nitride into ammonia by the addition of alkali and also to distinguish the crystals of the nitride under the microscope. Weston and Ellis¹⁵ have studied this reaction and have obtained up to 40 per cent. of the nitride in this way.

Aluminium nitride as prepared by Serpek is of value not only from its combined nitrogen but also from the valuable by-product of alumina arising from its decomposition. This should be available for the manufacture of aluminium. Without this advantage the process as one for the fixation of nitrogen would be of doubtful value; the alumina would have to be used over again as raw material after evolving the ammonia, and apart from the complications, alumina in the pure state requires a much higher temperature for nitrogen fixation than bauxite. So much so is this the case that if this were done it is very doubtful if the process could be carried on successfully.

In a recent paper¹⁶ I have attempted to show how much this production of alumina is concerned with the aluminium industry. If the Serpek process were to be worked on a scale commensurate with the Frank cyanamide process, the production of alumina would actually exceed the present demands of the aluminium industry in raw material to the extent of some 34,000 tons annually. However, there seems little doubt that the Serpek alumina would find a ready market. It is quite impossible to compare the cost of producing fixed nitrogen by the Frank and Serpek processes, because we know very little as to the costs of making cyanamide by the former, and still less as to the cost of the Serpek product. Perhaps the best way of comparing the processes is to contrast the chief points of each, as follows:—

Frank Process.

Favourable.	Unfavourable.
Low power costs for nitrogen fixed.	Process discontinuous.
Material can be used directly as fertiliser.	Heat losses at carbide manufacture stage.
	Expensive nitrogen.
	Two rather complicated grinding operations.
	Low nitrogen content in the product.

Serpek Process.

Favourable.	Unfavourable.
Continuous process.	Expensive raw material.
High nitrogen content in product.	Chemical treatment before nitrogen is available as fertiliser.
Heat conserved.	
Valuable by-product.	

From this it would seem that there were decided advantages attached to the Serpek process, but it remains to be seen just how it will work in practice. It is now being tried in France on a large experimental scale.

New York Section.

Meeting held at Chemists' Building on Friday, November 21st, 1913.

MR. G. W. THOMPSON IN THE CHAIR.

THE RELATION OF COMPOSITION OF ASH IN COAL TO ITS FUSION TEMPERATURE.

BY OSCAR W. PALMENBERG, D.S.

One of the most troublesome features in the combustion of coal is that due to the production of clinker, which influences the rate of combustion and the cost of maintenance, especially where automatic stokers are in use. A coal may clinker so readily as to be unfit for use, irrespective of its fuel value. When coal is burned under a boiler for the production of steam, it is especially

important to know whether the ash will clinker and at what temperature.

Several methods have been suggested to determine whether a coal has an ash which will fuse at a low temperature, and many persons have held that an analysis of the ash or the amount of iron in the ash, or of sulphur in the coal will give the explanation.

To show that there is no relation between the clinkering quality of a coal and the sulphur or iron content, the writer has made this investigation, and the analyses of the ash together with the fusing temperature determinations on a wide range of coals will readily show that no conclusion can be obtained from a chemical analysis.

The ash of coal is composed mainly of silica, iron oxide, aluminium oxide, calcium oxide, magnesium oxide, sodium oxide, potassium oxide, carbonates and sulphates. Since all coals, but particularly soft coals, consist of a mixture of pure coal substance and pyrites, bone, slate, fire-clay, etc., these elements will be present in a variable proportion depending upon the nature of the coal vein and the method and care by which the coal is extracted from the ground. In making an analysis, therefore, of a coal sample representing a mixture of all these materials, a definite percentage of the component parts of the ash may be obtained, but this analysis does not tell us how much pyrites, bone, slate, fire-clay, etc., is present. It is, therefore, apparently impossible to judge from this analysis whether the ash will have a high or low fusing temperature. It is true that the pyrites will fuse at a lower temperature than the slate, but since both may contain iron, the analysis does not indicate a method of arriving at a conclusion to show the fusibility of the ash due to the iron content. The problem offered is very similar to that of trying to determine a formula by which the calorific value of a coal may be estimated. This has been attempted by using the percentage of ash and volatile matter or of ash and fixed carbon, but since these constituents are so variable in their composition, depending upon their sources, it is impossible to arrive at a reliable method. For that reason a calorimetric determination must be made.

