

THE NATIONAL RESEARCH COUNCIL Washington, D. C.

# Clean Coal

### THE EFFECT OF HIGH ASH

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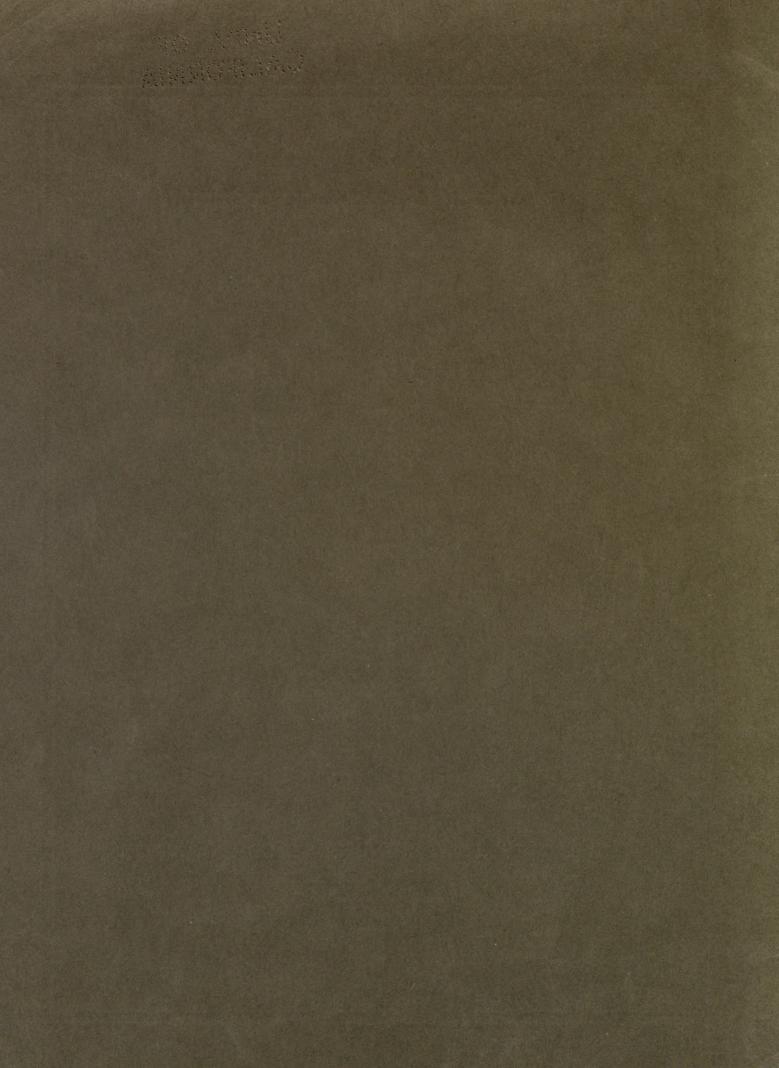
Thermal Efficiency Amount of Boiler Plant Amount of Transportation Equipment

