DISCUSSION.

Mr. Henry E. P. Cottrell said he could add little to what Dr. Frank had said. He was pleased to be able to report that the Odda works of the

North-Western Cyanamide Company were starting operations that very day, and he thought that they would be able to supply all the nitrolim required at present within the sphere of operations reserved to their Company. Of course it was difficult to get the British farmer to use new manures, but they had the support of the scientific agriculturalists, and they also had the support of those who best understood how to make the value of new manures understood by the British farmer. He believed that artificial nitrogenous manures had come to stay, for one reason because they were alkaline, and the ordinary nitrogenous manures were acid, and if applied constantly induced so-called sickness in the soil which the alkaline manure removed.

Mr. Walter F. Reid congratulated the Society on having heard such an admirable Paper from Dr. Frank. He himself was much interested in the subject, having, during the last two years, carried out some tests on nitrolim. He had found that its value as a manure depended largely on the nature and state of the soil. For example, a sandy soil deficient in clay was too light for it, and it needed a certain amount of moisture to make it useful. It was therefore necessary that it be applied under suitable conditions.

With regard to its use in explosives and in smokeless powder, he had made some small-scale experiments, and had found it decidedly efficient in slowing down the explosion—perhaps rather too efficient. There was a distinct reduction in the flame and a cooling down of the gases. It was somewhat strange that a compound of nitrogen could be used to lessen the activity of explosives, themselves nitro-compounds.

The uses of nitrolim as a raw material for the production of other chemicals, some of which were at present rare and expensive, should not be lost sight of, and on this account alone chemists should feel greatly indebted to Dr. Frank, to whose enterprises he wished every success.

Dr. H. Borns hoped that the author would be able to add some information concerning electrical features. The diagrams and views did not explain any details. How long were the carbide and nitrogen heated together? The electrical furnaces installed at Odda were apparently very small units arranged in a good many rows; could Dr. Frank tell them anything about the materials of the furnaces and their operations, and about the electrodes? When Mr. P. A. Guye had lectured on the fixation of atmospheric nitrogen before the Society of Chemical Industry two years ago, Dr. N. Caro had stated that the cost of fixation would approximately be the same for the three processes, the Birkeland-Eyde, Guye, and Frank-Caro processes; did the figures then given still hold?

Dr. J. A. Voelcker (Royal Agricultural Society of England) defended the British farmer in regard to the charge of conservatism and prejudice which had been made against him by the author of the Paper and by Mr. Cottrell, these having been put forward by them as constituting the principal bar to the utilisation of calcium cyanamide. The farmer, he (Dr. Voelcker) thought, was very wise to suspend his judgment. What were the circumstances? Here was a material, the claims of which were strongly advocated; but if he applied for it, the farmer could not as yet be supplied with it, nor was he told what it would cost him. Throughout the whole Paper which they had heard read that evening there was no statement whatever as to where calcium cyanamide could be obtained, what the cost of manufacture was, or what the price to the farmer was to be. Could they, then, be surprised that he was not prepared to abandon the use of nitrate of soda or sulphate of ammonia for this new material? The farmer knew what these latter manures could do for his farm, and he knew what the nitrogen cost him per unit in them. If the advocates of calcium cyanamide could show him that

he would get equally good results while purchasing the nitrogen at a lower cost per unit, they might be sure that he would not be slow to take it up.

That calcium cyanamide was a perfectly good and useful material to employ had been shown already by experiments made with it. He himself had employed it, experimentally, on the Woburn Farm of the Royal Agricultural Society. There was no reason why it should not do well, but the whole question resolved itself into one of cost. Was the nitrogen to be procurable at a cheaper rate than in the form of nitrate of soda or sulphate of ammonia? Until the advocates of calcium cyanamide could satisfactorily answer this, and also could tell the farmer where he could obtain it on a commercial scale, and not merely in experimental quantities, it was hopeless to look for any advance and unfair to attribute this lack to the prejudice of the farmer.

