# of POWER

A Big Business Problem

GERALD B. GOULD, M.A.
AND
CARLETON W. HUBBARD, B.S.

THE COST OF POWER

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A MANUAL OF VALUABLE INFORMATION
FOR BUSINESS EXECUTIVES

By
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AND
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PREFACE

THIS MANUAL was originally written for private distribution among about 200 manufacturers. It is the result of the co-operative effort of these manufacturers to eliminate guess-work methods in the selection and purchase of coal and the development of power.

The combined experience of these coal users in the purchase and use of nearly \$50,000,000 worth of coal has reduced this complex problem to basic principles. No plans or theories are advanced which have not had the test of actual use, and each fact given in the following pages has been verified by a large number of observations.

This problem of the Cost of Power necessitates the application of several branches of exact science for its solution, but it is, after all, the problem of the business man—of the man who pays for the power. Although he may delegate the details of his power problem to others, the business executive of to-day must have a clear conception of this problem, that he may point the way to improvement and set a standard of achievement for his organization.

In the form here presented, the book has been planned to fill the need of business men who have not had an opportunity to study the broader aspects of the problem; and its service is to supplement the reader's knowledge with an analysis of the experience of many users of coal and makers of power.

THE AUTHORS

TABLE OF CONTENTS

PART I

PART II

PART III

PART IV

PART V

PART VI

ILLUSTRATIONS AND CHARTS

IT has been said that we are an industrial nation. I feel that we are only just beginning to be an industrial nation, and shall not be fully entitled to that name until we have a more complete knowledge of the principles on which successful industry is based. Too many of our enterprises are still founded on what has been done rather than on what can be done. The real industrial leader must be guided by future possibilities rather than past performances. The growing disposition among the people of all lands to abolish special privileges of every kind, is going to make it necessary for those who carry on industrial operations to depend more and more upon their own efficiency, and to get away as rapidly as possible from the errors of past practice. We can no longer blindly follow the trail of those who have gone before simply because they were successful. What spelled success yesterday, may spell failure tomorrow. Knowledge, not precedent or opinion, must be our guide. The man whose special training fits him to acquire the necessary knowledge is the engineer; he works with facts which he obtains by investigation; others are usually guided by opinion, which is too often inherited or copied."

HENRY LAURENCE GANTT, M.E.

PART I

Do You Know What Your Power Costs?

To tell you that a plant manager in one of the largest factories in the United States did not know the amount of finished product his factory produced, or the quality of the raw material used, or anything about the economy of its use, undoubtedly would astonish you. You would properly answer: "It cannot be true—such a factory could not exist—it would spell 'failure.'" To tell you that *you*, perhaps, are one of ten thousand who are doing this very thing would meet with prompt and emphatic denial. But stop and think a minute:

You are engaged in making a product to sell. It may be anything from rubber bands to locomotives; but whatever it is, you have spent, without doubt, a large sum of money to improve your methods of manufacture—*to reduce the cost of your product.* The raw material you buy is carefully inspected and tested and probably bought under strict specifications. Your men have been trained to eliminate every useless motion, however small.

But let us ask you two questions: *Do you really know what your power costs? Do you know how much of that expense is loss?*

Do You Know What It Costs to Make Steam?

The foundation of your whole factory system—the first item of expense—is down in the basement, or off in a corner of the yard, forgotten as long as it keeps running—*your steam factory*—we will call it to distinguish it from the factory that makes your sales-product. You consider it a necessary evil, a constant source of rising expense. It can and should be made a dividend payer.

If steam were your finished product—the only thing that you made—and you were selling it to a machine shop next door, in competition with another steam factory, would you operate your steam factory the way you do now? Your answer, of course, is that you would not; but that you are now making car wheels, and your hands are too full to give up the necessary time to go into steam making with the care that a central station man does, who is selling power alone.

What the Business Man Needs to Know About Coal.

Let us investigate the conditions in your steam factory. Where shall we start to put it on the same kind of a business basis as the sales-product factory? The answer is, with *the largest single element in the cost of power—coal.* We must not waste time, however, in lengthy scientific discussion. The business man must enlist the aid of men trained in the scientific side of the coal problem. With confidence in our scientific foundation, we must jump right into the real practical business questions that must be answered. What is the most economical kind of coal for me to buy as a raw material in the production of power? What coal of this kind, judging from records of actual past performance, will give me the most power for the money? Where can I get it? How can I best protect my interests in contracting for this material? *Is my plant turning into power the largest possible amount of this energy that I buy for it? If not, how much is lost, and where is the lost energy escaping?*

How Do You Select Your Coal?

Most plants to-day simply buy so many tons of coal from some dealer who happened to be on the job when coal was needed, or perhaps because his coal *seemed* to work more satisfactorily than two or three others that were tried. These plant managers are doing the best they can, without doubt, but often the most economical coal to use in a given plant is rejected because the firing methods are not suited to the coal. Furthermore, any plant dependent solely upon its own organization must be limited to its experience with the few coals it has had an opportunity to try. Before proceeding further it will be well for you *to call in your bookkeeper* and ask him exactly what you are paying each year for coal—the gross sum of this *first cost of raw material.*

Do You Know the Value of the Coal You Buy?

This is an important question; it means dollars and cents—possibly thousands of dollars. *Coal varies in character* through a thousand gradations, from the anthracite of Pennsylvania to the lignite of Texas, and the value of coal varies tremendously according to the character of the coal seam and the care observed in preparing it for market. *How many plant managers, or engineers, know accurately the value* of each lot of coal they buy? Few can avoid costly experiments for they have no data in advance on the quality and character of coal offered to them. The result is a tremendous loss—the burning up of profits. Variations in quality equal to ten or fifteen cents a ton can occur without being noticed by your firemen or without being reported to you. Perhaps only a half or a quarter of the deliveries are of slightly inferior quality, but it would pay you well to know it promptly. It is watchfulness at every point that pulls down the cost of power. *The plant manager of the past cannot be blamed* for guesswork methods in this department of his business. Up to within the past few years the necessary information could not be obtained from any one central organization, or without very expensive investigation.

Have You a Basis for Establishing a Standard in Buying Coal?

Coal testing is only the first step. When you have your coal tested it is valueless unless you have one more important thing, i.e., a basis for comparison. Tests of your coal compared one with another are not sufficient; it is only comparing your own experience of to-day with that of yesterday. The real value of a test is in comparing it with thousands of other tests in hundreds of other factories. You should have the whole coal market before you in exact terms of coal quality. Then only will you be in a position to know whether you are getting the most for your money. *The selection and purchase of coal,* if done thoroughly, is so bewildering in its complexity and in its countless possibilities that a plant manager, in the midst of his other duties, cannot expect to make an exhaustive investigation of the coal market any more than he would study law rather than submit his legal questions to his attorney.

Why a Central Bureau Has Been Organized to Solve These Problems.

It is this great need of manufacturers and other large coal users that has shown the necessity for an extensive plan of co-operation for the scientific selection and purchase of coal and the economical production of power from it. This has resulted in the establishment of a central bureau managed by specialists whose business it is to gather exact coal and power data from hundreds of coal users and to organize this information so that it can all be focused quickly upon the problems of each plant. This organization is known as the Fuel Engineering Company of New York and confines its operations to this one part of manufacturing costs, based upon practical experience, scientific knowledge, and the accumulation of vitally important data which *cannot be secured in any other way.*

The Fuel Engineering Company operates a large specialized coal testing plant; but, what is even more important, this company has for years been collecting and indexing coal information. This library of records now includes more than 40,000 tests of coal made for several hundred coal consumers, and is being added to at the rate of about 6,000 a year. Coal dealers and miners are indexed to show at a glance the character of coal they supply, their reliability, and their attitude toward their customers. The coals are indexed to show the quality of each kind, its variations, its adaptability to certain plant conditions, etc.

Why Every Industry Has Its Coal Problem.

Many manufacturers use coal in gas-producing plants, and some lines of industry use the heat from coal in manufacturing processes other than the production of power. Each one of these has its own problem in the selection and purchase of coal, and specialized knowledge of coal is here even more important than in the case of the steam plant. The pottery manufacturer must avoid certain fumes. The terra cotta manufacturer requires a steady supply of heat, well under control. The brass foundry must get a certain amount of heat from a given volume of coal. The cement mill, the iron foundry, the smelter—*there are many special coal uses and each one demands an intimate knowledge of coal and the coal market.*

Are You Getting Full Value Out of the Coal You Have Bought?

Surprisingly few plants to-day are equipped to measure the amount of water evaporated, or the exact amount of coal used. Unless the amount of the product of the boiler room is known, as well as the quality and amount of raw material, no accurate comparison can be made between the coal or power costs of two periods. Few manufacturers can say definitely that their higher coal bill this year is due to poorer coal, or to the use of a coal not as well suited to the plant, or to wasteful firing methods, or to more steam used (or wasted).

Preparation Room in the Testing Plant of the Fuel Engineering Company, where the coal samples are pulverized and automatically reduced in size for the testing.

Are You Burning Up Your Profits?

This question can be answered only through a thorough knowledge of the coal market, the exact value of the coal you buy, and a continuous record of operating results. *The interest of the Fuel Engineering Company is identical with the business man's interest —to keep down the rising cost of power.* It does not buy or sell coal, or any form of plant equipment. Its aim is to get the most out of a plant as it stands. The Mechanical Engineering Department specializes on the use of coal, and the elimination of waste in the production of power. For those of its clients who desire it, this department will supervise the manufacture of their power, and thus give to them *a complete and accurate check upon every item of power cost,* from the selection of the coal to the delivered power. At this point the Fuel Engineering Company Service stops, leaving the problems of manufacturing your sales-product to those best fitted to handle them. The following pages therefore will treat of this technical subject with as little scientific discussion as possible. Facts will be found stated in the business man's measure of results—dollars and cents.

PART II

How a Coal Test Differs from a Chemical Analysis.

The coal test of commercial use is not what is commonly, but incorrectly, called—a "chemical analysis." The coal is burned completely to determine the amount of ash remaining, it is dried in an oven to drive off the moisture, it is subjected to a certain amount of heat for a certain length of time to drive off the volatile, and is burned in an atmosphere of oxygen in a calorimeter to measure the amount of heat developed. Is there anything chemical about these processes? And calorimetry is peculiarly within the field of physics, not chemistry. The sulphur determination alone can be called a chemical test. The real chemical analysis of coal is the ultimate analysis which breaks the coal down into its chemical elements; but the results of this ultimate analysis are of no direct commercial importance; and if they were, the cost of such tests and the length of time necessary to make them would rob them of all *practical usefulness to the business man or plant engineer.*

What Terms are Used in Coal Testing.

This coal test—the coal test that the business man needs—*tells the amount of ash, or unburnable material in the coal, the amount of moisture, of sulphur, of volatile matter, and the British Thermal Units.* While these terms are no doubt familiar, a few words about each will be in order before we look into the real dollars and cents meaning of each to the business man.

What Is Ash and Moisture?

Ash is the solid incombustible material remaining after the coal is completely burned. It should not be confounded with the refuse, which is removed from the ash-pit of a furnace. All coal contains a certain amount of solid substance called "ash" which is inseparably associated with its other constituents; but in all coal mined for commercial purposes to-day the amount of this is comparatively small. The major part of the ash in coal as delivered is composed of rock which is found above or below a coal seam, or in the form of partings within the seam. It cannot be measured exactly by the refuse from a furnace, for this always contains a certain amount of combustible matter which is a source of loss in the operation of a power plant, varying in importance with the care in firing methods, and the relation of the equipment to the coal. *The laboratory test is the only accurate means of measuring the ash element,* for there the coal is burned under ideal conditions, and all of the combustible matter is consumed. Moisture needs little comment. It not only produces no heat, but requires a part of the heat liberated by the coal to drive it off.

What Is Volatile?

Volatile matter is that part of the coal which is *driven off in the form of gas,* when the coal is subjected to heat. Part of it produces heat; pound for pound it produces more heat than any other part of the coal.

Differences in the composition of this volatile matter cause wide differences in the amount of heat that different kinds of coals will produce, assuming that each has the same amount of ash and moisture.

What Is Fixed Carbon?

Fixed carbon is simply what is left after the ash, moisture and volatile are accounted for. *It is not determined by experiment*, but is the difference between 100 per cent. and the sum of the percentages of the three determinations mentioned.

What Is Sulphur?

Sulphur is determined separately, and not reported in the test as a part of the 100 per cent., which is made up of the ash, moisture, volatile, and fixed carbon, because a part of it goes off as volatile matter, and a part remains in combination with other elements of the ash. A description of sulphur alone is a purely technical one. A discussion of its significance to the business man will be found on another page.

Why "B.T.U." Is the Measure of Heat Value.

The British Thermal Unit (commonly called the B.T.U.) is the measure of heat value used in this country, and *represents the amount of heat required to raise one pound of water one degree Fahrenheit.* This is not a full scientific definition of the B.T.U., but it is sufficiently accurate for the purpose of giving an idea of its value. 33479 B.T.U. per hour is equal to one boiler horsepower. The heat value of coal is expressed as the "B.T.U. Dry," or "B.T.U. as Received." The B.T.U. Dry is the measure of the heating value of a pound of coal which has been completely dried out. *The B.T.U. as Received* (sometimes called the B.T.U. Commercial) is the measure of heat value of the coal with whatever per cent. of moisture the particular sample is found to contain. If either one is known, together with the amount of moisture, the other can be calculated.

Example:—Given, B.T.U. as received 12,000, and moisture 5 per cent. $\text{B.T.U. dry} = \frac{\text{B.T.U. as received} \times 100}{100 - \text{per cent. of moisture}} = \frac{1{,}200{,}000}{95} = 12{,}632.$

What Is the Difference Between Kind and Quality of Coal?

There are certain characteristics of coal which have been fixed by Nature beyond the power of man to alter. Some of the most important factors in determining the *value of coal as a power producer*, however, can be and are controlled by the methods of mining and preparation of the coal for market. The coal buyer therefore should become accustomed to the consideration of these two classes of characteristics in their proper light. The amount and composition of the volatile matter cannot be changed by the methods of mining, and the amount of heat a given coal will produce is fixed, assuming it to be free from ash, moisture and sulphur. But the miner can, by his methods, very materially affect the amount of ash which a cargo of coal contains, and thereby directly reduce or increase that part of each ton which is of value. Part of the sulphur, like a part of the ash, is an *inherent part of the coal substance*, but in many coals it is largely in combination with iron as a part of the ash, and therefore also controlled to a considerable degree by methods of mining and preparation for market. The B.T.U. is affected in part by the character of the coal; but it is also directly dependent upon the care in excluding as much ash as possible, for as this increases per pound, the heat producing elements decrease in proportion.

Why the "Ton" Is Not a Measure of Fuel Value.

The coal delivered to you is nothing more than "power" in packages—raw material. The ton of black material is the package in which the goods are shipped to you; the volatile is the label which indicates the character of the goods; the ash is an indication of quality and the care in manufacture; and the number of B.T.U. gives you the quantity of power contained in the package. You, a maker of power, should be buying heat (B.T.U.) in the form most economical for you to use (indicated by the Volatile) and delivered in a package called a "ton of coal." Would you buy a box of tools without knowing how many there were in the box, or whether they were suited to your needs, or whether they had been so carefully manufactured that they would give you good service? The only excuse for buying heat units in such a way is that you can see the package, but cannot see the contents or heat units. *Science has devised means of measuring the heat units, and the effectiveness with which your plant uses them in making power.*

How Much Does Coal Vary in Quality?