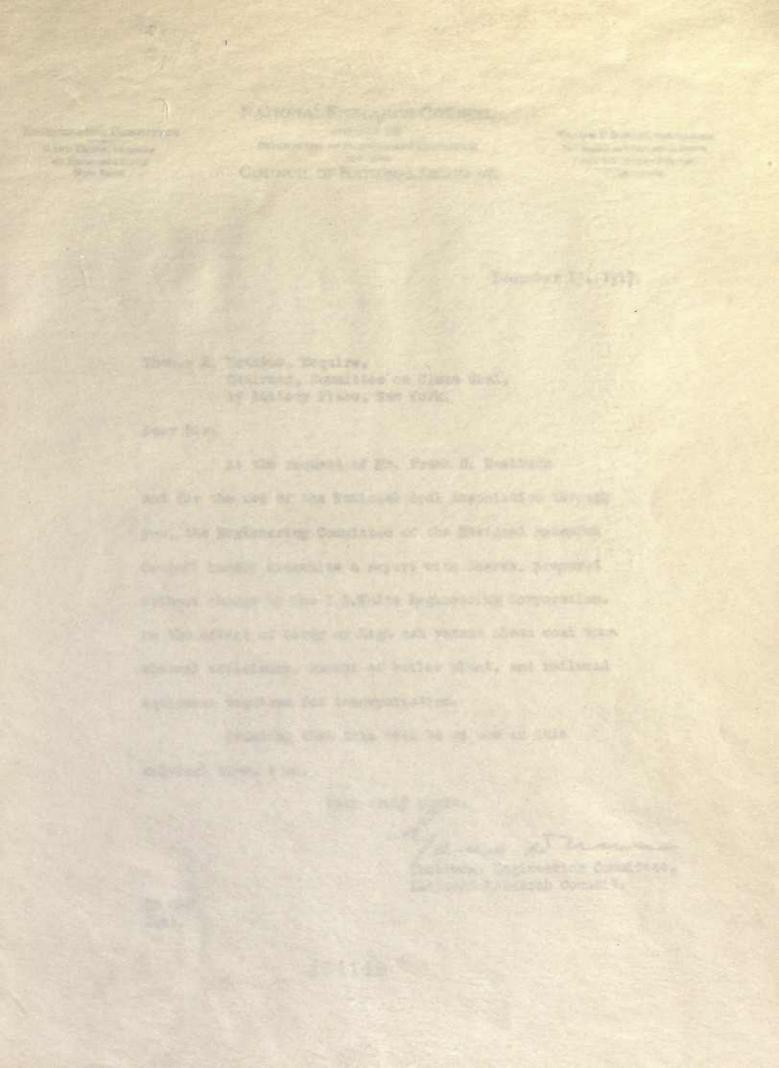
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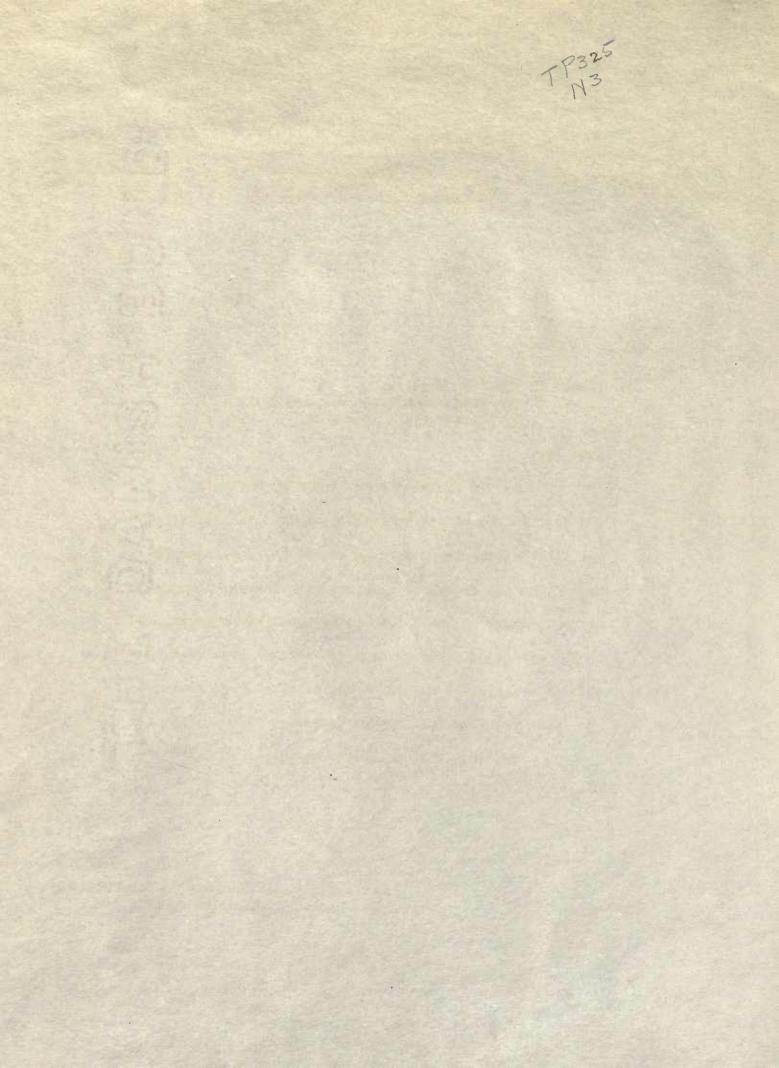
THE J. G. WHITE ENGINEERING CORPORATION