That the new material was any better than other nitrogenous materials, nitrogen for nitrogen, or better than its rival, calcium nitrate, he did not believe. Indeed, there were drawbacks to its use, as shown in the difficulties found in mixing it with superphosphate and other manures, and in the tendency for it to lose nitrogen on keeping. Here again the whole matter resolved itself into a question of relative cost of production, and the price at which calcium cyanamide could be put on the market.

In the Paper mention had been made of other uses to which calcium cyanamide could be put. One of these was the manufacture of sulphate of ammonia. But it was clear that, for this to succeed, the calcium cyanamide must be capable of being produced at a considerably less cost than the sulphate of ammonia, and it had not yet been proved that this could be done.

Much the same was true of calcium nitrate, a material which was not yet obtainable commercially, and for which no market price was quoted. And when the farmer found matters in this position, he could hardly be blamed that he did not show himself enthusiastic over this and other new discoveries, but that he preferred to wait until he knew what they were going to cost him.

Mr. W. Murray Morrison also hoped that more information would be forthcoming regarding cost of production and power absorbed in the various stages of the process, together with a description of the plant employed. He asked whether it would be possible to make the cyanamide directly from the raw materials in one operation, instead of having first to make carbide, cool it, crush it, and by a second process make the cyanamide. The exothermic nature of this second process apparently rendered the power absorbed very small, but it was obvious that a direct process would reduce the power, the labour, the capital expenditure, and other charges. He also asked whether a carbide of lower purity than that necessary for lighting purposes could not be employed. If so, the raw materials might be of a lower and cheaper quality, and the power absorbed by a lower grade carbide would be much less, the energy and the grade not following in direct ratio. The output mentioned on page 108, namely, 2 tons of carbide per kw. year, would seem to indicate a somewhat lower quality than the English standard carbide used for the production of acetylene.

Did the author think that there would be sufficient demand for all the product in the market when all the works mentioned in the Paper were producing to their utmost capacity? He thought that the heartiest congratulations were due to the author's father, and others associated with him, for the wonderful development of the cyanamide industry in so short a space of time.

Mr. H. L. F. Vogel asked what the effect would be if a charge of carbide were not completely saturated with nitrogen. Would there not be danger of acetylene being evolved if the powder became moist?

The percentage of calcium oxide present in the cyanamide seemed very high. Was it due to oxygen being left in the nitrogen? What was the degree of purity of nitrogen made in the Linde apparatus?

Mr. Leon Gaster, in drawing attention to the statement of Dr. Frank that the Birkeland-Eyde process apparently required about four to five times as much electrical energy to produce a ton of nitrogen as was necessary in his own process, asked whether he was prepared to give information on the following points: what proportion the cost of electrical energy bore to the total cost of production, how the cost of the various items, such as calcium carbide, and other materials employed, was distributed, and how they would influence the actual cost of cyanamide.

In the Birkeland-Eyde process, it appeared that the cost of the electrical energy formed the most important item. It was probable that, in the case of Dr. Frank's process, the cheaper the carbide was obtained, the lower would be the price of the cyanamide.

The Chairman thought the Society were very fortunate in having such an interesting Paper as that to which they had just listened, and was sure that members were extremely obliged to Dr. Frank for coming over from Berlin to read this very valuable Paper. From an agricultural point of view the "fixation of atmospheric nitrogen" was of the very first importance, and although there was the process of Birkeland and Eyde, there was room, as the figures which Dr. Frank had placed before them showed, for a very large and increased output of nitrogenous products. There was no doubt cyanamide had come to stay. The inventors were not to be blamed for being sanguine, and it was to be hoped that the product would be found to be of very great value to the agriculturalists. At the same time, they must be prepared to meet criticism, and this criticism would have to be disarmed by actual experimental demonstration. He thought it was all to the good that the agriculturists should be rather critical, because this was better than receiving the new invention with open arms and then finding out that it was not all that it claimed to be. A point that interested him very much was the large number of chemical products which it had been found possible to prepare using cyanamide as a starting material. He was sorry that Dr. Frank had been unable to tell them more about the new electric furnace, and hoped that it would not be long before he was in a position to give them the information which they desired.