Consider for a moment the percentage of ash as the only index of the quality of coal. Here are some facts and figures. The data contained in the tabulation below was obtained from tests of about 1,000 deliveries of No. 1 Buckwheat to coal users in New York City. The table gives the highest and lowest ash percentage found during each month. On another page these same figures will be found combined with the B.T.U., and interpreted in terms of money value.

	1912		1913	
	High Per Cent.	Low Per Cent.	High Per Cent.	Low Per Cent.
January	24.92	11.30	23.43	8.62
February	28.42	10.18	33.38	10.20
March	24.60	8.89	22.90	12.16
April	24.13	10.60	25.72	11.92
May	23.93	11.83	27.40	11.70
June	26.18	10.29	31.85	6.32
July	29.50	11.22	28.18	11.66
August	25.40	12.71	24.83	10.77
September	23.95	11.36	30.02	11.40
October	26.80	12.36	26.06	10.64
November	23.70	9.73	26.75	12.10
December	26.68	9.30	25.80	10.63
Average	25.68	10.81	27.18	10.68

How to Interpret This Tabulation.

This tabulation shows the great variations in quality constantly occurring. Considering the whole period, it will be seen that there is a difference of more than 27 between the highest percentage of ash and the lowest. The greatest difference within one month occurred in June, 1913, amounting to 25.53, and the smallest spread from high to low in March, 1913, when it amounted to 10.74. The average high and low percentages for each year show a difference in 1912 of 14.87, and in 1913 of 16.50. It is, of course, extremely unlikely that any one purchaser would get all the poorest deliveries, or all the best. The figures prove, however, that *big variations in value are occurring every day* in the quality of coal delivered.

How Impartial Data is Valuable as a Guide in Buying Coal.

It is only human nature for a dealer to see that his better coal goes to the buyer who has the facts, and *knows what he is getting.* Many coal consumers who have tried it consider systematic tests of coal to be well worth their cost for this reason alone. *The importance of selecting the coal and coal dealer*, on the basis of impartial data collected from many sources, can be seen from an analysis of the facts in the foregoing table. This shows that ten dealers contributed to the good records (low ash). Of these ten, one was credited with ten of the twenty-four good records. Eighteen dealers are represented in the list of poor records, and three of them are responsible for one-third of the high ash figures, without contributing a single one to the good records. Much costly experiment can be avoided by having available such information as that from which this data was compiled.

How Many Grades are There of Each Kind of Coal?

Now let us look at this matter of variations in coal quality from a different angle. We will disregard the variations in quality between shipments from the same mine, and compare the average value of shipments from a number of mines with each other. For this comparison fifteen well-known Semi-Bituminous coals have been selected from the Fuel Engineering Company Library of coal records. The tests were made on coal actually delivered to consumers. In the case of each mine, tests on more than 100 deliveries have been averaged, thus obtaining results which are thoroughly representative of each coal. The sulphur and volatile, as well as the ash, are given in this case, for these elements are of equal importance in selecting Semi-Bituminous or Bituminous coals. The table below shows, first, that different mines producing the same general character of coal may have a distinctly different rating for the quality of coal they produce, accepting the ash as an index of quality; second, how great the differences are in the percentages of sulphur in coals from different mines; and third, how many combinations of these three important factors in coal selection—ash, sulphur, and volatile—are possible.

No. of Tests Averaged	Per Cent. Ash	Per Cent. Sulphur	Per Cent. Volatile	District	Index Number
122	7.48	1.57	21.22	Cambria County	1
138	6.28	.84	19.42	West Virginia	2
294	8.96	2.20	22.22	Cambria County	3
503	7.22	.79	19.55	Cambria County	4
184	9.36	1.01	16.35	Somerset County	5
247	8.74	.97	16.45	Somerset County	6
102	10.55	1.37	22.91	Cambria County	7
168	7.57	1.53	17.27	Cambria County	8
134	6.68	1.35	15.81	Cambria County	9
116	6.49	1.98	20.79	Cambria County	10
139	8.58	1.71	17.61	Huntingdon County	11
153	8.83	2.29	20.90	Cambria County	12
257	10.06	1.57	16.12	Somerset County	13
345	5.24	.69	17.20	Cambria County	14
306	8.86	1.12	15.85	Somerset County	15

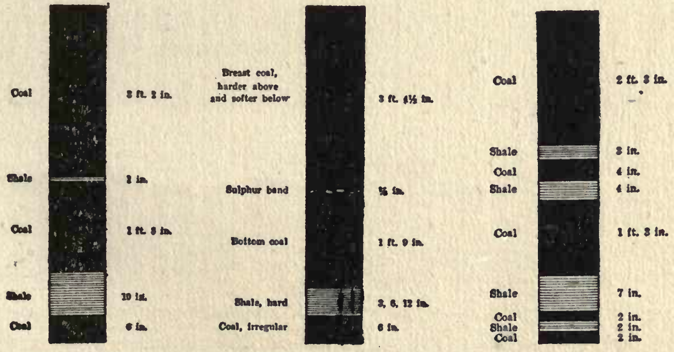
A little study of this table will show how valuable to the coal buyer are the records from which these figures were taken. You now may be using one of these fifteen coals; but do you know which one? Do you know that it is more economical for your use than some one of the others? If some one of the other coals were offered to you, think how valuable data like this would be in making an accurate comparison of value, and in making possible prompt decisions with certainty.

How to Fix the Responsibility for the Quality of Coal.

The inability or neglect of the users to protect themselves on this important point causes the loss of thousands of dollars. The dealer, and back of him the miner, should be responsible for the quality of the product he ships to market. Moreover, he would be held responsible if the coal buyer was not grossly ignorant of what he is buying and unable to prove whether his coal is good, bad or indifferent. The claim that because two shipments of coal came from the same mine they therefore must be of equal value is a fallacy. The character of the coal bed constantly changes as the mining operations advance, sometimes to such an extent that the mine has to be abandoned. But even with mining conditions the same, there is a big human element in the methods of mining and in the preparation of the coal for market. *Every manufacturer knows that the quality of his own product is dependent upon the character of management of the plant*, and upon the interest and reliability of his foremen, his inspectors, and his workmen. How long would you keep your customers, solely upon the strength of your reputation, if you let the quality of your product decline? Your customers test and inspect your goods, and are quick to claim rebates, or to change to your competitor, if the goods are not up to standard. *Why should you not apply the same good sound business principles in buying coal?*

How You are Affected by the Preparation of Coal for the Market.

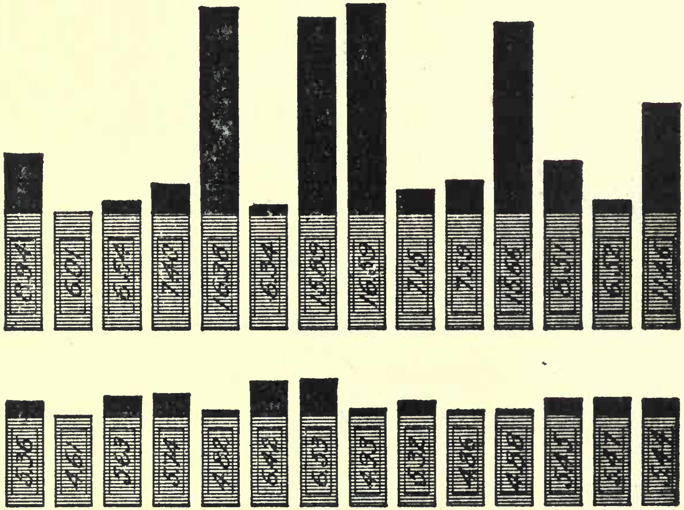
This is an important item and you pay the bill without knowing why. The necessity for preparation of coal, before being shipped to market, varies in different mines. It is your business to know about it. In one place there may be a thick vein of coal, with no parting and easy to mine without taking out too much of the surrounding rock. In another the vein may be thin, or divided by one or more thin partings of slate or other rock material, which must be mined with the coal. Cross sections of several coal veins are given below to illustrate this point.



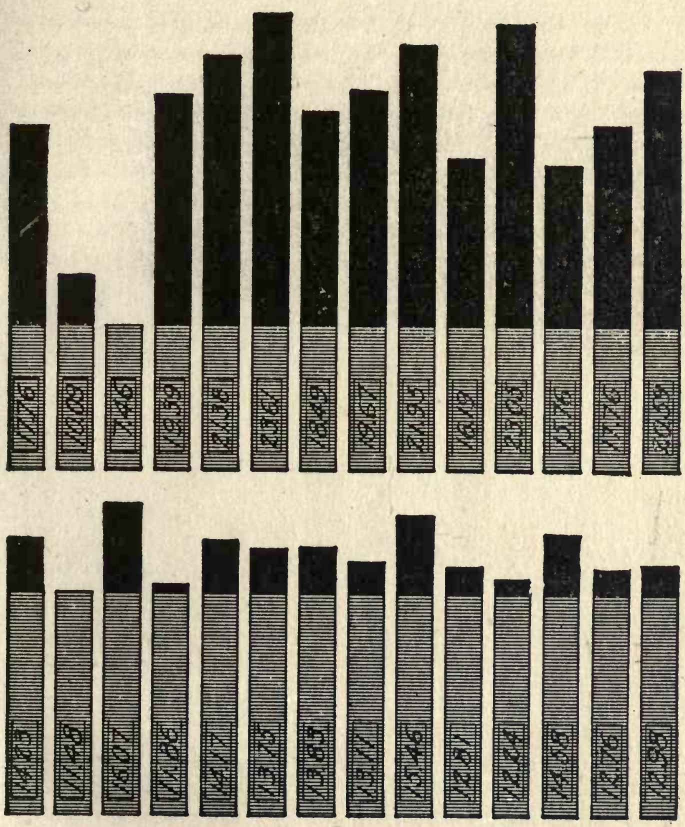
CROSS SECTION OF THREE COAL SEAMS—From the "Maryland Geological Survey."

Why Uniformity Is a Factor in Selecting Coal.

The unreliability of this human element in mining and the variations in quality can be seen clearly from the charts below. Two charts show the ash percentage in fourteen consecutive deliveries of two well-known semi-bituminous coals, and the others of No. 1 Buckwheat. The wide range of the upper semi-bituminous chart is a clear indication of careless preparation (or perhaps none) as contrasted with the lower one which represents one of the best coals of this character offered in the Eastern market.



SEMI-BITUMINOUS CHART—These charts illustrate the varying ash percentages in fourteen consecutive deliveries of two different semi-bituminous coals. The coal represented by the upper chart was poorly prepared and consequently shows wide variations in quality, as contrasted with the lower one.



ANTHRACITE CHART NO. 1 BUCK—These charts illustrate the varying ash percentages in fourteen consecutive deliveries of No. 1 Buckwheat by two dealers. They show how the quality of coal delivered to a given plant may be affected by the degree of care exercised by a dealer in selecting his coal.

What the Government Advises.

The United States Bureau of Mines, in a bulletin, said: "*The quality of coal from a given mine may vary from time to time* through the failure of the miners to reject impurities; or the physical and chemical character of the coal in a certain bed may vary from place to place. In some coal fields different beds of coal are mined at the same time and the output is mixed. When there is need of preparation, as by picking slate or other impurities, or by jigging or washing, the quality or value of the coal marketed depends a great deal on the care taken in the processes employed. The mining companies are responsible in a large measure for variations in the grade of prepared coal. The purchase of coal under a contract that distinctly specifies its quality, stimulates the operator to prepare coal better before shipping it to market."

Why Good Reputation Does Not Guarantee Coal Quality.

A significant story will illustrate how *even the greatest care, and a good reputation, do not guarantee coal quality.* A certain coal mining company had been for some years shipping a very high grade coal. The coal was quite uniform in quality, indicating careful mining methods. The coal was being shipped to several of the Fuel Engineering Company's clients when all at once the tests began to show up unusually bad for any coal of this kind. The sales manager of the mining company insisted that there must be something wrong with the sampling or testing, for he said it was simply impossible for his coal to run as bad as the reports showed it, and pointed to its good record extending over several years. He was finally persuaded to take a trip to the mines to investigate. The result was that he discovered his mine superintendent had some weeks before become extremely intoxicated and remained in that condition to the neglect of the mine.

How You May Pay for Water at the Price of Coal.

All coal contains a certain amount of moisture when mined. Within any given class of coal this factor does not vary to any serious extent. It is beyond the control of the miner. Minimum moisture, therefore, must be considered an unavoidable loss. There is a big variation in moisture, however, that comes from the additions by rain or snow, or from a hose, the latter method usually being of more importance to the purchaser than the former. Coal purchased in car-lots is paid for on the basis of the weights at the mines at the time of loading the cars. This weight, of course, includes the inherent moisture and is not affected by the moisture which is added in transit because of storms.

But reverse the conditions, and pay for the coal on the basis of its weight at time of delivery. Then the moisture is as important as the ash, for it must be paid for at the price of coal, and the excess above the minimum moisture at the mines is a pure loss to the purchaser. This question usually arises where coal is sold in wagon lots, in which case the moisture may have been added through exposure in the dealer's yard, or the dealer may wet it down to make it easier to handle. *There is no apparent reason why the coal dealer should be paid for this excess weight* of moisture at the price of coal, for if it came in the shape of rain it entailed upon him not even the expense of water tax or the little labor with a hose which he would assume if he wet it down himself. His coal is purchased on the basis of the mine weights, and all the moisture he can put on the scales over and above the mine moisture means a very handsome profit in the sale of water. This should not be taken to mean that coal dealers generally wet down coal for the purpose of deliberately defrauding their customers, although it furnishes a splendid opportunity to a dealer inclined to sharp practices, and the percentage of dishonest men, unfortunately, is probably as great in the coal business as in any other. It is, without question, necessary at times to wet down a load of coal, especially coal in fine form, to avoid flying dust as the coal is carried through the streets or is being unloaded. Too much water may be added by *an irresponsible employe* without any instructions or even the knowledge of the dealer; but *the purchaser should be protected from this loss,* and an honest dealer should be willing to accept a reasonable *basis of adjustment.*

How Much Moisture Does Coal Contain?

Moisture varies with the kind of coal (we are now speaking of total moisture at time of delivery), according to its capacity for retaining the water when

Balance Room in the Testing Plant of the Fuel Engineering Company. More than 75,000 weighings are made on these delicate balances each year. (See page 22.)