New York

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#### ENGINEERING COMMITTEE

Gano Dunn, chairman 43 Exchange Place New York

#### NATIONAL RESEARCH COUNCIL

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

WILLIAM F. DURAND, VICE CRAIRIAN IN CHARGE OF WASHINGTON OFFICE ROOM 327 MUNNEY 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,

Chairman, Engineering Committee, National Research Council.

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### THE J.G. WHITE ENGINEERING CORPORATION ENGINEERS AND CONTRACTORS 43 EXCHANGE PLACE New York

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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. <u>Reduction in Heating Value of Coal Due to Presence of Ash.</u> 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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THE J.G. WHITE ENGINEERING CORPORATION ENGINEERS AND CONTRACTORS 45 EXCHANGE PLACE 15 WEW YORK

January 16th, 1918.

> Mr. Oano Dunn, Shairman Engineering Counittes, Mational Research Council, (45 Exchange Flace, New York Sity.

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3. <u>Influence of High Ash on Boiler Capacity</u>. 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. <u>Increase in Transportation Equipment due to High Ash</u>. 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 moisturefree 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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2. Increase in Ocal Constantion for a Given Borne. The reduction in belier efficiency greatly increases the mount of coal that must be purchoosed to produce a given amount of work. This is a direct financial loss, atoes the consumer is not only paying for amoundents with the include good feel which is corrised off through the bolier grates with the accessive amodes Chart No. 2.

