of moisture, volatile matter, carbon and ash, he may calculate the calorific value of his fuel to a very satisfactory degree of accuracy by the following method, proposed by Goutal:—

Calorific power (calories per kilo) = 82C + aV, where C = percentage of fixed carbon, V = percentage of volatile matter, and a = a valuable factor depending on the ratio of volatile matter to the total combustible matter in the fuel. The value of a may be ascertained by consulting table No. 1. To find the ratio of V to V + C, calculate thus $\frac{V \times 100}{C + V}$

The use of these factors may be demonstrated by assuming an analysis to read:—

Moisture	1.20%
Volatile combustible matter	23.20%
Fixed carbon	62.40%
Ash	13.20%
Sulphur	1.10%

Then $\frac{V \times 100}{V + C} = \frac{23.2 \times 100}{23.2 + 62.4} = 27$. Thence a, by the table, has a value of 101. Then the calorific value of the fuel would be $82 \times 62.4 + 101 \times 23.2 = 7{,}460$ calories or 13,428 B.t.u.

Table No. 1 showing value of a variable factor being the ratio of V to V plus C.

Ratio.	(a)	Ratio.	(a)	Ratio.	(a)
1-4	100	16	115	28	100
5	145	17	113	29	99
6	142	18	112	30	98
7	139	19	110	31	97
8	136	20	109	32	97
				33	96
9	133	21	108	34	95
10	130	22	107	35	94
11	127	23	105	36	91
12	124	24	104	37	88
13	122	25	103	38	85
14	120	26	102	39	82
15	117	27	101	40	80

The British thermal unit (B.T.U.) is that quantity of heat required to raise 1 pound of pure water one degree Fahrenheit, at or nearly 39.1° F. The calorie is the amount of heat necessary to raise one kilogram of pure water from 4°C to 5°C.

The relation existing between calories and B.T.U. may be readily calculated since 1 kilo is equivalent to 2.205 pounds, and one degree C equal to 9/5 of one degree F. The calorie is equivalent to 9/5 × 2.205 or 3.969 B.T.U., and the B.T.U. to 0.252 calorie. To reduce calories per kilogram to B.T.U. per pound, multiply by 9/5 or 1.8, to reverse the calculation multiply by 5/9 or .555.

Estimation of Sulphur.

The amount of this element present in coal and coke often enters seriously into the consideration of the metallurgist and to a lesser extent the foreman or superintendent of the factory or mill. The methods used in reporting this ingredient are several in number, but generally depend on the final precipitation of the sulphur as $BaSo_4$; the amount of this sulphate in milligrams multiplied by 0.1373 will give the amount of sulphur in the sample.

The fushion method is detailed below and will be found excellent, doing away with unpleasant odors of bromine, which are sometimes present when other systems are used. One gram of the powdered sample is mixed with 9 grams Na_2CO_3 and 5 grams KNo_3 thoroughly in a mortar and transferred to a large crucible; cover this and heat it over a Bunsen burner, applying a gentle heat at first, and then increasing, observing the contents from time to time to ascertain that the heated mass does not boil over; when the contents of the crucible are in a quiet state of fusion give the crucible a slight turning motion to bring the mass well up on the interior sides and allow the whole to cool.

Dissolve the fused mass out with hot water and disintegrate it by boiling, filter off the insoluble matter and wash it on a filter with warm water, add a few drops of hydrochloric acid and evaporate to dryness, the dryness is then moistened with hydrochloric acid and dissolve in 100 c.c. of water, the whole being brought to boiling point over a burner. The liquid is then filtered and diluted to 350 or 400 c c, again brought to the boiling point and the sulphur precipitated by adding 15 c c of a 10% solution of barium chloride. The sulphur is collected on a filter, washed, dried and weighed in the usual manner. For precise results it is best, when using chemicals of doubted purity, to run a blank determination deducting any results obtained from the final determination.

Estimation of Phosphorus.

Secure the ashes from 10 grams of the sample and treat with hydrochloric acid, dilute with water and filter. Dry the collected matter and fuse with a little sodium carbonate (Na_2CO_3), dissolve the fusion in hot water, filter and wash any collected matter. (A) Add sufficient hydrochloric acid to render the filtrate distinctly acid, and evaporate to dryness. Drop a little hydrochloric acid on the residue, then dilute with 100 c.c. of water, boil a few minutes and filter; wash the insoluble material in the filter paper and add this to that obtained at A. To the combined filtrates add a few drops of ferric chloride (C.P.) adding just enough ammonia to give an alkaline condition; then add acetic acid and boil for one or two minutes, when a precipitate will form containing all the phosphorus. Filter and wash this precipitate and then dissolve it in hydrochloric acid and reduce to a small bulk by evaporation, using extreme caution to see that an insoluble scale of iron oxide does not form. Add 5 c.c. of nitric acid ($H\ No_3$) and dilute with 30 c.c. of water. Filter this into a flask and wash the collected matter with a 2% solution $H\ No_3$, then add 30 c.c. of strong ammonia solution to the filtrate, and dissolve the precipitate formed by concentrated nitric acid, adding a very slight excess. The solution is now heated to 85°C and 60 c.c. of ammonium-molybdate solution added while being vigorously stirred; in a few minutes a yellow precipitate will form; consisting of ammonium phosho-molybdate, which contains 1.31% of phosphorus. Phosphorus, as a rule, is determined in coals used in metallurgical operations, and very seldom enters into the ordinary routine coal analysis. The heat determinations by calorimeters has been omitted; this mode of ascertaining the heating values calling for considerable expenditure. The calculation methods will yield better results than a poor or even middle grade calorimeter.

The purchase of coal under specification is a marked onward step in the conservation of natural resources; this form of purchase being conductive to the use and purchase of lower grade coals. The poorer grades find a market by actual comparative competition with the better grades, not by the price per 2,000 pounds, but as to the actual heating values, which is indicated by the number of heat units it contains per pound of coal.

In purchasing coal for any power plant the aim should be to obtain a fuel which, all things considered (such as equipment, price of coal, and cost of labor and repairs), will produce a horsepower for the least cost.

It would appear from experiments that almost any fuel may be burned with a reasonable efficiency in a properly designed apparatus. The recognized requirements are as follows: (1) A uniform and continuous supply of fuel to the