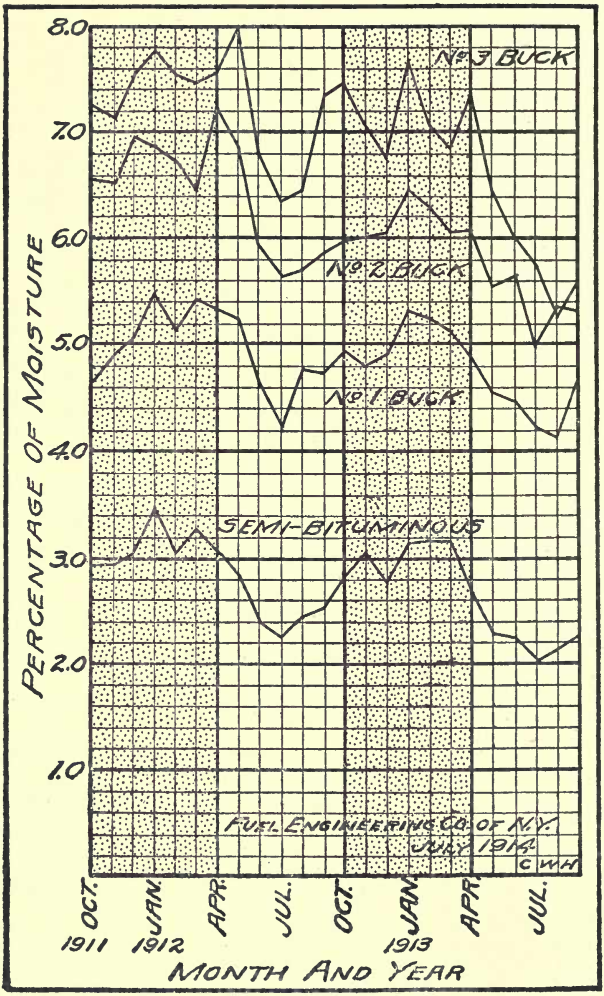
once added. In anthracite coal the smaller the individual lumps of coal the more moisture the coal will hold. Below is a table which shows the average moisture determination on several thousand samples of each steam size of anthracite:

Anthracite—	Pea	4.12 per cent.
	No. 1 Buckwheat	4.34 per cent.
	No. 2 Buckwheat	5.39 per cent.
	No. 3 Buckwheat	6.52 per cent.
	Screenings	7.03 per cent.

Semi-bituminous and bituminous coals are not included under this rule, because they have a certain property of absorbing moisture as well as holding it mechanically. The bituminous coals of the Middle Western field, unlike the Eastern coals, contain a very large percentage of inherent moisture when mined. In comparing the fuel values of different classes of coals this moisture factor should be taken into account, but in a comparison between two coals of the same class, it should be eliminated to avoid differences that are likely to be purely accidental.

How Moisture in Coal Varies With the Seasons.

Although not of any particular commercial application, the relation of moisture in delivered coal to the calendar is interesting. *The chart on the next page was made up from monthly averages of moisture tests during a period of two years* on several hundred samples of each kind of coal each month. The close relationship between the curves would seem to indicate that the variations are truly seasonal ones.



MOISTURE CHART—Notice how the amount of moisture in these four classes of coal changes in the same direction according to the season. There is a marked tendency to higher moisture during the winter months.

One more point in regard to moisture must be considered, and that is in relation to operating records. When coal is weighed, as fired, as a part of the boiler room record, moisture should be taken into consideration, for it makes up a part of the weight of the coal fired, but reduces by that much the heating power introduced under the boilers.

How the "B. T. U." Is a Positive Measure of Value.

Up to this point we have been discussing negative indications of fuel value. Ash and moisture are not heat producers, and their relative presence or absence lowers or raises the *possible limits* of the positive factor —*the heat-producing power of a given lot of coal.* It does not, by any means, indicate the *actual heat-producing power*, which can only be determined by direct experimental methods with an instrument known as a calorimeter. To demonstrate the necessity of actually determining the B.T.U., tests of ten samples of coal have been taken, and each one reduced to the same basis—10 per cent. ash in dry coal.

1.	Semi-Bituminous . . .	14,350 B.T.U.Dry	Normal
2.	Semi-Bituminous . . .	13,950 B.T.U.Dry	Normal
3.	Semi-Bituminous . . .	13,510 B.T.U.Dry	Known to have been heated in storage
4.	Bituminous	14,000 B.T.U.Dry	Normal
5.	Bituminous	13,500 B.T.U.Dry	Normal
6.	Anthracite	13,810 B.T.U.Dry	Normal
7.	Anthracite	13,050 B.T.U.Dry	Normal
8.	Anthracite	12,410 B.T.U.Dry	
9.	Anthracite	12,180 B.T.U.Dry	
10.	Anthracite	11,780 B.T.U.Dry	

Why the Calorimeter Is a Necessity.

It can be seen at a glance, first, that there is an *appreciable difference in heat value* between two samples of the same general character of coal of the same ash percentage and, second, that there is a marked difference in the heat value between different classes of coal.

The first two tests are of perfectly normal, fresh-mined semi-bituminous coal. No. 3 is a semi-bituminous coal, *the heating value* of which has been reduced by heating in storage. In this particular case, the fact that this lot of coal had been heated was known, but the purchaser cannot always have means of knowing such a fact. The coal delivered may actually be considerably poorer than a simple statement of the ash percentage would indicate.

The two bituminous coal tests (Nos. 4 and 5) are both normal, and show the *possible variations under normal conditions.* The distinction between semi-bituminous and bituminous coal will be described later, as well as the reason for the variation in heating value between the different classes of coal.

Why It Is Not Safe to Depend on Ash Tests Alone.

Of the five last tests, the first two are normal anthracites. The last three are tests of a peculiar kind of anthracite, which makes its appearance from time to time. It usually runs quite low in ash, and very low in *heat in comparison to the amount of ash.* The explanation of this phenomenon has not been determined exactly. This much is known, however, that these coals contain some substance which is not a heat producer, and which is not commonly a constituent of the volatile matter of coal, although it is driven off as volatile. Thus one of these anthracites, when tested by the standard method for volatile, showed over 17 per cent., which is the normal volatile of a high-grade semi-bituminous coal. The delivery of a cargo of coal represented by one of the above tests nearly shut down the plant of a client of the Fuel Engineering Company. The coal had been sampled and the test was being run when a frantic telephone call was received from the client to ask what the results of the test were. *He said that he could not keep up steam,* although the coal did not seem to contain more than the ordinary amount of ash. When the test was completed, it was apparent that he had received a lot of this "freak" anthracite. Had this consumer been judging his coal, or paying for it on the basis of ash alone, he would have paid the full price for a very inferior coal. This experience clearly illustrates the fact that the buyer of coal is buying heat units and not an absence of ash.

Why It Is Difficult to Obtain Accurate Heat Value Determinations.

Mr. Joseph W. Hays, a prominent engineer, in an article published in "System," March, 1912, said:

> "A heat value determination is an exceedingly difficult thing to make with accuracy. An ordinary laboratory, be its chemists ever so able, should not be trusted with a B.T.U. determination. Such determination, if it is to be relied upon, requires high-priced calorimeters not found in average laboratories, and also involves a great deal of skill and experience in the manipulation of such

apparatus. There are a great many calorimeters on the market for the determination of fuel values —some of them cannot be depended upon within 500 heat units. There is no such thing as a calorimeter that 'anybody can use' and be sure of accurate results. The more reliable the calorimeter is, the more expertness is required in its manipulation."

The author of this statement has no financial interest in any coal-testing plant, as far as we know, but through his work as an engineer has discovered the difficulty of getting accurate results.

How Heat Determinations Have Been Made More Reliable.

Almost any one of the calorimeters on the market to-day will give reliable results *if sufficient care is used in their operation*. The extreme care and the precautions necessary in their operation make them unreliable in the hands of an inexperienced operator, and impractical for commercial purposes where it is as important to keep down the time consumed in testing (and thus the cost) as it is to have thoroughly reliable results.

The Fuel Engineering Company, long ago, realized the importance of this problem, and after extensive experiments were conducted over a period of several years with thousands of coal samples and a number of different calorimeter designs, an instrument was built which is both reliable and free from the usual chances of error. This instrument is manufactured in the company's own shop for its exclusive use. The U. S. Bureau of Mines has also recognized this need, and now uses calorimeters designed and built by its own organization. Some persons, evidently desiring to impose upon the uninitiated and for the purpose of inspiring confidence in their calorimeter determinations, advertise that their calorimeters are "U. S. Government Standard." There is no such instrument, unless it be considered one of those which are in actual use by the Government, which cannot, manifestly, be in the hands of a private individual. And even if such a thing were possible, it would have little meaning, for the operation of the instrument is so very important. You would hardly choose a surgeon whose sole qualification was the possession of a fine set of instruments.

PART III

How Volatile Matter Indicates the Kind of Coal.

Before passing on to a *translation of coal terms into money terms,* we should understand the kinds of coal as contrasted with the varying quality of coal. Volatile matter was briefly described earlier in this volume as that part of the coal which is driven off in the form of gas when the coal is subjected to heat. This is the part of the coal that makes smoke, and in its improper combustion lies *the secret of many power plant losses.* In its composition lies the explanation of variations of heating value between two coals of the same ash content. The commercial coal test gives only the quantity of volatile, for an ultimate analysis showing its composition is a slow and expensive thing to make—too costly and of too little commercial significance to be of value to the plant manager. We therefore will discuss volatile chiefly from the point of view of quantity, its composition being treated only in general terms.

How Coal Is Scientifically Classified.

Many authorities have suggested *methods of scientifically classifying coals.* Practically all of the suggested methods have depended upon the volatile in some way. For commercial purposes the following divisions have been pretty generally accepted.

Anthracite . . .	up to 8 per cent. Volatile
Semi-Anthracite .	8 per cent. to 12 per cent. Volatile
Semi-Bituminous .	12 per cent. to 25 per cent. Volatile
*Bituminous (Eastern)	25 per cent. to 40 per cent. Volatile

*Middle Western Bituminous runs even higher than 40 per cent. in some cases.

This classification includes the *three great classes of coal used by power plants.* The semi-anthracite is included to explain the gap that would otherwise exist between the anthracite and semi-bituminous, although coal of this character is comparatively rare. This is not as arbitrary a subdivision as it may appear at first glance, for it has been found that the heating value of coal, free from ash and moisture, varies with the character of the coal and helps to define the limits of this classification. In the coal trade the term bituminous is often used to include both bituminous and semi-bituminous coals, and therefore care should be taken to determine exactly what is meant when the term bituminous is used.

How Heat Values of Different Classes of Coals Compare.

On the basis of the same percentage of ash, the heat values of the coals listed above rise as the volatile increases until it reaches about 25 per cent., and then become lower in the higher volatile coals which go to make up the strictly bituminous class. Thus the combustible portion of bituminous and anthracite overlap in their limits of heat value. It should be understood that this is a general classification which is sufficient for commercial purposes. These limits can be more clearly defined only with additional data beyond that supplied by the commercial coal test. The figures given on page 41 for the purpose of demonstrating *the necessity of the calorimeter determinations* will now have greater significance, and those on normal coals are repeated here:

Anthracite . .	10 per cent. Ash	From 13,050 to 13,810 B.T.U.Dry
Semi-Bituminous	10 per cent. Ash	From 13,950 to 14,350 B.T.U.Dry
Bituminous . .	10 per cent. Ash	From 13,500 to 14,000 B.T.U.Dry

What Is Shown by Typical Tests of Three Important Classes.

Let us examine a little further typical tests of the three important classes:

	Anthracite	Semi-Bituminous	Bituminous
Ash	10%	10%	10%
Volatile	7%	17%	27%
Fixed Carbon .	83%	73%	63%
	100%	100%	100%
B.T.U. Dry . .	13,800	14,250	14,000

Assuming, as we have, that the ash remains constant as the volatile percentage increases, the amount of fixed carbon must become less. Carbon is uniform in heat value, and for the purposes of this discussion it may be taken as 14,500 B.T.U. per pound. Subtracting the proper B.T.U. for the respective percentages of fixed carbon above leaves the amount of heat value due to the volatile, thus:

	Anthracite	Semi-Bituminous	Bituminous
B.T.U. per lb. of Coal	13,800	14,250	14,000
B.T.U. of Carbon	12,035	10,585	9,135
B.T.U. from Volatile	1,765	3,665	4,865
B.T.U. per lb. of Volatile	25,214	21,559	18,018
Per cent. of Volatile	7%	17%	27%
Per cent. of total heat from Volatile	13%	26%	35%

To get the heat value of the volatile in the *different types of coal on a comparable basis,* the amount that a pound of volatile will produce has been calculated. A glance at this item above will show that as the amount of volatile increases, its heat value per pound becomes less. The reason is that the additional volatile, as we go up in the scale, adds little or nothing to the total amount of heat-producing gas. This rough comparison is simply to indicate some of the *basic differences in coal.* The heat values calculated for the volatile are only true of these particular samples, which have been taken as representative of types, but give a little indication of the impossibility of calculating the heat value of any coal without an analysis of the volatile constituents. This is not disclosed by the commercial coal test. *The only way is to obtain the heat value with a reliable calorimeter carefully operated by an expert.*

Why the Amount of Volatile Is Important in Selecting the Kind of Coal to Burn.

The per cent. of the total heat of the coal produced by the volatile is worth considering. The last line of the tabulation shows that this may be anywhere from 13 per cent. in anthracite to 35 per cent. in bituminous. Thus a very appreciable amount of the *heat-producing power introduced under your boilers* is liberated in the form of an elusive gas—ready to float out the top of your stack unless your furnace is designed to mix and burn it with a proper amount of air. The coal must be properly fired, and draft and thickness of fire regulated to accord with the character of the coal and the design of the furnace, or a large part of the energy in the volatile will escape.

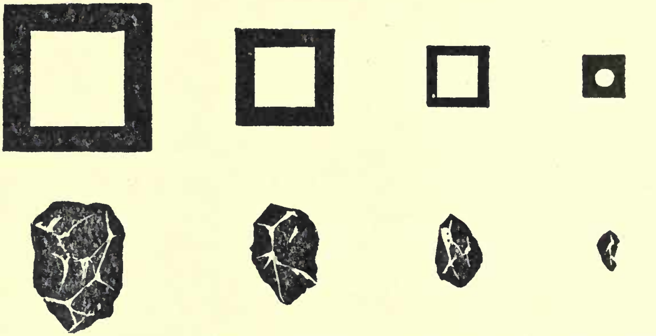
A plant should be designed for the particular kind of coal which is most economical at a given point. Unfortunately, most plants have been built with little regard to this factor, and so the problem is to suit the coal to the plant, and then teach the firemen to use it to the best advantage. Sometimes local conditions make it necessary to burn the lower volatile coals, for they are easier to burn without dense smoke, and this, of course, must be considered. At some points small sizes of anthracite are more economical than semi-bituminous; under some conditions it is advisable to mix the two; or a low grade bituminous coal may be the thing. Thus we have another element to consider in selecting coal—its character—fully as important as the *question of quality of coal obtainable or the reliability of the dealer.*

How the Classes of Coal are Further Subdivided After Mining.

We have seen how coal is divided into certain broad classes based upon its natural characteristics. Some coal, after mining, is shipped to market containing lumps and fine coal, just as it happened to come out of the mine, while at other mines the coal is passed over a series of screens to separate the lumps of certain sizes. Thus we get such terms as *Screened Lump*, *Run-of-Mine*, *Slack*. These terms apply to bituminous and semi-bituminous coals.

Anthracite coal has an elaborate system of sizes from *Broken or Grate*, made up of lumps about four inches in diameter, down through *Egg*, *Stove*, *Chestnut*, *Pea*, *No. 1 Buckwheat*, *No. 2 Buckwheat* (Rice) to *No. 3 Buckwheat* (Barley), which is made up of particles about one-eighth of an inch across. The Grate, Egg, Stove and Chestnut sizes are known as domestic sizes and their use is almost entirely limited to stoves and house heaters. They produce the chief revenue of the anthracite mines. The smaller sizes were long considered useless, and great culm banks grew up at the mines until the coal shortage at the time of the great coal strike of 1901 aroused wider interest in the use of this small coal. Furnaces were designed to use this small coal, and since then millions of tons have been shipped from these culm banks for steam purposes.