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

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

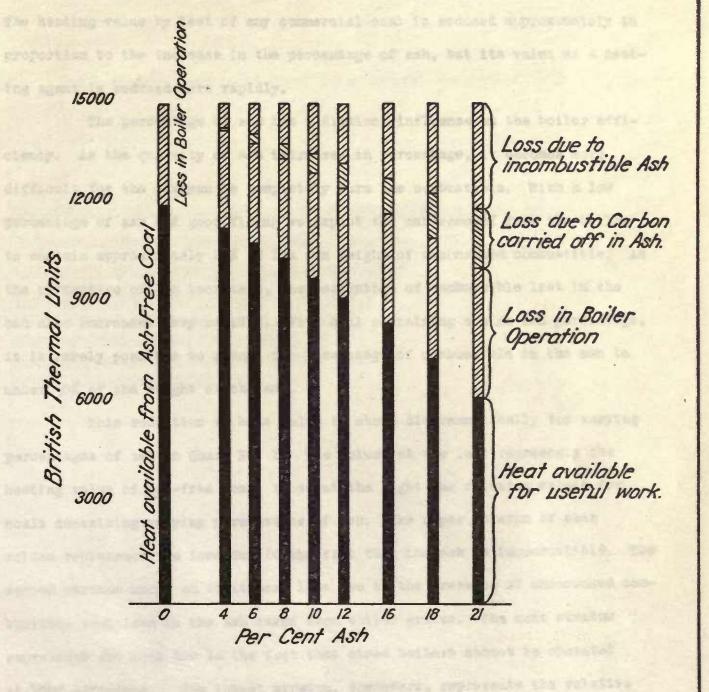
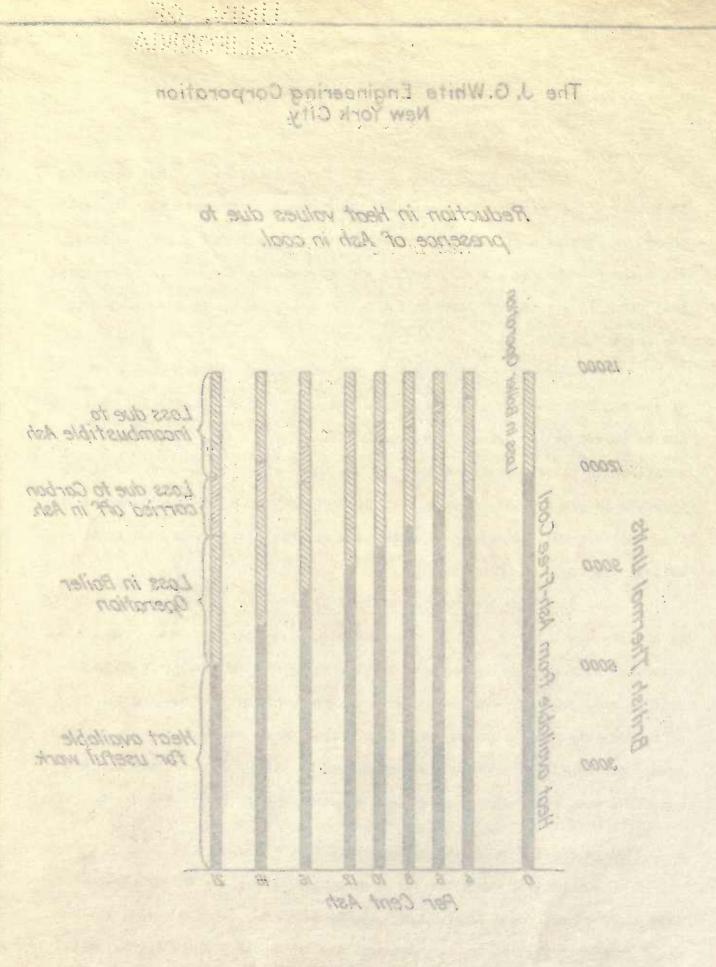


CHART Nº1



CHAPT Nº1

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 ashfree 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

