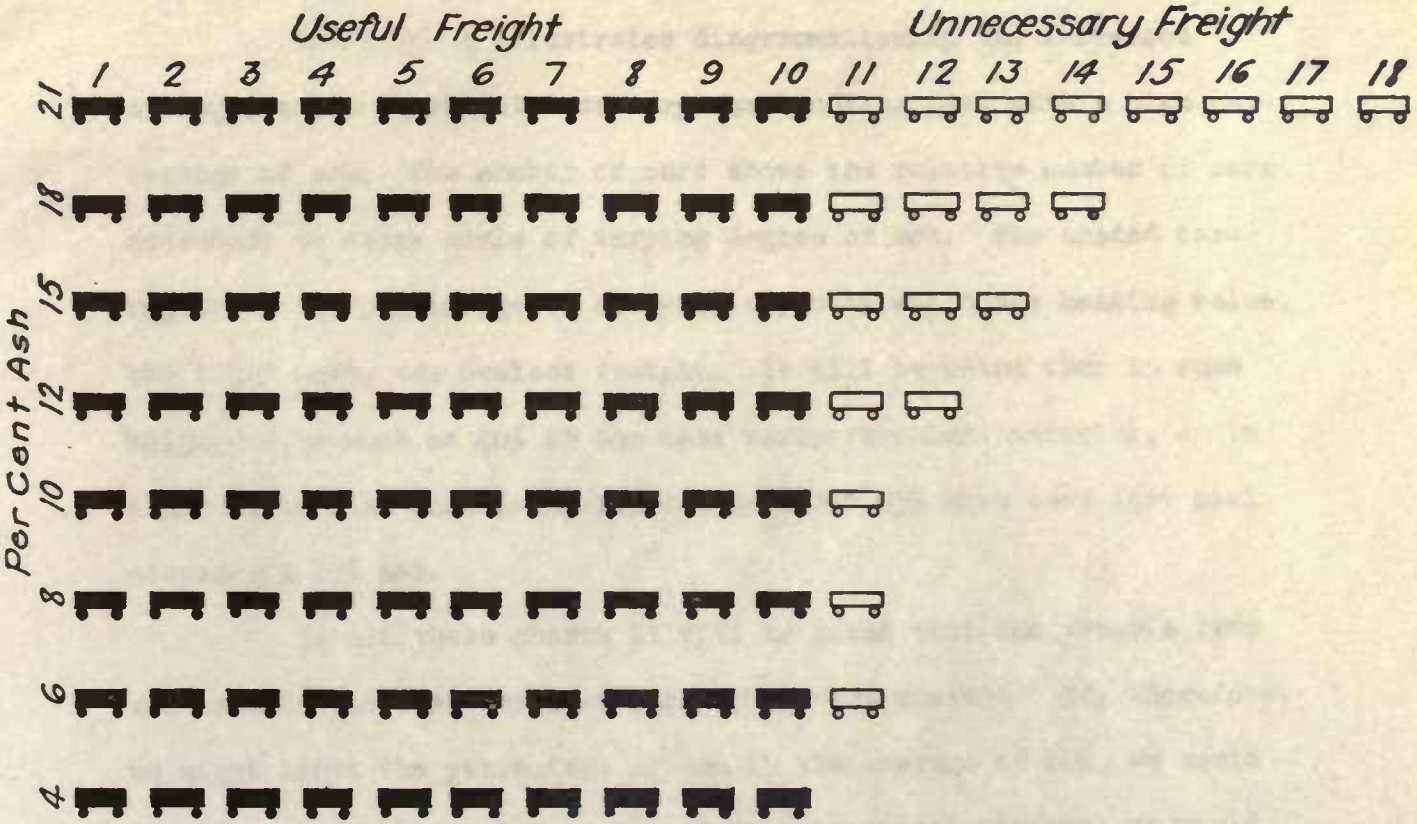
TABLE I

TONS OF COAL MINED IN 1914 AND THE PER CENT. OF USE IN THE COAL FROM THE PRINCIPAL COAL PRODUCING STATES

	Coal mined per annum. Tons [2000 lbs.]	Average per cent. of unavoidable ash
Pennsylvania	189,000,000	9%
West Virginia	77,000,000	7%
Illinois	59,000,000	13%
Ohio	22,500,000	10%
Kentucky	21,400,000	9%
Indiana	17,000,000	11%
Alabama	15,000,000	12%
Colorado	8,600,000	16%
Virginia	8,100,000	8%
Iowa	7,500,000	13%
Kansas	6,800,000	12%
Wyoming	6,500,000	6%
Tennessee	5,700,000	18%
Other States	89,500,000	12%
AVERAGE FOR THE COUNTRY		9.9%

The J. G. White Engineering Corporation
New York City.

Increased Cars Necessary for Transportation of High Ash Coal.



Comparative Number of Cars.

CHART Nº 4.

The J. G. White Engineering Corporation
New York City.

Increased Cars Necessary For
Transportation of High Ash Coal.

Useful Freight

Unnecessary Freight

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Per Cent Gain

Comparative Number of Cars.

CHART No 4

There will be mined this year probably six hundred million tons of coal. 85% of this coal will be transported by the railroads; hence for each per cent. above the average 10%, the excess ash will add to the work of the overburdened railroads 5,000,000 tons of useless freight.

Chart No. 4 illustrates diagrammatically the increased transportation equipment necessary for handling coal with a high percentage of ash. The number of cars shows the relative number of cars necessary to carry coals of varying degree of ash. The shaded cars represent the percentage of carrying capacity which has heating value, the light cars, the useless freight. It will be noted that in some shipments as much as 40% of the cars carry worthless material, or in other words coal containing 21% ash requires 65% more cars than coal containing 10% ash.

In all these charts it will be noted that the trouble from ash is not excessive until we pass 10% to 12% content. If, therefore, we might limit the percentage of ash to the average of 10%, we would reduce our transportation equipment to a practical minimum; we would be able to operate all boilers at a reasonable efficiency and would reduce the number of boilers operated to a little over one-half of the number required for the dirty coal (that is 18% ash or over) besides making a saving in money that cannot be accurately estimated.

Very truly yours,

THE J.G. WHITE ENGINEERING CORPORATION.

W.A. Shoudy

Mechanical Division.

WAS:HD:9:

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THE U.S. SMOKE ENGINEERING CORPORATION.

Mechanical Engineer.

... Clean coal ...