These small or steam sizes are the *by-product of the breakers* which crush the coal to the larger domestic sizes. The supply of the steam sizes will gradually become smaller as the culm banks are exhausted until finally there will only be the annual output, and about 10 per cent. of this will be used in operating the mines. The demand for anthracite in localities with strict smoke regulations will probably force up the price beyond its power value as compared with semi-bituminous and bituminous coals, until the larger coal users within our metropolitan districts wake up to the fact that *these latter coals can be used without causing smoke.*



PEA | No. 1 BUCK | No. 2 BUCK | No. 3 BUCK

This illustrates the steam sizes of anthracite. The lump of coal passes through a screen having openings the size of the outside of the hollow square and passes over a screen having openings the size of the inside of the hollow square. The inside of each square is the same size as the outside of the next smaller square.

Why the Size of Anthracite Is Important.

Each of the steam sizes of anthracite *sells at a different price,* each smaller size selling at a lower price although there is no marked difference in fuel value between the various sizes, considering each class as a whole. It is therefore important to use the smallest size of anthracite possible. Many plants now using Pea or No. 1 Buckwheat can be equipped at a comparatively small cost to burn No. 2 or No. 3 Buckwheat, or a mixture, and within a year make a saving that will more than pay for the alterations. *The equipment of your plant will determine which size you must use,* but it is important to see that you get the size you have ordered. For example, if your plant must use No. 1 Buckwheat, it is important to know that you are getting it well screened to size. If it runs 50 per cent. of smaller sizes, you are not only losing too large a part of your coal through the grates and probably choking up your draft, but half of the coal has a market value of from 25 to 50 cents less a ton. The screening test is therefore a necessary part of a coal test on the steam sizes of anthracite. No matter how carefully the coal is screened, there is likely to be a certain amount of the smaller sizes present; but this should never exceed 15 per cent.

Why Sulphur Is an Undesirable Element in Coal.

Another quotation from the Government report will be found valuable in this connection:

"Sulphur is an undesirable element in coal. It generally occurs in combinations with iron, as iron pyrites, and in combination with calcium, as calcium sulphate or gypsum. Pyrites can readily be recognized by its heavy weight, bright brass-like color, and crystalline structure. The calcium sulphate occurs in small, thin, white flakes, more or less transparent. Of the two sulphur compounds, the pyrites is generally contained in larger quantity in coal, and is harmful because it increases the tendency of the coal to clinker. The clinkering is especially bad if the percentage of ash is small in proportion to the sulphur. In such coals the pyrites and the ash fuse together and form a thin layer of solid clinker, which effectively stops the passage of air through the grate, thereby permitting the grate bars to become heated from the hot fuel bed just above. The clinker then melts down into the spaces between the bars, and the sulphur seems to combine with the iron of the grate. The heat warps the grate bars, and the clinker has such corrosive action on the hot iron that a set of grate bars is destroyed in the course of a few days. When such clinkering occurs, any attempt to slice the fire fails, and only slow and very difficult cleaning of the fires will remove the clinkers."

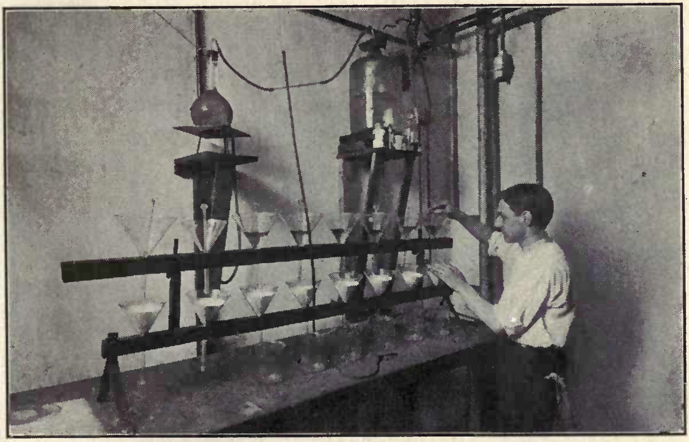
Why Low Sulphur Coals are Usually to be Preferred.

From the fact that the sulphur percentage is an index of clinkering tendencies, the generalization can be made that low sulphur coals are preferable to high sulphur coals, other things being equal. The U. S. Government, at the Fuel Testing Plant at St. Louis, investigated the relation of sulphur to clinker, and to efficiency. Two quotations from the report of *these tests give the conclusions reached very clearly:*

"A curve through the average efficiency points shows a drop of 5 per cent., with an increase of 5 per cent. in the sulphur, or, in other words, every increase in the per cent. of sulphur in dry coal decreases the efficiency in equal amount."

"The curves . . . show that as the per cent. of clinker in the refuse increases the per cent. of sulphur increases; also that all the highest values for per cent. of clinker are grouped with the higher value for per cent. of sulphur. The low per cent. of values for sulphur are grouped with the high values for per cent. of efficiency and vice versa."

Starting a high-temperature furnace to determine the fusing point of ash in the Testing Plant of the Fuel Engineering Company. (See page 57.)



A corner in the Sulphur Room in the Testing Plant of the Fuel Engineering Company. Determining sulphur in coal is the only part of the coal test of a chemical nature. (See page 53.)

How to Avoid Clinker Troubles.

The amount of sulphur in a coal will not tell us definitely whether that coal will clinker under certain conditions. Some plants can burn a coal satisfactorily which will clinker badly in others. Furthermore, of two coals of about the same per cent. of sulphur one may cause clinker trouble while the other will not, although both are tried in the same plant under identical conditions. Clinkers are caused by the melting of the ash, and therefore in selecting a coal for some plants we ought to know the melting point of the ash in the coals we have to choose from. This is determined by heating a cone made of the ash in a special furnace so constructed that the cone can be watched. The temperature at which the cone melts is known as the "fusing point," and is determined by a thermo electric pyrometer. Where the requirements of a plant are known in this regard, *much experiment with coals in the plant can be avoided by making fusing point determinations in advance.* In line with the collection of other coal data, the Fuel Engineering Company for years has been determining the fusing points for a large number of coals in addition to the requirements of its clients, the purpose being to build up comprehensive records on this point so that many questions along this line can be answered for its clients *without delay or additional cost to them.*

How Systematic Tests Simplify Coal Troubles.

Did you ever complain to your engineer that he was not keeping up steam, and receive the answer that the last lot of coal was too poor? Did you then call up the coal dealer and have him insist that he had delivered a very fine coal, and just the same that other plants near you were using satisfactorily? And then wonder which one was right? No matter which opinion you accept you may be doing an injustice to the other, and thereby an injury to yourself. If you had the test of that coal before you, you would know positively whether it was of the same quality, or better or worse than previous shipments. *You could settle that point conclusively, and without any argument.* But what if the test showed the coal to be of high grade, and your engineer reported trouble with it? Then either the character of coal you have been using has been changed so that it does not meet your plant requirements, or there is something wrong with the way in which it is being used. Whatever the situation, the coal test gives you a starting point, indicates which way to turn to locate the trouble. Suppose you have changed your coal because *the coal bill was climbing too fast.* The new coal gives you trouble, and in desperation you go back to the first one. If you had been systematically testing your fuel you could have discovered the reason for the rising cost of power, and before making any change you would have known definitely the character of coal to buy and would have avoided a costly experiment.

How Often Should Coal Be Tested?

Every consignment of coal you buy should be tested. This does not mean that you need a test for every wagon load, or every car; but it does mean that all the coal you buy should be *sampled.* A sample can be so taken that it will fairly represent all the deliveries by wagon over a period of a week, two weeks or a month, as conditions may require; thus one test will give you the average value of all the coal delivered within the period selected. A similar plan can be adopted for car deliveries, making one test cover all the coal contained in two, three or five cars as the case may be. If the coal is delivered in barges, usually one test can be made to satisfactorily check up the cargo, although in some cases it is advisable to make two samples for each barge load. In general, a safe rule to apply, to *keep a thorough check on your coal,* is that you need at least four or five samples for each 1,000 tons. More than this is usually not necessary, except where the consumption is so small that the tests would come at too wide intervals to furnish a thoroughly continuous record. But no matter how many or how few tests you have made, above all things be systematic. Give definite instructions for some systematic method of taking samples, for if it is done only when some one thinks of it, it will surely be neglected, and you will be sure to miss sampling the lot that you most wanted tested. Spasmodic sampling will also fail to give you that definite basis of comparison which you will need so much when the time comes to consider your next year's supply. *Careful and systematic sampling is no burden whatever.* There is always some one around a boiler plant who can be entrusted with this duty and who can easily spare the small amount of time necessary.

How to Take a Representative Coal Sample.

There is nothing intricate or mysterious about taking a sample of coal. Good sampling can be done by any reasonably intelligent, able bodied man if he has proper instructions. Sampling methods for coal, like almost anything else, can be and often are refined to such a point that it would take a bright technical graduate to interpret the instructions. Experience and a knowledge of fundamental principles mixed with a fair share of common sense on the part of the instructor will make a good sampler out of *any man of average intelligence who is willing to follow instructions.* It should be borne in mind that in sampling a quantity of coal the purpose is to represent by a small quantity the whole pile, or car, or barge of coal, as the case may be. Therefore one shovelful taken at random, or a few handfuls, or a single lump, selected here and there will not be representative. In taking a sample of coal, *always use a shovel or scoop* if no mechanical means are provided. Never use the hands, for there will be an involuntary inclination to select lumps that are either particularly good looking or especially bad looking. Take at least a hundred pounds (two hundred is better), remembering that the size of the largest lumps more than anything else affects the size of the sample that should be taken. Try to get about the same proportion of lumps and fine coal in the sample as there is in the lot of coal being sampled. The larger the lumps the larger should the sample be to be representative. When this gross sample has been taken, the lumps are broken down, the coal thoroughly mixed, and the sample reduced in size by successive quartering and mixing. The fineness to which the coal is pulverized determines how small the sample may be reduced in size and still remain representative; therefore a sample should never be reduced below two pounds before being put through a grinding machine. It is impossible to go into more detail here because *specific sampling instructions will vary* with the amount of coal to be sampled, its character, the method of unloading, and the exact purpose for which the sample is taken. Enough has been said however to show some of *the basic principles in taking a good coal sample.*

How Good Sampling Has Been Demonstrated.

There is a certain amount of variation throughout a load of coal, and it is therefore impossible to take a sample upon which a definite statement can be made that a ton of coal or a car of coal contains exactly so many heat units, or exactly so many pounds of incombustible material. The only way this could possibly be determined would be to test the entire quantity of coal which is manifestly an absurdity. Careful sampling will give us the result very closely, well within the limits of *accuracy demanded* for *power plant and business requirements.* It is also true that the slight variations in sampling are as likely to be on one side as the other of a perfect sample, and there is a tendency of these slight variations to equalize themselves in a series of samples. To find out how closely two sets of samples would agree, two of the Fuel Engineering Company's samplers were sent to sample each one of ten barges of coal independently. When the samples were brought in, one was marked No. 1 and the other No. 2 without regard to which sampler took either sample. The tests were made, and the results tabulated and averaged. Here are the ash and sulphur results obtained on each test:

Serial Number	Per Cent. Ash		Per Cent. Sulphur	
	No. 1	No. 2	No. 1	No. 2
1	8.33	8.33	1.14	1.35
2	10.07	9.32	1.78	1.29
3	8.80	8.29	2.11	1.88
4	8.09	8.46	1.64	1.32
5	10.02	9.87	1.35	1.73
6	10.02	10.02	1.46	1.41
7	8.70	8.28	1.28	.96
8	8.36	8.62	1.04	1.14
9	8.38	8.97	1.33	1.34
10	10.07	10.63	2.51	2.34
Average . .	9.08	9.08	1.56	1.46

The fact that the average of the ash percentages for each series came out exactly the same is, of course, pure chance; but both sets of figures show how closely two sets of samples properly taken will check each other, and how the slight variations offset each other. *These samples were taken in the regular course of business for a client of the Fuel Engineering Company*, and the results on each barge were sent to the client as soon as run, the samples on the different barges being several days and in some cases weeks apart.

How a Plant Manager Proved the Accuracy of Sampling.

A certain plant manager, who incidentally was buying his coal under specifications, became involved in a discussion as to whether it made any difference whether he had a test for each car of coal or made a composite sample of several cars. *He made up his mind to test it out and see for himself.* He instructed his engineer to take a sample from each car separately, mix and quarter it down to the usual two-pound sample for testing, and then take what was left of the three gross samples, mix them all up together and quarter this composite sample down to a two-pound sample. All four samples were then tested with the following result:

	Three cars sampled separately			Average of these three tests	Results of test on composite sample
	No. 1	No. 2	No. 3		
Ash	11.22%	12.97%	12.67%	12.29%	12.07%
Volatile Matter .	17.70%	18.52%	18.12%	18.11%	18.54%
Fixed Carbon .	71.08%	68.51%	69.21%	69.60%	69.39%
Sulphur . . .	2.13%	3.49%	2.36%	2.66%	2.77%
B.T.U.Dry . .	13,910	13,590	13,660	13,720	13,765

The man who took these samples was not an experienced sampler, but had learned how to sample from instructions that covered less than half a typewritten page, and had followed his instructions.

How the Testing Plant Is a Model of Accuracy, Speed and Efficiency.

The fact that the Fuel Engineering Company's plant is the *largest commercial coal testing* plant in the world has made it possible in that institution to divide the testing work up so that each man becomes an expert in his one particular part of the test. Accuracy is not only promoted by this specialization, but by the fact that the results cannot be influenced, even unconsciously, by a knowledge of a part of the results. For example, the man operating the calorimeters has no opportunity to form any preconceived notion that his results on a particular sample should come out high or low, for he neither knows the character of the coal nor what results the ash and moisture department has obtained on that sample. Each sample is entered under a number as soon as it is received, and goes to the testing department with no other identifying marks, all the data being retained in the office. By a specially designed system of labels it is made impossible to assign the wrong number to a test. *Each part of the test is determined by different men*, and the results turned in to the office separately. Here the different parts of each test are assembled, and the necessary computing done. The quality of any particular coal sample is of only secondary importance at this point, for the test is first examined for the harmonious interlocking of the various elements.

How Each Test Is Subjected to Closest Scrutiny.

In spite of the specialization of equipment and men, which makes accuracy almost automatic, no results are assumed to be correct simply because the testing department made them. There is, of course, a certain amount of the human element that enters into all scientific observations, but this has been reduced by the Fuel Engineering Company to a minimum by the improvement of apparatus and equipment. What little of this human uncertainty remains, is rigidly guarded against by careful inspection and comparison of results; if any part of the test does not bear its proper relation to the other parts, or shows even the slightest evidence of being a little different from what experience would indicate that it should be, a check test is ordered. Each test is subjected to the same careful scrutiny before the final O. K. releases it. This feature of the work protects the interests of Fuel Engineering Company clients and the Company's own reputation for accuracy, just as the inspection department of a factory insures the maintenance of standard quality of the goods shipped to customers. No records or notes are permitted to remain in the testing department.

Why You Pay More and Get Less by Making Your Own Coal Tests.