-3-

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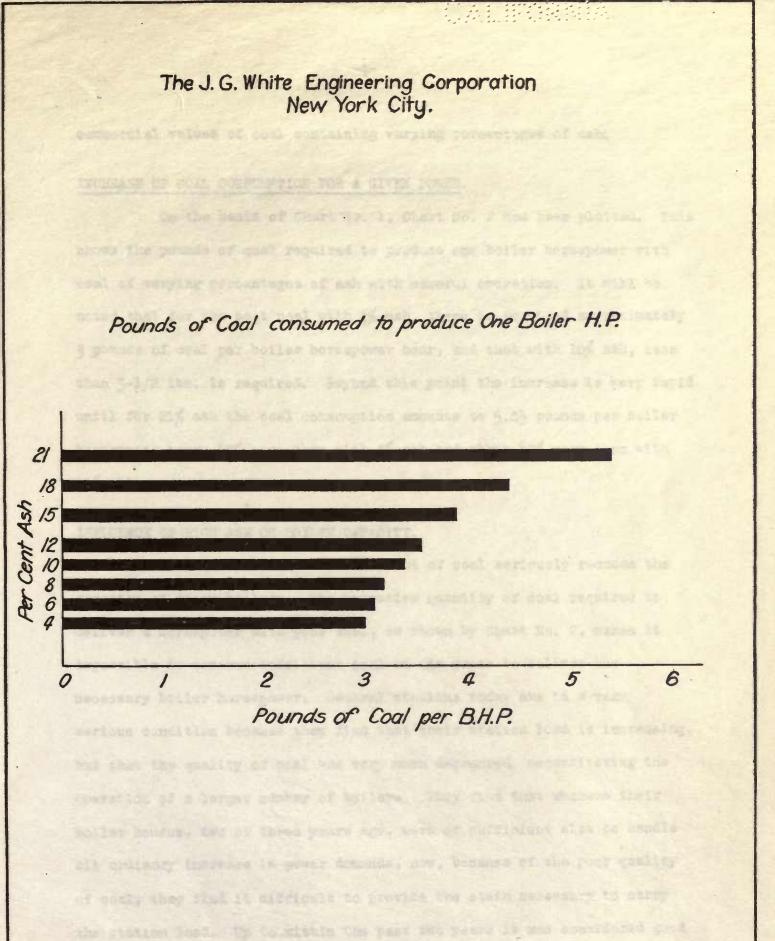
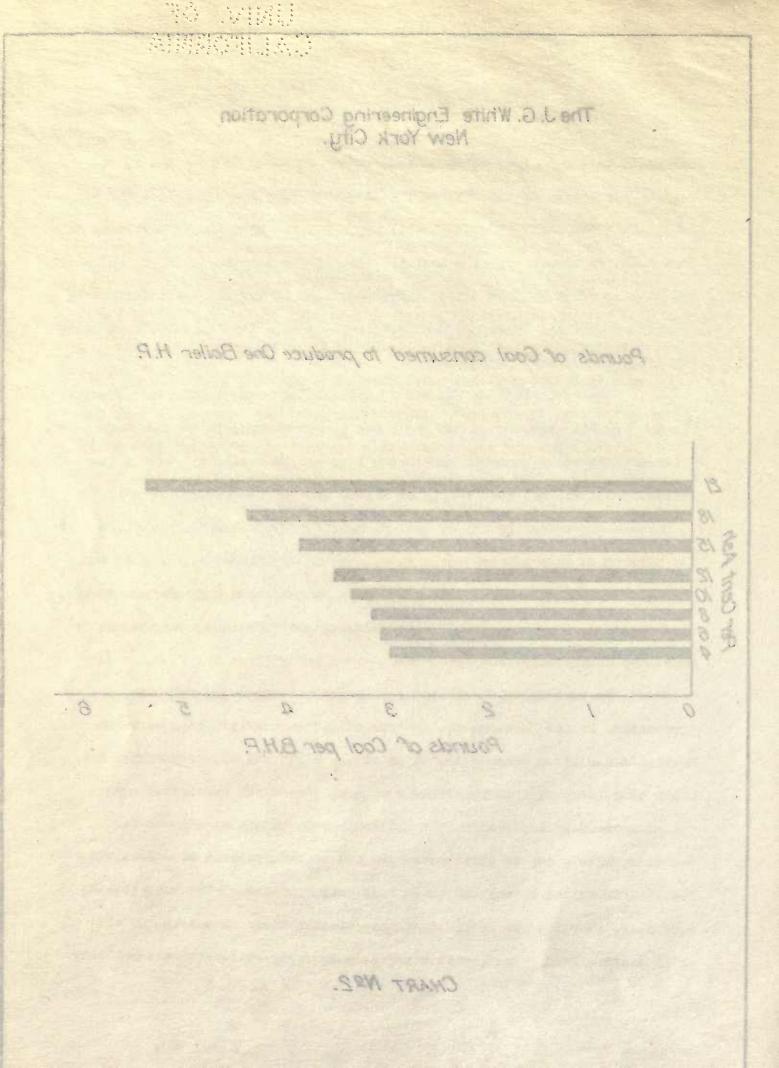


CHART Nº2.



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 des is sealered a values of out shiring varying percentages of ash.

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#### INTERASE OF COAL OCCUPIED FOR A CIVER FORES.

On the basis of Ohert No. 1, Onert No. 2 has been plotted. This shows the pounds of coal required to produce one boller horsepower with coal of warying percentages of ash with central operation. Is will be noted that for the bost coal with 4% ash, there is required approximately 3 pounds of neal per boller horsepower hour, and that with 10% anh, less than 3-1/2 lbs. Is required, Beyond this point the increase is very repid ustil for 21% ash the coal consumption amounts to 5.45 pounds per boller boreasever hour: Boy more than with 4% ash and about 60% more than with the series of series the coal consemption amounts to 5.45 pounds per boller boreasever hour: Boy more than with 4% ash and about 60% more than with

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

Percent of Ash.