The following analyses and fusing temperature determinations were made on coals mined in Pennsylvania and samples were obtained either from the mine or place of consumption:—

Fusing temperature of the ash in coal arranged according to the iron content.

No.	Fe ₂ O ₃ %	S %	Ash. %	Fus. T. °C.
1	4.81	0.51	5.15	2700
2	6.23	1.01	9.15	2600
3	7.29	0.90	6.41	2600
4	7.88	0.74	5.57	2600
5	7.94	1.52	15.61	2750
6	11.28	1.94	8.53	2745
7	13.84	1.80	13.51	2700
8	14.14	1.46	7.88	2815
9	15.15	1.07	6.38	2560
10	15.21	1.42	7.98	2400
11	15.38	1.57	..	2156
12	16.00	1.63	9.80	2809
13	17.43	..	7.68	2518
14	17.95	2.11	11.04	2300
15	19.19	1.79	7.90	2138
16	19.54	2.41	11.33	2380
17	22.28	2.06	9.70	2400
18	22.28	1.90	7.23	2372
19	22.38	2.56	..	21
20	22.57	3.00	9.03	2336
21	23.17	1.16	9.52	2555
22	23.30	2.40	8.10	2156
23	24.40	2.23	10.80	2190
24	26.50	2.13	9.86	2192
25	27.22	3.13	13.54	2158
26	28.39	1.96	6.05	2084
27	28.81	2.32	7.55	2318
28	30.67	2.17	7.90	2246
29	33.27	2.86	9.33	2520
30	35.13	2.13	6.25	2300
31	36.12	3.04	8.40	2284
32	36.17	2.60	7.50	2500
33	38.75	3.07	10.60	2180
34	39.51	3.97	8.22	2310
35	39.88	2.41	8.98	2372
36	40.93	2.68	9.08	2415
37	44.00	4.12	..	2246
38	44.89	3.51	9.34	2318

¹⁵ Weston and Ellis, *Trans. Faraday Soc.*, 4, 60, 1906.

¹⁶ Tucker, *The relation of alumina to the fixation of nitrogen*, *Jour. Ind. and Eng. Chem.*, 5, 191 (1913).

Analyses showing the composition of the ash of bituminous and semi-bituminous coal.

No.	Fus. temp.	Fe ₂ O ₃	Sulphur.	SiO ₂	Al ₂ O ₃	CaO	MgO	K ₂ O, SO ₂ , Na ₂ O, CO ₂	Ash.
	°C.								
1	2700	4.81	0.51	51.93	36.82	3.84	1.00	1.60	5.15
2	2615	14.14	1.46	44.74	36.91	2.18	0.41	4.85	7.88
3	2600	6.28	1.01	48.83	42.62	1.64	0.30	3.90	9.15
4	2400	7.29	0.90	54.18	34.53	3.01	0.47	0.52	6.41
5	2400	22.26	2.06	40.61	32.94	1.77	0.51	1.91	9.70
6	2372	39.88	2.41	30.07	25.31	2.63	0.39	1.71	8.96
7	2309	17.95	2.11	47.94	28.47	4.17	0.51	0.96	11.04
8	2300	13.84	1.80	46.40	35.30	3.58	0.31	0.57	13.51
9	2300	35.13	2.13	30.90	31.14	2.00	0.52	0.31	6.25
10	2246	30.67	2.17	35.48	30.73	2.10	0.44	0.28	7.90
11	2180	38.75	3.97	29.37	29.52	1.57	0.37	0.44	10.60

These analyses seem to show that there is no relation between the percentages of the various constituents of the ash and the fusing temperature. Therefore a chemical analysis is of no value to arrive at a conclusion regarding the clinkering quality of a coal. It may be noted that although coals having an ash with a very low iron content seem to give the highest fusing ash, no definite fusing temperature fits a definite percentage, and when the iron content goes beyond 10 per cent. the fusion temperature cannot be judged at all. That the sulphur content of the coal has no bearing whatsoever upon the fusibility of the ash is also apparent.

The writer intends to continue this investigation on coals from other sources than Pennsylvania with the object of determining whether there may not be some having practically no iron and showing a low fusing ash.

Since the sulphur occurs in coal combined either with iron, lime, or the hydrocarbons, there naturally exist innumerable combinations, and for this reason the sulphur content cannot be used as an index to clinkering. Only in those cases in which the sulphur is in combination with the iron, in the form of pyrites, would it be possible to judge the clinkering property, if the iron content of the ash had any bearing upon the fusion temperature.