Some manufacturers who have laboratories of their own make coal tests. *Perhaps you are one of them.* These men in your laboratory are specialists in your particular manufacturing processes, and in the materials you use. Coal testing with them is a side issue—and if the truth were known, probably a good deal of a nuisance and an interruption to their regular work. If your coal tests are made as often as they should be, *how much is it costing you for the time your men spend on it?* Did you ever look into this point? It would be worth your while to find out how much time your men spend merely in getting the apparatus for the coal test in shape to run the test. This might give you a clue to the reason why the Fuel Engineering Company's specialized testing plant can turn out *results at less cost, quicker and more reliably than you can yourself,* and besides give you valuable coal information which your own organization cannot supply *at any cost.* You may answer: "These coal tests do not cost me anything because I must maintain the laboratory anyway." Can't your men apply their time much more to your advantage on their own special work? *If not, it is time to look into the efficiency of your laboratory.*

How the Fuel Engineering Company Protects Its Clients.

And there is another point to consider. In case of dispute, your own laboratory work is at once under the suspicion of bias, whether there is any good ground for such a suspicion or not. Isn't it better to have this important work done by an independent organization *whose very business existence depends upon results which can be proven to be correct*—whose reputation is worth a thousand times more than the favor of any coal consumer or dealer? In order to doubly protect its clients, the Fuel Engineering Company keeps on file the last 10,000 samples tested, and these samples are at the command of any client for checking purposes under certain regulations which will insure checking by competent authorities outside the commercial field and so removed from all possibility of being swayed by self-interest.

How Test Reports are Mailed Regularly the Day Following Receipt of Sample—or, if Necessary, the Same Day.

The large amount of coal testing makes it possible to turn out complete reports in very short time without sacrificing accuracy in the slightest degree. The subdivision of the testing work reduces the time for the complete test to the net time of the longest single determination; therefore when special occasion requires it, a *coal sample received up to noon can be reported on the same day.* It is only occasionally that test reports are really necessary in such a short time, but the Fuel Engineering Company client knows that quick results can be obtained when the necessity does arise. Prompt reports, however, are always important, and therefore *the rule is that all samples received to-day must be reported to-morrow.*

PART IV

How Coal Tests Can Be Easily Read in Terms of Money.

We have now established the meaning of the terms in a coal test, a thing which *every business man who is a user of coal should know.* It is not necessary for him to sit down and work out for himself the application of these different points to his own plant, for the Fuel Engineering Company's *staff of specialists takes that burden from him.* The significance of each part of the coal test has been explained in detail so that you will understand the basic principles. There is another step of equal importance to the test itself, and that is the financial significance of the figures of coal variations already given. *Coal is bought to produce heat, but the coal bill must be measured in dollars.* Before proceeding with coal values in terms of money, one point should be made clear. The coal which will produce the largest amount of heat for a dollar is not necessarily the most economical coal to use in a given plant. For the sake of simplicity, one thing must be discussed at a time; so for the time being the intricate problem of coal selection will not be considered, and for the present all coal will be assumed to be equally well adapted to the plant.

How the Value of Coal Is Computed.

There are two commonly used methods of comparing coal values. One is to compute the cost of 1,000,000 B.T.U., and the other to figure the number of B.T.U. obtained for one cent. It is obvious that with coals of different heat value, and at different prices, we must have some way of combining the two variables into one figure for comparison. To obtain the cost of a million heat units, it is simply necessary to multiply the B.T.U. per pound by the number of pounds in a ton, and divide the price per ton expressed as cents by the number of million B.T.U. The figure known as the "B.T.U. Net for 1c." was introduced some years ago by the Fuel Engineering Company, and has been used successfully ever since. This figure is not exactly the reverse of the "cost per 1,000,000 B.T.U.," for it also takes into consideration the cost of removing the ash. This added variable does not change the result to any great extent, but it *brings the results nearer to a true value for comparative purposes;* for the higher the ash percentage is the lower will be the probable furnace efficiency. Another advantage is that when two coals, having nearly the same heat value, are compared, the one which produces the given heat with smaller amount of ash has slightly the better of it. The difference in method is not great, however, and need not be discussed here at length; for all value comparisons which follow the B.T.U. Net for 1c. will be used as the basis. It should be understood clearly that from the results of a test no one can fix an absolute value for any given coal. All results are relative. We cannot say that a certain coal at a given point is worth \$2.50 a ton, but it can be definitely calculated that it is worth \$2.50 as compared with another coal which is offered at \$2.60.

How Coal Tests are Translated Into Money.

If this method is applied to the tests previously given to illustrate the variations in quality of No. 1 Buckwheat (page 27), we find the greatest difference within one month is \$1.35 a ton, using as the standard the average of about 5,000 deliveries, at an assumed price of \$3.50. The smallest difference in value, from highest to lowest, within one month is 65 cents a ton. To repeat all of the figures for the two years would become tedious, for the reader is already familiar with the possible variations in quality; but a few of the figures are given below, with the B.T.U. added, as well as the money value based on the standard stated above.

Month	Ash	B.T.U.Dry	Comparative Value	Difference in Value Per Ton
February, 1912 . .	10.18	13,675	\$3.95	
	28.42	10,605	2.96	\$0.99
May, 1912	11.83	13,235	3.81	
	23.93	11,205	3.16	.65
February, 1913 . .	10.20	13,590	3.92	
	33.38	9,420	2.58	1.34
June, 1913	6.32	13,950	4.05	
	31.85	9,795	2.70	1.35
October, 1913 . . .	10.64	13,360	3.85	
	26.06	10,845	3.04	.81

Why Many Coal Losses are Not Discovered.

It has been pointed out before that it is unlikely that any one purchaser would get all of the best or all of the worst, but some figures on the coal actually delivered to two neighboring plants will show the *difference in value* that may be present in actual practice. The figures below are averages of tests made systematically throughout a year. For comparative purposes, the price which plant A paid is given, and the relative value of the coal delivered to plant B is calculated from it.

	Ash	B.T.U.Dry	Comparative Value
Plant A	14.04	12,757	$3.50
Plant B	18.62	12,000	3.27

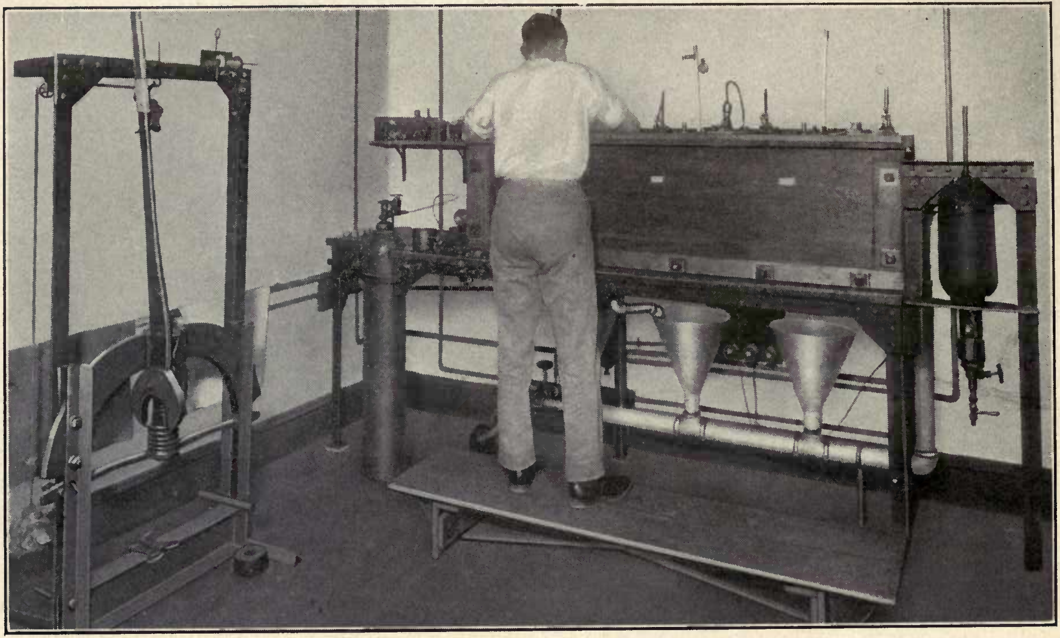
Here is a difference in value of 23 cents a ton for the *average quality throughout a year*. The coal that plant B was using would not make any particular trouble, and no complaints would probably be heard from the boiler room. With no tests, or even with tests and with no basis for comparison, the manager of Plant B might easily have gone on buying this coal at the $3.50 price and never know that he could do better; yet here was a difference of $230 for every 1,000 tons shoveled into his bunkers. With such comparative data the manager had the choice of changing to the dealer supplying the better coal, or of obtaining the poorer coal at a price sufficiently lower *to make it pay to use it.* The purchase of coal under specifications will be treated in detail further on, but it is fitting to mention here that the purpose of properly drawn specifications is to make such comparisons automatic, and to insure the maintenance of the standard throughout the year.

Why Wide Differences in Money Value are Not Limited to Any One Kind of Coal.

The example given above is not extreme, by any means, and hundreds of similar comparisons could be taken from the *records on hundreds of plants* contained in the Fuel Engineering Company library. Bituminous and semi-bituminous coal varies in value even more than anthracite, as a general thing, and the problem is more complicated, for there are many more mines or dealers from which to choose. Here are averages of tests made during a year at two plants using semi-bituminous coal. They were picked out at random, and the better of the two coals is not of exceptionally high quality. There is a difference of 31 cents a ton, using the quality of coal delivered to Plant D at $3.00 a ton as the standard for comparison.

	Ash	B.T.U.Dry	Comparative Value
Plant C	7.96	14,469	$3.31
Plant D	15.42	13,253	3.00

The selection of anthracite coal is largely limited to comparisons of value like this, but when bituminous or semi-bituminous coals are used there are added the equally important considerations of *adapting the coal to the plant* and to the special requirements demanded

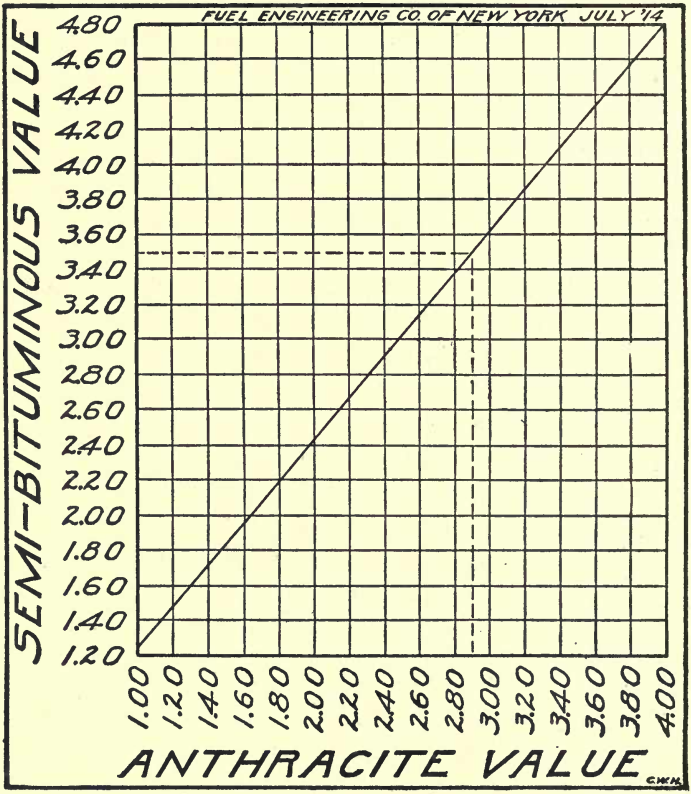


Calorimeter Room in the Testing Plant of the Fuel Engineering Company.
(See pages 42-44.)

of it. A disregard of these features might easily increase the real difference shown above to 40 or 50 cents a ton. Costly experiments can only be avoided by knowing the record of the coals and shippers together with a wide knowledge of the principles of efficient use of coal, and a *study of the conditions at the particular plant in question.*

How the Cost of Transportation From Different Fields is an Important Factor in Selecting the Most Economical Coal to Use.

As the cost of transportation rises, it becomes increasingly important to secure a coal of uniformly high quality. The freight rates from different coal fields of course are affected by the geographical locations of the plant and mines. Therefore, taking into consideration a fair average figure for the heat value of coals from the various fields the freight rates will *determine the class of coal most economical to use*, plant conditions permitting. Take, for example, the relative value of No. 2 Buck, No. 3 Buck and semi-bituminous, based on the average of several thousand tests of each kind. Taking representative prices during April, 1914, at tidewater New York, the figures show that No. 3 Buck at $1.70 would yield about 147,000 B.T.U. Net for 1c., while No. 2 Buck at $2.30 would yield 110,000, and semi-bituminous at $3.00 only 102,500. Thus assuming that the same plant efficiency could be obtained with each kind, No. 3 Buck would be 33 per cent. cheaper than No. 2 Buck, and this, in turn, would be 7 per cent. cheaper than semi-bituminous.



This chart shows the relative value of anthracite and semi-bituminous coal of average quality. For example, it will be seen that any one of the steam sizes of anthracite of average quality selling at $2.90 per ton is roughly equal to a semi-bituminous coal of average quality at $3.51. The average coal quality upon which this chart is based was determined from 8,495 tests of semi-bituminous and 9,885 tests of steam sizes of anthracite, all of which were made by the Fuel Engineering Company of New York. See page opposite for a complete explanation of the significance of this chart.

How the Location of the Plant is an Important Factor in Selecting the Most Economical Coal to Use.

Let us follow this further. If $1.00 a ton is added to the cost of each kind for additional transportation, the relationship is entirely changed; No. 3 Buck is now only 21 per cent. cheaper than No. 2 Buck, while the difference between No. 2 Buck and semi-bituminous is slight—about ¼ of 1 per cent. The infinite number of possible combinations makes it impracticable to do more than generalize on this point, but the example above will illustrate how important it is to have accurate data on the relative fuel values of different coals. The figures given above are summarized in the following table:

Kind of Coal	Price	B.T.U. Net for 1c	Price	B.T.U. Net for 1c
No. 3 Buck . . .	$1.70	147,000	$2.70	94,100
No. 2 Buck . . .	2.30	110,000	3.30	77,400
Semi-Bituminous .	3.00	102,500	4.00	77,200

It is clear that in either of these two assumed cases No. 3 Buck is the coal to use, because of the wide spread between its value and the value of its nearest competitor. If, for any one of a number of possible reasons, it happened that a plant could not use No. 3 Buck, the final choice between No. 2 Buck and semi-bituminous would depend upon a closer study of the quality and price of particular coals available within each group, as well as a study of the equipment and operating conditions of the plant in question. The chart which is shown on the opposite page will be found useful in making a rough *comparison of the relative value of the steam sizes of anthracite and semi-bituminous.* For example, the chart shows that any one of the steam sizes of anthracite of average quality selling at $2.90 per ton is roughly equal to a semi-bituminous coal of average quality at $3.51. This does not mean, however, that it would pay to use No. 2 Buck at $2.90 as against a semi-bituminous coal of average quality at $3.51, for as a general thing the small sizes of anthracite will not give as high furnace and boiler efficiency as can be obtained with a semi-bituminous or bituminous coal. The amount of this difference depends upon the individual plant, and will modify the figures obtained by the chart to that extent. The possibility of the anthracite or semi-bituminous in any particular case being above or below an average quality will further modify the figures also. There is always the further possibility, advisable under some conditions, of mixing a small size of anthracite with a soft coal.

Why Accurate Coal Quality Reports are Necessary for the Operating Department.