Number of Boilers.

CHART Nº3.

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

Number of 500 HP Bailers required to generate 300,000 paurids steam per Hour.

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Number of Boilers.

CHART Nº3.

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,

-5-

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#### 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.

-6-

this is noteerary to operate their extire boller equipment, or cortail production, and their bollers are rept in service for longer periods than is good precise. It is impossible to take the bollers out of service long enough to properly eleme them from scale and to properly repair balfies and briek work in the formance. The consequence is that the boller errichment is emilously reduced until they are in such poor condition that they must be emilously reduced until they are in such of production. With responsibly clean cost this estuation would not exter:

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#### TABLE 1 COSSORY FOR Transporta

on of High Ash Coal.

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### 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 1bs.)	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 Comportatione Alim	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%	
Chant M	AVERAGE FOR THE COUNTR	a 9.9%	

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Average per cent.	Cool mired per emuth. Tonn [2009 104.]	
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202	000.000.77	Wort Virginia
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jio1	22,500,000	0250
NC .	21,400,000	Zontuoky
315	17,000,000	Indi ana
125	15,600,000	At 6b cms
161	8,600,000	Colorado
18	000,001,8	Blaigt 17
ME .	7,500,000	Iowa
AGE .	600.008.8	CARCOL
N	6,500,000	Wyonias
NY	5+900+000	Tamasnoo
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The J.G.White Engineering Corporation New York City. Increased Cars Necessary for Transportation of High Ash Coal. Unnecessary Freight Useful Freight 2 3 4 5 6 7 9 10 100 5 -----Per Cent Ash 12 그 뜨그 ç 10 \_\_\_\_\_ 00 0 4

Comparative Number of Cars.

CHART Nº 4

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

Increased Cars Necessary For Transperfation of High Ash Coal.

Camparative Number of Cars.

CHART NOG

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.

Mechanical Division.

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There will be mined this year processly its hundred militon tons of doal. Soft of this coal will be transported by the railroads; bence for each per cent, above the avarage 10%, the axeus cal will add to the work of the overburdened railroads 5,000,000 tone of useless tratent.