The fusion temperature determination of the ash of coal will in the future displace the sulphur determination in coals used for steaming purposes, and will readily show the fallacy of buying and selling coal on an analysis basis where specifications are used containing sulphur tables penalising beyond a certain guaranteed amount of sulphur. It has been quite a common practice to place 1.50 per cent sulphur as a limit and penalising as much as 4 cents per ton for every 0.25 per cent. above 1.50 per cent. The injustice of this practice is very evident, as it often happens that coals with a high sulphur content are extremely high in heat value and do not clinker readily at all. Since the sulphur has no appreciable effect upon the metallic parts of the furnace it need therefore not be considered in the selection of a coal for steaming purposes.

To arrive at the value of a coal for steaming purposes it is therefore just as essential to make the fusion test of the ash as it is to make the calorimetric determination. If these determinations are made there is a ready explanation why two coals of apparently like proximate analyses give entirely different evaporation when fired under like conditions.

DISCUSSION.

Mr. J. B. F. HERRESHOFF said that the practical results of coal users seemed at variance with the conclusions of Mr. Palmenberg. In the experiments of his own company, it had been found that when the ash contained less than 8 per cent. of iron, the amount of clinkering was tolerable, but that when the amount of iron was as high as 15 per cent. of the ash, the clinkering was so marked that they could not use the coal, while with 30 per cent. of iron in the ash, the ash was so fusible that it would drip through the grate bars. Coal with not more than 10 per cent. of ash, and of which ash 8 to 8½ per cent. might be iron, was found to be satisfactory. With coal high in fixed carbon there was more clinkering than in the case of coals low in fixed carbon on account of the higher temperature to which the ash was subjected during combustion in the

former case. The great difficulty that his company had experienced with coal analyses was that of sampling.

Mr. FUERNER asked if from these analyses, calculations had been made upon the probable fusibility of the ash in the manner understood by metallurgists in the calculation of blast furnace slags.

Mr. G. W. THOMPSON asked if in the tests to determine the fusing point of the ash, the coal had been completely burned before making the melting test, or if some carbon had been left associated with it, and upon Mr. Palmenberg's reply that the ash was tested after complete burning so that the ash was thoroughly oxidised and free from any contamination with carbon, he suggested that the discrepancies between Mr. Palmenberg's results and those found by Mr. Herreshoff in actual practice might be accounted for by supposing that in the laboratory tests of Mr. Palmenberg the iron in the ash was in the ferrio condition while in actual practice the iron would be in the ferrous condition at the time it was subjected to the heat which produced clinkering, ferrous iron being a fluxing ingredient though ferric iron might not be.

Mr. F. S. HYDE asked what the effect of lime in the ash might be; in his experience a clay containing 5 per cent. of lime would be much more fusible than the same clay without it.

In answer to Mr. Herreshoff, Mr. PALMENBERG said that he had found many coals running higher than 15 per cent. that would not clinker readily, and those showing the higher fusion test would give splendid results under actual firing conditions. The clinkering of a coal in a furnace depended upon the rate of combustion, and if the nature of the coal was such that it generated a higher temperature than the fusion temperature of the ash, then clinker would be formed if the ash were in sufficient quantity and exposed to the hot fire-bed. He presumed that the coals that Mr. Herreshoff referred to were burned under conditions that the rate of combustion would give a very high furnace temperature.

In answer to Mr. Hyde's question, lime in appreciable quantity would no doubt influence the fusion temperature as it would flux with the silica. The coals investigated had all been low in lime and, therefore, no conclusion could be obtained in regard to its influence. The analyses bore out the fact that the fusion temperature was not influenced by the small amount of lime present, and should the lime reduce the fusion temperature, the effect might be offset by the presence of a larger amount of alumina which had the property of making the ash infusible.

Scottish Section.

Meeting held at Glasgow on Tuesday, November 25th, 1913.

DR. THOMAS EWAN IN THE CHAIR.

A NEW FORM OF EXTRACTION APPARATUS AND REFLUX CONDENSER.

BY PROBODHA CHUNDRA CHATTOPADHYAY, M.A.

(A) Extraction Apparatus.

After working with various forms of extraction apparatus, the writer has tried to rectify some of their