The value of the coal test in distinguishing between classes of coals, in selecting the most economical kind, and in choosing the best coal for the money within a given class, *in other words, the value of the coal test from the purchasing angle* covers only a part of its usefulness to the power plant owner. To buy the largest amount of heat producing power for a dollar is only half the problem, for the coal buyer must turn his coal into power; there are many chances of loss between the coal bunker and delivered power. The possible losses of this kind and their prevention will be discussed in detail at another place, but it is worth while to recall, at this point, that the coal test is a vital part of the operating department's records.

The statement that the plant is evaporating so many pounds of water per pound of coal means nothing unless the quality of the coal used is known. For example, an equivalent evaporation of 8 pounds of water per pound of coal, may mean anything from 70 per cent. to 50 per cent. efficiency, depending upon the heat value of the coal used. Losses due to the purchase of inferior coal, or the wrong kind of coal can be prevented by proper supervision of the quality and kind of coal delivered—the records used in buying must be used by the operating department if the losses occurring after the coal has been delivered are to be discovered and reduced. *Efficiency is the relation of the output of energy to the input.* The efficiency of furnace and boiler is that proportion of energy in the coal fired which is actually transferred to the water in the boiler. It is obvious that we cannot determine how efficient a plant is unless we know how much energy there was to start with; consequently the coal test is the foundation of every determination of power plant efficiency. Tests made to assist the buying department therefore should always be placed freely at the disposal of the engineer in charge of the operation of the plant.

Why Greater Efficiency Does Not Always Mean Lower Cost.

Efficiency, economy, capacity—these three terms are often confounded, resulting usually in loss to a plant manager who does not clearly distinguish between them. In many plants there is a constant struggle to increase the efficiency of a power plant, to reduce the proportion of heat supplied to it that is lost, without realizing that the result may not be true economy. For example, investigation of coal value may disclose that it is really more economical to use a certain coal which will only produce 65 per cent. boiler and furnace efficiency than to use a higher priced coal from which 75 per cent. efficiency can be secured. In short, to reach true economy in power production we must not stop with the mechanical efficiency of the plant, but must go back to *the efficiency of the dollar.* The confounding of the real meaning of efficiency and capacity is responsible for many costly experiments with power plant equipment. Some special devices are sold on the claim that they will increase the efficiency of the plant, when what they really do is to make it possible to burn more coal in the same equipment in a given time. You get more power from the plant, you increase the capacity of your plant, but often at a sacrifice in efficiency. It is also true that an increase in capacity, even at a sacrifice in mechanical efficiency, may make for greater economy due to a saving of fixed charges on additional boilers which otherwise might have been necessary. Efficiency, economy and capacity should each be considered in its true meaning to reach the desired result—*the right amount of power, at the right time, at the least cost.*

Why "Evaporation" Alone Does Not Indicate Efficiency.

Here is the answer: "Very frequently unreliable reports are made as to the performance of boilers, and large indeed is the number of false or misleading statements of this kind. The average layman accepts as criterion a statement or determination of 'water evaporated per pound of coal.' . . . And yet it remains true that when in some manner they have obtained a single one of the numerous evaporation figures from their boiler plant, they frequently imagine that they know the degree of economy with which their boilers are working. But as a matter of fact, they have no such knowledge, even if the determination is entirely correct, which is seldom the case. For the economy indicated by an evaporative result depends entirely upon the heat value of the fuel. Thus an 'equivalent' evaporation of 8 pounds based on dry coal will represent the fairly high boiler and furnace efficiency of 70.5 per cent. if a pound of the coal contains 11,000 heat units; but the same evaporation with the coal of 14,500 B.T.U. will exhibit the poor efficiency of only 53.5 per cent., a vast difference indeed. And so the *evaporative result of a boiler means nothing whatever as indicative of its efficiency unless the heat value of the fuel be taken into our calculation.*"*

* Preventable Losses in Factory Power Plants. By David Moffat Myers. "Engineering Magazine," April, 1914. Italics are our own.

PART V

How the Coal Test Plays an Important Part in a Vital Business Problem.

Much has been said about coal tests in the preceding pages, because it is through these tests that we ascertain exact differences in character, or in quality, and *base definite conclusions as to the relative value of different lots of coal.* The experienced engineer accustomed to dealing with such problems uses the test to tell him whether a coal is the particular kind that he has found to be most economical to use in a given plant, and combines it with other data to discover how efficiently the plant is using the coal. This alone, however, is not sufficient to make the coal test a vital business force—a real factor in the conduct of a coal consumer's business. It is very interesting to be able to make comparisons of value of coals accurately, and is of more than passing importance to know what a coal test means; but at the same time you probably have said to yourself: "*Where are the records upon which I can depend for my information?*" "How can I, busy as I am in running my plant, spare either the time or the money to investigate all these different kinds of coal, dig out the records of performance of all these hundreds of different mining operations or coal dealers?" It is too big a job, clearly, for any but the very largest industrial organizations even to attempt. *The ideal solution of the problem* would be for several hundred coal users to combine the results of their coal investigations into one central bureau where the data could be classified and indexed, so that each one might have the benefit of the combined experience of the others. Such a plan for organizing the kind of coal information of importance to the business man—a method of vitalizing coal data—is now in operation. It is not only ideal, but it has been proven thoroughly practical, and has been fruitful of unexpectedly far-reaching results after more than seven years of building. The test of years of service rendered to the coal users participating in the plan has demonstrated its value by *the saving of hundreds of thousands of dollars.*

What Is This Central Bureau of Accurate Coal Facts for the Buyer of Coal?

Back in 1907, a company was formed with one new idea as *its sole claim to distinction.* This company is the Fuel Engineering Company of New York. The new idea was to build up a central bureau of information to supply to coal users every kind of data relating to coal and its use. To do this several other things were necessary. A reliable and efficient testing department was the first essential so that all the data collected could be depended upon implicitly, and a thorough system of indexing had to be devised to make any particular fact immediately available no matter how large the library of records grew. *The co-operation of a large number of coal users* had to be obtained to make the records really comprehensive within a reasonable length of time. To obtain this co-operation on a large scale it was necessary to create an organization along new lines, capable of supplying a service both accurate and prompt, and, equally important, at a cost which would bear a relatively low ratio to the cost of coal. *All this is now an accomplished fact*, and to-day the Fuel Engineering Company library contains more than 40,000 tests of coal delivered to its clients. The amount of coal represented by these tests would fill a solid train of 40-ton coal cars extending from New York to San Francisco.

How the Fuel Engineering Company Records are Collected.

These records are not only unique because of their size and wide application, but they stand out as the product of co-operation of the coal users themselves—*the men who buy coal to produce power.* The Fuel Engineering Company has never sought the business of the man who occasionally wants a sample of coal tested, for such business means nothing more than the operation of a coal testing plant, and contributes nothing to what many consider the most valuable part of the Fuel Engineering Company Service. The company's coal testing plant is operated primarily *for the benefit of coal users who join in the plan* under certain conditions, the chief one being that for each sample tested for them the dealer's name and name of coal (if known) will be furnished. Thus each client furnishes a small amount of information, which is in no way detrimental to his interests to divulge, and receives in return the use of all of the information of like kind supplied by the large number of other coal users.

How to Secure Information From This Confidential Library of Records.

The use of this great library of coal information is absolutely restricted to those who agree to do their small part in constantly adding to it. Furthermore, it is not even necessary for the client to come and dig out his own information; a *request by mail or telephone* will put trained Fuel Engineering Company investigators on the trail of the desired information immediately. It is obvious that the use of the valuable records must be limited further to coal consumers who are willing to agree to furnish a certain amount of information (or in other words will agree to have a certain number of coal tests made each year); also, to a certain extent, the permanency of the relations between the client and the company must be assured. Were this not insisted upon, it would be possible for a coal user to test out one or two samples and then demand a report based on these records, although he had added almost nothing to the common fund of information. This plan also makes it possible to estimate quite accurately the size of the organization needed to supply the service, and *thus help to keep the cost of supplying the service down to a minimum.*

How the Record of a Particular Coal or Coal Dealer Can be Found in Less Than a Minute.

So thoroughly has the Fuel Engineering Company's system of indexing been worked out that the *record of any particular coal dealer or miner can be found almost instantly* in the midst of this really tremendous mass of coal information. The answer to a coal question does not have to be worked out *after* you ask it. The work of indexing and classifying every bit of coal data obtained goes on constantly, so that when you want some particular information it will be found in its place waiting for some one to use it. Starting with the name of the dealer or miner, the name of the coals he sells can be found; this *leads direct to the information on the character and quality of the coal.* Or you can start with the name of a coal, find its characteristics and then turn at once to the dealer or miner who furnishes it and ascertain his record of reliability, perhaps something about his attitude toward his customers, the annual production of his mines, whether he has bid on specifications, etc. If you wish you can select a certain county or district, and pick out the names of the miners in the district, or the names of dealers supplying coal of a particular character. *It makes no difference from what angle of your coal problem you start,* these records automatically lead you direct to the desired information. As a time saver, a money saver and a trouble saver this system of records is invaluable to the coal user; this is especially so when it is considered as the foundation of a complete Coal Service, *an organization of specialists at your command for advice and counsel.*

How the Records are Used by Coal Consumers to Save Money.

When the time comes around for determining upon next year's coal supply, the coal consumer, fortified with Fuel Engineering Company records, has no fear of costly experiments. Too often are coal contracts renewed for no better reason than that the coal has kept the plant running, and the buyer fears to try a change because it will be a pure gamble whether he happens to choose a better or poorer coal. It is only natural to hesitate to make a change under such conditions of uncertainty—it is perhaps wisdom to let well enough alone. The best information he can get is the optimistic statement of a coal salesman, or perhaps a few tests selected for sales purposes. The salesman is not an engineer nor has he made a careful study of the buyer's plant, but even if he were a trained engineer and thoroughly familiar with the plant, how much of a chance is there that he would ever recommend the use of some coal he was not selling? Though he may be as honest as the day is long, his sole interest is to sell his own coal, and he will bring into play all the resources of an able salesman to persuade you to buy it. Contrast with this situation the methods of a client of the Fuel Engineering Company, which *does not buy or sell coal, and has no interest, however remote, in the sale of any coal.* This company sells nothing but its services, and the members of its staff have only one interest—to see that you select, buy and use your coal, in the most economical manner. The records which this organization has at its command to aid it in solving your problems make those of any single manufacturing plant or coal dealer seem insignificant.

How These Records Help the Coal Buyer to Reach the Correct Decision.

Mr. Jones, a client of some years' standing, writes: "We are now ready to take up the question of our coal supply for next year. Will you please send us a list of coals, and dealers selling them, so that we can obtain prices?" Mr. Jones knows that his requirements have been studied long since, and that the exact character of coal best suited to those requirements is well known to our organization. It is a simple matter, therefore, to select from the list of coals of this character those which have a demonstrated record of uniform quality, and the dealers who are best able to handle his business, eliminating those who have been unfair or unreliable in their dealings with other clients. Mr. Jones gets the boiled-down list by return mail, and obtains competitive bids. *He is able to take advantage of competitive conditions* because he has no fear of experiment, knowing that his final selection will be based upon the actual past performance of the coals under consideration. On the other hand, if his present dealer can make an offer which is demonstrated to be the best of the lot, he has the satisfaction of *knowing* that it is still the best coal for him to buy. The bids received are submitted to the Fuel Engineering Company, the prices are carefully compared with the quality of the coal offered, and a report is made from which Mr. Jones can *quickly and easily make his decision.*

How it is Easy to Settle Each Coal Question as it Arises, Conclusively and Promptly—if You Have the Facts.

Every coal consumer receives during the year many requests to consider this or that coal. Many clients settle each one of these offers as it comes up. Here is a typical letter from a client who uses the service in this way:

"The John Smith Coal Company has offered us its coal called 'Red River' at $3.05 per ton.

Please let us know what your records show on the quality of this coal, whether it is the kind of coal adapted to our conditions, and how it compares in value with the coal we are now using."

Return mail would bring a report in this form:

"The 'Red River' coal sold by The John Smith Coal Company has proven of very uniform quality, running low in ash and sulphur. The character of this coal is the same as the coal you are using, but the price asked for it is too high to make it more economical than your present coal. The average of tests on 128 deliveries is as follows:

Ash	7.41%
Sulphur	1.12%
Volatile	20.32%
B.T.U.	14,482

Based upon this average you would have to buy this coal at $2.95 to do as well as you are doing."

The particular coal offered might have been ill-adapted to this plant for any one of a dozen reasons, or it might have been an offer which the owner could not afford to let slip. In either case, it was important to be able to come to some definite conclusion, *based on established facts, and to do it promptly.*

How You Can Find Unexpected Sources of Coal Supply.

Some coal users say: "It is no use to try to adopt scientific methods because I am dependent upon one dealer and one kind of coal." But are you sure that you really are so limited? Certainly it is worth while to investigate this point thoroughly, and find some other source of supply if it is humanly possible. There is no better way to run this point down than to enlist the resources of this extensive system of coal records and *trained investigators who are accustomed to settling just such problems.* A large brewery in one of the larger Eastern cities took Fuel Engineering Company Service for this very reason. They felt that their condition was hopeless, and needed outside assistance. Their problem was solved, and quickly too, with the result that they saved 90 cents a ton on more than 10,000 tons of coal. And if you *are* really limited to one source of supply under present conditions, *it is possible that the conditions can be changed.* Assuming that your dealer is doing the very best he can for you, that he even takes a philanthropic interest in the success of your business, is it good business policy to place the power of controlling such a vital part of your business in the hands of another who has no responsibility for your profits? As a matter of protection, whether you change your dealer or not, you should certainly find a secondary or *reserve supply to draw upon.*

How This Bureau of Coal Information Meets Your Emergencies.

Events which interfere with or cut off the coal supply of a plant usually occur unexpectedly. When they do occur, *quick and decisive action is necessary to avoid great loss,* for it is no small matter to shut down a plant because of lack of fuel. A strike, a flood, or a blizzard may suddenly cut off the customary source of supply, and at such times one little hint or suggestion may be worth thousands of dollars. For example, a large plant in northern New York State suddenly

Library of Records—The original records of more than 40,000 coal tests are protected against loss in this way in the vaults of the Fuel Engineering Company. (See page 83.)

found itself without coal because the dealer with whom it had contracted was tied up by a shortage of cars. A force of men was put to work cutting wood to keep the plant in operation, and a telegram went to the Fuel Engineering Company to find some coal en route that could be purchased and diverted to them. By knowing where to turn, and by being located at a great coal market, we were able inside of two hours to locate ten cars of coal and start them on their way. *Thus within a few hours and at a cost of a short telegram* this plant accomplished what a plant without the facilities of this organization at its command could not have accomplished without days of negotiation, if at all.

Another large plant in New York City had a contract for a particular coal which had been selected with great care to meet certain conditions. It was vitally important to keep the plant running twenty-four hours a day, and only a limited number of coals could be depended upon to do this. A local strike cut off the supply of the regular coal, and a quick decision had to be made. A telephone call obtained from the Fuel Engineering Company a list of the coals which would be suitable, and the manager of this plant was able to make arrangements immediately for the delivery of one of them, knowing in advance that *it would meet his peculiar requirements.*

How One Manufacturer Saved the Cost of a Year's Service by Asking One Question.