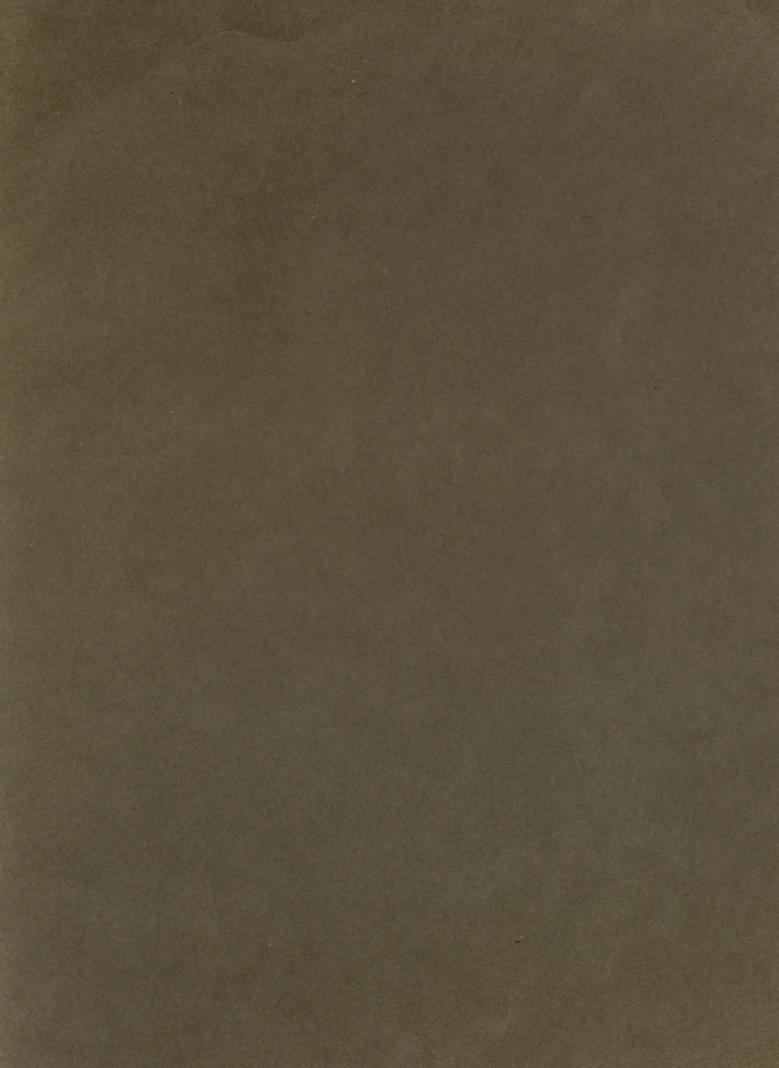
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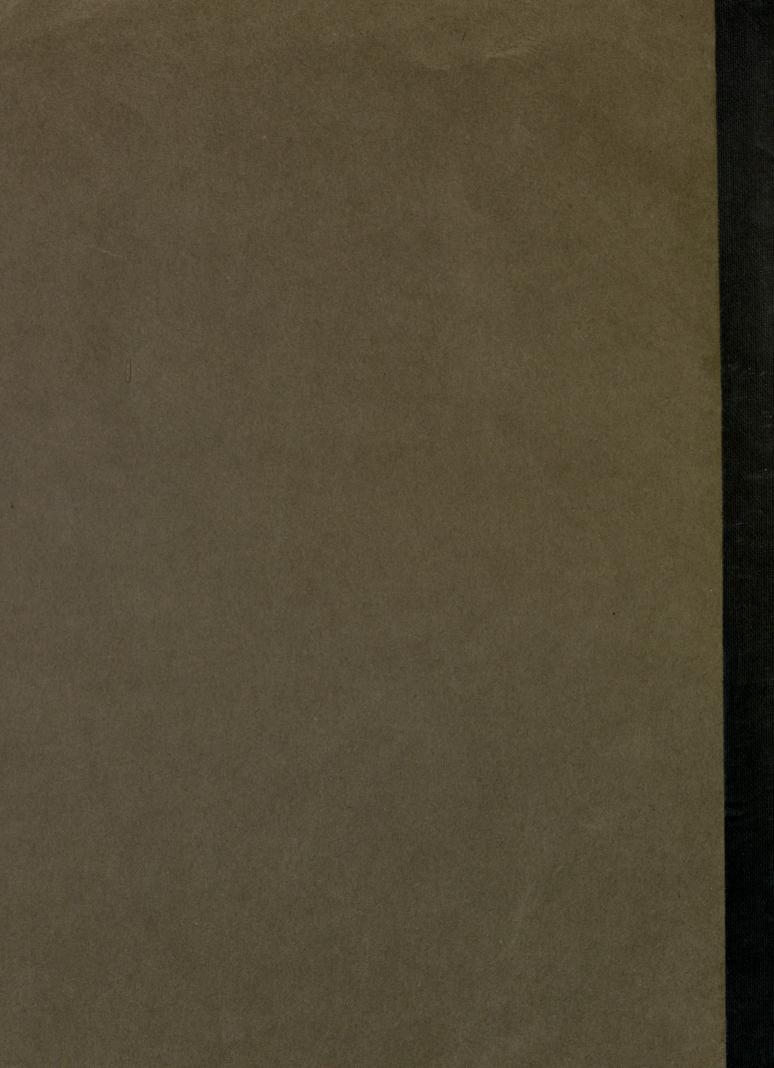
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Syracuse, N. Y. PAT. JAN. 21, 1908