A New England manufacturer, at a time when a general suspension in the coal fields was being talked of, wrote that he was seriously considering the purchase of fifteen cars of coal which had been offered to him, as a reserve in case of a tie-up, and asked for an opinion on the matter based upon a sample of the coal that he was forwarding. The reply that went to him contained the information that this coal was worth fully 30 cents a ton less than the coal he was regularly using, and was not adapted to his conditions at all. He was further advised that a general strike in the coal fields was extremely unlikely. His regular coal supply was not interrupted, as a matter of fact; he did not buy the coal, and an expensive experiment was avoided. *Emergencies like these can seldom be fore-seen;* you may be fortunate enough to avoid such a situation, but it is good insurance to have the resources of an organization such as the Fuel Engineering Company at your command, especially as it goes along with a complete service which *gives you protection from coal mine to delivered power.*

How Current Additions to the Records are Placed on Your Desk Each Month Through a Loose-Leaf System of Printed Monthly Reports.

A large amount of coal data is furnished to each client regularly through a system of confidential reports, compiled in loose-leaf form. Toward the end of each month, all of the tests made for all of the plants participating in the co-operative plan are compiled and printed. Strict measures are taken to guard against a single copy of one of these reports getting into the hands of any person not participating in the plan, and these reports are furnished under the *express agreement that they are to be used only by the recipient.* The report gives for each test the name of the plant, the name of the dealer, the kind and trade name of the coal, and the test result. The price paid, or any other confidential information, of course, is not included in this report. Each report is punched for insertion in a loose-leaf cover furnished for the purpose, so that each client has in convenient form for reference a large amount of valuable data on the quality of various coals. Regarding these reports, a large lighting company wrote to another coal user:

> "The report furnished by the Fuel Engineering Company each month on all the coal tested during that period is a very complete record. It covers all grades of coal, and is alone worth the yearly price charged for the service. We have several times referred to the report on certain grades of coal when a representative of that coal has stated that he would guarantee the B.T.U., etc. It showed up the facts so that the representative would not stand by his statement."

Why Now Is the Time to Make the Big Savings by Scientific Methods in Coal Buying.

It is an established law that the price of a product is controlled by the relation of demand to supply. This is, of course, also true of different grades of a product. At the present time only a very small proportion of the coal used is selected and purchased scientifically. There are thousands of kinds and grades of coal, but so little is known by coal buyers generally about coal values that the prevailing prices of the various coals in innumerable cases bear no relation to the real value. Now is the time to dig deeper into this subject, to get the real facts and *take advantage of these discrepancies in value* which are not seen by the guess-work buyer, whose rule of thumb methods are really making these opportunities. When scientific coal selection and purchase becomes universal, or nearly so, intelligent demand will adjust prices and bring them into their proper relationship. Then, thoroughly scientific methods will be an absolute necessity, but chiefly as a means of protection, although there will still remain the opportunity of seeking out certain general classes of coals for which there is a relatively small demand, and adjusting the plant to use this kind. The most successful trader in any market is the man who gets below the surface, and *gets at the real facts before they become public knowledge.*

Why Specifications are the Clincher of the Coal Purchase Problem.

Buying coal on specifications, often called the B.T.U. basis, has been generally considered to be all that is necessary to put the selection and purchase of coal on a thoroughly scientific basis. It has been much discussed in print as the *essence of fuel economy.* You have already read of the possibilities of the proper use of coal records and coal tests. You have seen what they mean and how they work. What can a form of coal contract do to improve methods of coal selection and purchase based upon such accurate data and complete records? It will make certain that a stated quality and character of coal will be delivered throughout the life of the contract at a standard price; but if the seller delivers better or poorer coal than he has agreed he will be paid in proportion. *Specifications therefore are not the foundation of scientific coal purchase, but the finishing touch—the clincher.*

How Specifications Secure Lower Prices for the Buyer.

The other thing that specification buying does—*that is buying under specifications that protect the seller as well as the purchaser*, which is only fair—is almost invariably to obtain prices lower than under the so-much-a-ton method. This is a curious effect which many will claim to be without reason, although it has been found to be a fact in a large number of cases. The reason lies partly in the fact that properly drawn specifications will increase competition by placing coals of varying degrees of heat value on an equal basis, for all bids are reduced to a comparable basis—the amount of heat delivered for one cent. The other reason is more intangible, but perhaps no less real. The premium that is ordinarily put upon salesmanship, the effect of persuasion, is eliminated. The bidder under such specifications knows that the success of his bid depends entirely upon cold-blooded figures. Put a salesman of any product in a position where he cannot "talk his goods," and limit him to the bare statement of facts—just what he is ready to guarantee his goods are, and the price—then watch him sharpen his pencil, or withdraw from the field with what grace he can. If the latter, he is either too poor a business man to be able to put his product on a pure business basis, or he lacks confidence in the goods. The prospective purchaser has lost nothing by his withdrawal. He has gained the benefit of genuine competition and protection—*the knowledge that he will get, throughout the term of the contract, just what has been offered to him.*

Why Specifications Do Not Depend Upon Penalties or Price Reductions For Their Value.

It should not be thought that penalties exacted for poor coal under any specifications are the full measure of the value of the method. Primarily the method is intended to supply *an incentive to the dealer to maintain the standard of quality,* or improve upon it if possible. Providing a fair standard has been set, the purchaser will find greater economy if the coal earns a higher price than the standard, for the poorer the quality of the coal the poorer will be his operating results in proportion. But a fair standard is a necessity to the satisfactory use of specifications; a standard too low will mean premiums paid for coal of only average quality. Much dissatisfaction on the part of the dealers has been caused by reckless bidding, offers which were unreasonably high, or by the insistence on the part of the purchaser of a standard which could not be reached. The failure of many amateur experiments with specifications is due to ignorance of the importance of a correct standard. It is this very feature that makes a wide *knowledge of coal values essential to a satisfactory use of specifications.*

What the United States Government Bureau of Mines Advises in Bulletin 41.

"Under the old plan of purchasing coal, when the consumer had cause or thought he had cause to find fault with the quality of the fuel he received, he was assured that it must be good because, like all the other coal sent him, it came from a mine with an established reputation. Such a state of affairs made it difficult to take advantage of the competition which usually results from a considerable number of bidders being asked to submit prices. The purchaser was afraid to buy from any dealers but those he knew and trusted, because although each dealer claimed that his coal was equal in quality to that of the others, yet if it did not prove to be satisfactory there was no standard for settlement or for cancellation of the contract.

"Many thousands of dollars worth of coal is still bought each year in this manner, yet a buyer or investor would consider it absurd to make a contract for a building with no specification other than it should be of a certain size and well constructed. Neither would he buy gold, silver, or even copper or iron ores on the mere information that they were mined at certain localities. All such products are now purchased to a great extent according to their value as shown by chemical analysis. This is true of coal in only a small degree, but the number of coal contracts made on such a basis is increasing every year.

"A contract for purchase of coal under specifications is as advantageous as a definite understanding regarding the quality and other features of any other product, or of a building operation or an engineering project. The man who buys under specifications gets what he pays for and pays for what he gets."

Why Imperfect Specifications May Be More Costly Than None.

The purpose of specifications for any product is primarily to protect the purchaser, but to be successful they must also protect the honest dealer. It is a nice question to protect the honest dealer against trickery or incompetence on the part of the consumer without leaving loop-holes by which a dishonorable dealer may escape the provisions intended to protect the consumer. There may be serious consequences either way for the buyer. If the dealer is not assured of a higher price for coal better than the standard agreed upon, he will surely make a bid high enough to offset possible reductions, whether he expects them to occur or not. On the other hand if the settlement price is exactly in proportion to the fuel value of the coal he delivers, he *can safely set a fair standard and a fair price*, depending upon the fluctuations above standard to offset those deliveries which fall below. There is sure to be a certain amount of variation at best, and if his coal runs consistently above standard he is sure of a corresponding reward. If the dealer is not protected against the rejection of shipments without adequate reason, he will insure himself against such a possibility by making a higher price, because the rejection of a shipment is often a very severe penalty. The consumer has an equal right to protection, and good business practice demands this protection, no matter how much confidence the buyer may have in the other contracting party. A contract between friends should be as binding as one between total strangers. It is not difficult for one inexperienced in the art of drawing coal specifications to eliminate *unwittingly* an important class of possible bidders, or even actually to put a premium on the delivery of poor coal.

How Coal Specifications Have Been Proven a Success.

It is not easy to draw coal specifications. Probably more discussion and argument has centered on coal specifications than on any other part of the complex problem of getting the most power out of every dollar spent for coal. Of all the phases of the coal problem the drawing of specifications is the most difficult to do *right*, the least understood, and the most experimented with by the inexperienced. In principle, coal specifications are simple; in practice, the method is full of surprises for the unwary. *Good specifications, once drawn, are easy to understand and simple of enforcement.* Of a hundred different specifications, drawn by individuals connected with industrial plants, and recently examined, there was not one which did not either contain at least one vital flaw in the protection intended for the purchaser or were so unfair to the seller that strict enforcement was impossible.

This is where Fuel Engineering Company service supplies another need of the coal purchaser, for the wide and varied experience of its staff with coals is combined with its many opportunities to watch closely the operation of a large number of specifications besides those drawn by its own organization. Here again the experience of many is focussed upon the problem of a single plant. The best evidence of the value of this particular service is the fact that not one concern has ever changed to another form after once purchasing under Fuel Engineering Company specifications. *Within a single year more than 500 bids have been made on these specifications.* One client of the Fuel Engineering Company has made a contract for his coal supply under these specifications for a period of ten years, with an option of continuing them in force for an additional five years. More than half a million dollars' worth of coal is bought each year by business concerns under the Fuel Engineering Company specifications and tests.

How an Association Can Save Money For Its Members by the Collective Buying of Coal.

The collective purchase of any material has certain obvious advantages over individual effort, providing the material purchased can be standardized; and many *plans for co-operative buying have proven very successful, especially in Europe.* The collective purchase of coal for manufacturers would seem to offer almost insuperable obstacles. There is likely to be among the members of an association of manufacturers a wide diversity in the kind of coal needed for individual plants. A plant manager also naturally hesitates to delegate any of his authority in such an important matter, and he may fear that his individual needs will not get the attention they should. The problem therefore becomes one of studying the requirements of each plant separately, and fitting these diverse needs into a plan which will retain final authority for each manufacturer, and at the same time retain the full value of the collective method. It is also essential in such a plan that each member be absolutely protected and guaranteed in advance a certain fuel value for his money. To the solution of such a problem must be brought an *intimate knowledge of the coal market,* a thorough understanding of plant requirements, and extensive experience in adapting specifications to complex situations. Adequate specifications under such a plan are not only desirable, but an absolute necessity. The staff of the Fuel Engineering Company is *peculiarly fitted for the development of such a plan.*

What One Prominent Manufacturers' Association Says About Collective Buying.

Here is a letter from a client of the Fuel Engineering Company, one of the largest manufacturers' associations in New England.

"The first three months' operation of our plan for the collective purchase of coal for our members under strict heat unit specifications has so well demonstrated its advantage to our members that we are prompted at this time to write and express our thanks and appreciation to you for your valuable assistance and help in perfecting this plan.

"We are certainly indebted to you for the large amount of time and effort, backed by your years of experience as fuel engineers, all of which you placed at the disposal of this Association during the months of our preparation for putting the plan into effect, and which has, we believe, resulted in the adoption of a plan offering exceptional opportunity to our members for a saving in their coal bill, and at the same time a guarantee of the quality of the coal delivered.

"We estimate that the actual saving to our members through the operation of the plan will amount to a very large figure, the price which the members are now paying being ten cents per ton lower than the prevailing market price, and in addition to this saving they are also protected with a strict guarantee of the heat value of the coal."

How States and Cities Can Safeguard Coal Purchases.

Sound business management requires the protection of properly drawn specifications. State and municipal buying introduces still further advantages in this method of buying coal; the best interest of the taxpayers requires impartial expert supervision of purchases. Properly drawn municipal specifications prevent not only the exercise of favoritism in the award of contracts, but even the suspicion of favoritism, for all bids are reduced to a definite and comparable basis of value and the determination of the lowest bidder becomes a mathematical calculation. Our governmental system brings frequent changes in the holders of important positions. Harmonious and continuous administration of such an important matter as coal buying is impossible unless some outside organization is engaged under conditions which make it free from political uncertainty. Furthermore, state and city officials are frequently lawyers, merchants or bankers in private life, and have not even the experience which the average manufacturer has acquired in coal buying. Coal testing done by State or city departments is open to a very obvious objection. It is common knowledge that such departments are notoriously open to political influence, or the influence of selfish private interests. *The Fuel Engineering Company has successfully supervised the coal purchasing of State, county and city departments*, and its extensive and valuable clientèle among industrial concerns, dependent as it is upon the maintenance of its professional reputation, *stands as a continuous guaranty of freedom from political or private influence.*

PART VI

How Coal Is Turned Into Power.

Money, coal, steam, an engine, whirring machinery —your product. Before your check in payment of the coal bill has left your office every tangible thing that your money has bought has disappeared. You have purchased energy, and used part of it in changing the form of your raw materials into a salable product. Part of it has been wasted. You can see the coal shovelled under your boilers; you can see the shafts, pulleys, wheels moving in the factory. Energy has been liberated in the furnace to go where it can. It is invisible, intangible. You have paid good money for the energy. Some of it is sure to escape unused. Most of it you can use. Science has provided us with means of accurately determining just where this energy goes, methods of keeping track of it all the time. Do you realize that a plant using 5,000 tons of coal at $3 per ton can lose $7,500 dollars after the coal has been fired and before the energy reaches the engines? Do you realize that half of this may be *unnecessary* loss? And once lost, gone forever!

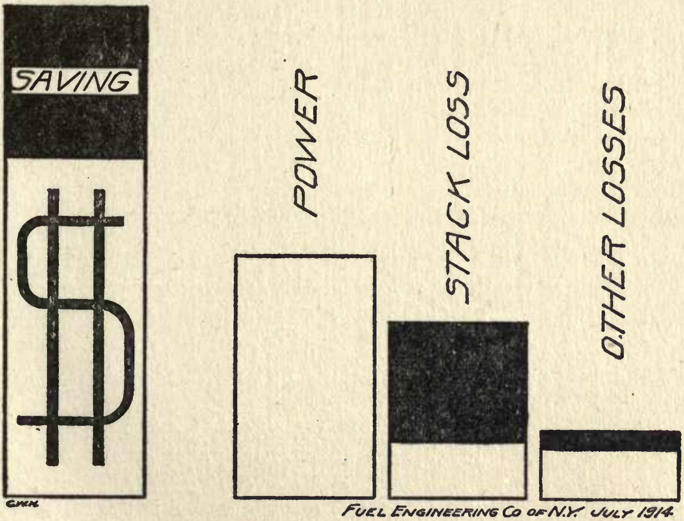
How Power Losses Can Be Prevented.

There is no reclaiming of power losses. They are most elusive and exist on every hand, *but they can be* *prevented.* A certain amount of energy has been put into the plant in the form of coal. *It is comparatively simple to measure the amount of energy* which is delivered to your machinery, but this does not tell you how much has been lost or where the losses are. You must know how much energy you started with. Therefore, we must start with the heat value of the coal, and the weight of the coal used. Let us assume that your coal has been carefully selected, and is purchased on the B.T.U. basis; that it will give you the largest amount of energy in the form most suitable for your use for the money; that, in this particular case, you will get 14,000 B.T.U. per pound, or 31,360,000 B.T.U. per ton for $3; and that you use 5,000 tons a year. Let us see what may become of this $15,000 worth of energy—how much may be lost—*how much can be saved.*

How the Savings Disclosed by the Power Plant Balance Sheet Mount Into Money.

Every business concern keeps an exact record of all money received. The books show exactly how much has been received, the date, and whence it came. This money is in turn paid to others. A record is kept of just where this money goes, and for what it was paid. A part is paid in salaries, a part in materials, and in all lines of business some is lost. The income and outgo must always balance, and the general manager demands a statement in detail showing how the outgo was divided.

What business man could hope to reduce costs if he only knew the total amount of money spent? Furthermore, how much real money does the business executive of to-day actually see? The morning's mail brings certain pieces of paper which indicate that somewhere in the channels of trade there are a certain number of dollars which have been transferred to him. He has faith that the money is there, although it is not visible. He in turn pays it out by means of similar pieces of paper. The laws of nature prescribe that *every bit of energy you put into your furnace must come out somewhere,* even though you cannot see this energy.



This chart illustrates graphically the results indicated by the Energy Account on following page. The black areas indicate the unnecessary losses which were eliminated, while the amount of power produced remained the same.

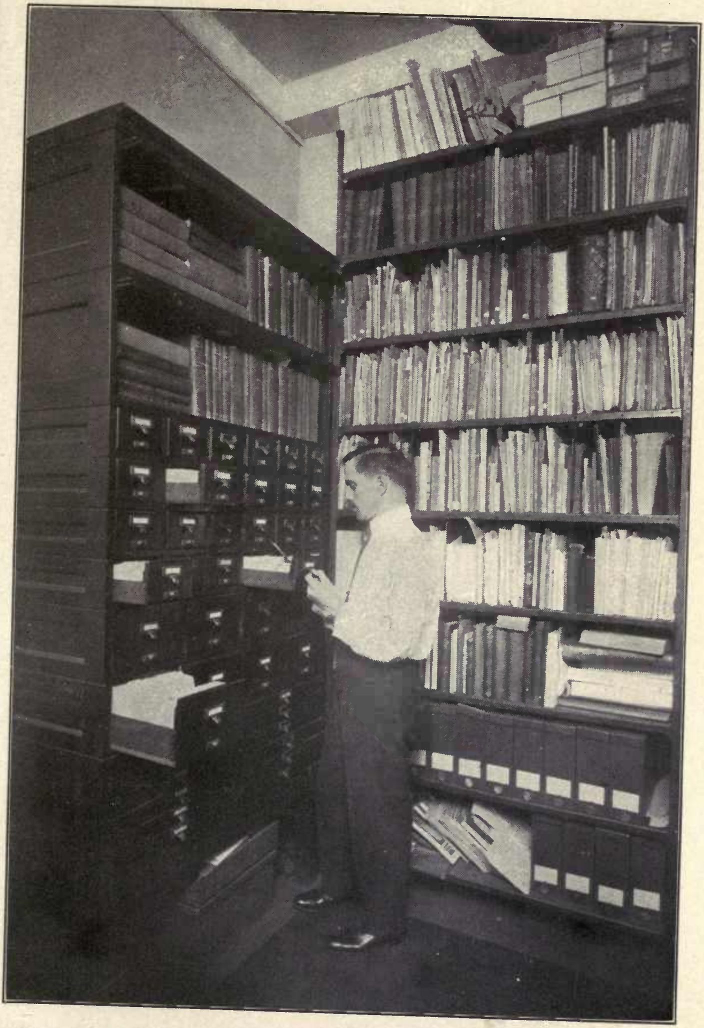
How an Energy Account Looks in Actual Figures.

Science has made it possible to measure this energy that you put in, and also to keep account of just where it goes and in what quantities. The "Energy Account" must balance just as much as your "Cash Account." You trade good money (which is carefully and painstakingly accounted for) for energy in the shape of coal. Doesn't just ordinary good business practice demand that every bit of this energy should also be accounted for? Let us see what the "Energy Account"—the power plant balance sheet—looks like:

To 5,000 tons of coal, averaging 14,000 B.T.U. per pound, @ $3.00 per ton		$15,000
Lost up the stack in dry flue gases	$5,430	
Lost by incomplete combustion	None	
Lost through grates	870	
Loss from moisture in coal	375	
Loss from hydrogen in coal burning to water	315	
Loss from radiation and minor losses	570	
	$7,560	
Turned into steam	7,440	
Total	$15,000	$15,000

How This Same Energy Account Was Made to Save Money.

A statement like this is not only a satisfaction, but it *points the way to a reduction of the losses.* The business executive need not necessarily know the treatment indicated by these figures, but he can readily see the significance of the facts when he has faith that



Library of Records—Part of the secondary records which are subdivisions of original records by dealers, mines, districts, trade names, etc., in the Fuel Engineering Company Library. (See page 85.)

this energy account is as real as the cash account. Conditions were improved in this plant, and the balance sheet now looks like this:

To 3,566 tons of coal, averaging 14,000 B.T.U. per pound, @ $3.00 a ton		$10,700
Lost up the stack in dry flue gases	$1,720	
Lost by incomplete combustion	162	
Lost through grates	481	
Loss from moisture in coal	267	
Loss from hydrogen in coal burning to water	224	
Loss from radiation and minor losses	406	
	$3,260	
Turned into steam	7,440	
Total	$10,700	$10,700

It shows the same amount of power developed with $4,300 less spent for coal of the same quality at the same price.

How Every Power Problem Is Different.

The "Energy Account" of no two plants will look alike. The design of the plant, the demands put upon it, its location, the method of operation, the kind of coal—each of these has an effect upon the size of the total loss, as well as upon the distribution of the losses and the method of reducing them. Another plant with insufficient stack capacity had a power balance sheet like the following. The figures are converted to our adopted average plant for sake of easy comparison, and the figures before and after the faulty condition has been remedied are given in parallel columns:

	Before		After	
To 5000 tons of coal, averaging 14,000 B.T.U. per pound, @ $3 a ton		$15,000		
To 3,980 tons of coal, etc., @ $3 a ton				$11,950
Lost up the stack in dry flue gases	$1,455		$1,192	
Lost by incomplete combustion	2,295		251	
Lost through grates	480		394	
Loss from moisture in coal	315		251	
Loss from hydrogen in coal	345		274	
Loss from radiation and minor losses	1,860		1,338	
	6,750		3,700	
Turned into steam	8,250		8,250	
Total	$15,000	$15,000	$11,950	$11,950

This shows the same amount of power, but more than $3,000 saved in the operating account.

Why the Energy Account Should Show the Losses For 365 Days of the Year.

A large number of plants run tests to determine the evaporation per pound of coal, but fail to determine the amount of heat originally supplied to the furnace and thus cannot determine the losses. The real question to be answered is not "How much water is being evaporated per pound of coal?" but "*How much of the energy that we have bought is wasted?*"

Many plants run occasional tests to give some indication of the amount of loss or the distribution of the losses. Such tests, however, only show what the losses were *on one day under test conditions.* The losses that eat up the coal bill are going on every day of the year. They may be changing in direction. An attempt to reduce one loss, indicated by a test, may have increased one of the others still more. This loss goes on until another test is run, and in the meantime more energy is lost than before. Fuel Engineering Company Power Service checks up *all the losses all the time*, and reports to you the condition of the Energy Account at frequent intervals.

How to Open the Energy Account.

To open the energy account—to put the plant manager in a position to know just where the energy that he buys is going—does not require costly changes in equipment or radical changes in operating conditions. It simply means getting accustomed to applying the same careful methods in the making of power as are used in the manufacturing department or the treasurer's office. Until the plant has been equipped so that the direction and amount of the losses can be determined and a continuous record maintained, attempts at power economy are little better than guesswork. Lucky guessing, or any other method that reduces the cost of power, is valuable; but if it does not indicate how near you are to the goal of maximum economy, it fails in its real purpose; for it is not what you have done, but what you can do, that counts. Here the power engineer has an advantage over the efficiency engineer, for his 100 per cent. is known and every part of it can be definitely determined, while the latter may increase the efficiency of the workmen 40 per cent. without knowing how near he is getting to the possible maximum—or, in other words, how much farther he could go if he knew how. *The purpose of Fuel Engineering Company Power Service is to guide you in the introduction of an Energy Account, to keep the account for you, to analyze the results, and to use the facts disclosed to reduce the losses and to keep them down.*

How the Services of the Operating Engineer Become More Valuable.

Scientific methods applied to power production do not diminish the *importance of the operating engineer.* His duties are many and important. In fact, they are so many and so important that he cannot be expected to take up the particular problem with the thoroughness it deserves and must have for complete success. A quotation from an article by an engineer, who has had wide experience both as an operating engineer and as a consultant, is worth repeating here:

> "In order to obtain the best results, it is necessary for all parties concerned to recognize their own and the other fellow's limitations and organize a working unit. On the one hand, the supervising engineer must admit that the operating engineer knows his plant in detail more intimately than others can. He knows the individuality of his machine better and can best tell the results of application of oils, packing, etc., and knows many things one cannot learn in any other way than to be with them continually. The operating engineer must feel that the consulting engineer can bring a training due to association with business men that is denied the man in the engine room, and can bring to bear a wide range of knowledge of general practice. The consulting engineer is called upon to consider problems so varied that each one is a special study and cannot help but give him a general knowledge at least of more phases of engineering than can be gained in the engine room alone. For one to disregard the knowledge of the other is foolish. For each to recognize that the

other can bring special knowledge into a working combination for the common employer means good for all."—Outside Supervision in the Plant, by Hubert E. Collins, "Practical Engineer," January 1, 1914.

How the Coal Service Assists the Plant Manager.

Fuel Engineering Company Coal Service is complete in its application to your power problem up to the delivery of the coal. It acts as a searchlight to penetrate the depths of the coal market, a market bewildering in its greatness and in the wide field of choice it offers. *It acts as a guide in making the best choice, and as a protector in making sure that you get all the time all you are paying for.* The Fuel Engineering Company of New York does not buy or sell coal, or any other material or product. The Coal Service is therefore a tool for you to use. Its value will depend largely upon your desire to use it.

How the Power Service Protects and Assists You at Every Step From Mine to Delivered Power.

The Power Service includes all of the features of the Coal Service; it goes farther and covers the distinct problem of *getting the most out of the coal after it has been bought*, thus covering each step from the time you think of next year's coal supply until the steam has been delivered to your engines. This service determines the amount and direction of your present losses, takes the full responsibility for the reduction of them, and maintains a complete and continuous record of operating results, which are reported to you at frequent intervals. The engineers in charge of the Power Service not only have the full information in regard to the quality of your coal, which is essential to a complete knowledge of your power losses, but have access to the great mass of coal records in the coal library already described. This is a unique feature of this Power Service which should not be overlooked. Its importance lies in the value of carrying the problem through from start to finish under the direction of a single organization, insuring harmony of plan, and avoiding a duplication of effort which a division of the problem would cause.

Why the Cost of Power Is a Big Business Problem.

Economy in purchase, efficiency in use—these are two parts of one vital business problem, the reduction of the cost of power. To buy coal haphazard, to judge of it with incomplete data, to select it without a thorough survey of the field, to accept *any* business situation as being impossible of improvement—truly, these have no place in the creed of the American business executive; they mean the deliberate neglect of an opportunity to *increase profits by the most direct and certain road—the decrease of costs.* That such methods have been the rule in the past is not to the discredit of any coal buyer, because this condition was not due to a lack of desire to improve, but to the absence of opportunity to get the facts upon which better methods could be built.

For years there has been building a central bureau of information for the coal buyer, and an organization equipped and trained to supply complete, exact and detailed information on the selection and purchase of coal—the foundation of all power economy. To have accomplished the greatest economy in purchase, to have placed in your coal bunkers the largest amount of heat in the form most economical for your use at the least cost, is a distinct step forward. This much of the power problem may be considered as a complete unit in itself.

After the ooal has been delivered, the work of reducing the losses and of keeping them down is absolutely necessary to a complete solution of this vital business problem, but for its success it must depend upon the facts developed in the solution of the first division. The service of the Fuel Engineering Company therefore is divided into two parts, each a complete unit, the one related to the other as a house is to its foundation. The Coal Service may be used alone, or the Power Service may be added to it, thus making the protection of your interests complete from mine to delivered power.

Why You Need the Coal Service.

First: Because it gives you systematic tests of your coal which

—— make it possible to compare accurately its value with the value of other available coals;

—— give you, at frequent intervals, definite information as to whether you are getting the quality of coal that you have been promised;

—— are an absolute necessity to complete operating records if you would know how efficiently the coal you buy is being used.

Second: Because it places at your command a library of coal information which

—— supplies a basis of comparison with your present practice;

—— guides you in the selection of coals of higher quality or lower price;

—— enables you to find these coals with a minimum of effort or expense;

—— gives you accurate data, in advance, on coals you may consider buying and thus avoids costly experiment.

Third: Because it adds to your staff an organization of experts, devoting its whole time to coal and power problems, which

—— is ready at all times to give you the benefit of experience gained in supervising the purchase of more than 15,000,000 tons of coal for plants in more than fifty different lines of industry and operating under all kinds of conditions;

—— relieves you of all technical details by supplying to you, as a basis for your decisions, concrete recommendations based upon the tests of your coal and our library of coal records;

—— studies your plant conditions, and determines the kind of coal best adapted to the economical production of your power;

—— assumes all the detail work in preparing specifications for the purchase of your coal, examines all bids received, and prepares an accurate comparison of the bids to guide you in awarding the contract;

—— stands constantly at your service to look up and report any kind of coal information you may desire;

—— makes suggestions and recommendations on firing methods and operating problems, which can be made without extensive investigation or inspection of the plant.

Fourth: Because it gives you all of these things quickly, and

—— at a nominal cost—from three-fourths of one per cent. to two per cent. of your coal bill. The total cost to you is fixed in advance. There are no fees of indefinite amount.

Why You Need the Power Service.

First: Because it gives you systematic supervision of your power generation;

—— finds out what your plant is doing;

—— determines not only the *amount* of the losses, but *where* they occur;

—— stops preventable wastes;

—— gives you complete operating records.

Second: Because it places on your desk at frequent intervals reports which show:

—— the exact cost of your power;

—— what your plant has been doing;

—— what it is now doing;

—— what it is going to do.

Third: Because it adds to your staff an organization of experts devoting its whole time to coal and power problems; which

—— gives you, at all times, the benefit of experience gained in supervising the power output of many plants;

—— makes concrete recommendations based on tests at your plant and extensive supervision records; thus relieving you of all technical details;

—— studies your plant conditions and welds your plant, coal and men into a harmonious unit devoted to the economical production of power;

—— assumes all detail work in keeping of records, installing of instruments and planning improvements;

—— relieves you of the necessity of spending your time on a lot of technical details which are foreign to your ordinary trend of thought, and so gives you additional time and energy to devote to the sales-product end of your business.

Fourth: Because it gives you these things quickly (the engineering staff is ready and doesn't have to be built up);

—— the cost is small and in every case it is determined in advance;

—— furthermore, the expenditure usually pays large dividends the first year.

The Problem and Its Solution.

We have stated the problem and pointed out the solution. We have shown how hundreds of manufacturers and other makers of power and users of coal have solved each part of their problems. We have shown how you may profitably leave the application of the principles, here presented, to specialists who are equipped to gather the facts and able to focus the composite experience of many others upon your individual needs. With confidence in your good business judgment, we leave you with this question:

ARE YOU BURNING UP YOUR PROFITS?

REFERENCE INDEX

A

B

C

L

M

O

P

Q

R

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