Dr. A. R. Frank: In reply to the questions of Dr. H. Borns, Dr. Frank replied that he regretted not being able to give at the time exact information with regard to the new electric furnaces which were being used at Odda for the manufacture of calcium cyanamide. He hoped, however, soon to be able to give the desired information, and he could already say that the method of working the furnaces was, like the carbide process, thermal.

Since the lecture of Prof. P. A. Guye before the Society of Chemical Industry two years ago, on the fixation of nitrogen in the form of cyanamide, substantial improvements and simplifications had been effected, so that the price estimated by Prof. P. A. Guye respecting the manufacture of cyanamide has now been considerably lowered.

Dr. J. A. Voelcker raised a very important question from the point of view of sales of calcium cyanamide—*e.g.*, the sale price. He (Dr. Frank) was only aware of the price which was asked for nitrolim in Italy and Germany. This was at the present time 10 to 20 per cent. lower than that

for corresponding amounts of nitrogen contained in sulphate of ammonia or nitrate of soda. At this opportunity he would like to point out that the price for Norwegian calcium nitrate in Germany was higher than for the corresponding amount of nitrogen contained in Chili nitrate. He was pleased to learn from the statement of such a high authority as Dr. Voelcker that as a fertiliser nitrolim behaves as well as nitrate of soda and sulphate of ammonia, and that, as already asserted, the price of the material would be decidedly lower than that asked for other nitrogenous fertilisers, and he confidently expected that the English farmer would willingly consume the new fertiliser in large quantities. The difficulties already pointed out by Dr. Voelcker with regard to the mixing of nitrolim with superphosphate might, as stated in the lecture, be considered as solved, and he referred again to the interesting and conclusive trials made by Dr. Hall in this direction. Losses in the percentage of nitrogen contained in calcium cyanamide, which Dr. Voelcker had referred to, had been proved by conclusive experiments to be non-existent. The decrease noticed earlier resulted from the increase in weight, but this difficulty also had been overcome by selecting special raw material and methods of packing. The regrettable fact pointed out by Dr. Voelcker, that nitrolim was not yet on the market in England, would soon be overcome by the North-Western Cyanamide Company, who would be able to furnish all the quantities required by the English farmer at no late date.

In reply to Mr. Morrison's question, he must say that the experiment of preparing calcium cyanamide from the raw materials—lime and coal—had been carried out on a large scale for a number of years. Furnaces of a capacity of 500–600 kw. had been employed, but succeeded only in producing a 10–11 per cent. nitrogen product against that containing 20 per cent. and over yielded by the indirect method in employing carbide of calcium. The amount of power used in the direct process was originally not less than that required for the preparation of carbide and its subsequent nitrification, but, on the contrary, was even higher. The cost of labour and apparatus for the direct process was not more favourable than that required for the indirect process, and this the more so when the considerable disadvantage ensuing on the production of a low percentage product as compared with a high percentage product was considered.

Notwithstanding this, the former method had not been entirely abandoned; but it would take up too much time at this stage to enter into particulars of the trials made and the resulting conclusions. The quality of the carbide used in the preparation of cyanamide was essentially the same as that employed for lighting purposes as made at all the good European works, which, as stated on page 108, yielded 300 litres of gas per 2 tons of carbide per kilowatt per annum, and, in addition, satisfied the normal standard of carbide lighting. So long as the carbide works installed for the production of carbide did not give up their claim, under certain circumstances, to manufacture carbide for lighting purposes, it would appear that to reduce the quality of the raw materials would render it unmarketable, although such a reduction for the purposes of cyanamide could undoubtedly be effected. It could not at present be decided whether the demand for nitrolim would embrace the production of all the works. When, however, one considered the steadily increasing demand all over the world for nitrogenous fertilisers, one must become convinced that many times the present anticipated production of nitrolim would find a ready market without the least difficulty, without taking into consideration the fact that at some time the Chili nitrate supply must become exhausted.

In reply to the questions of Mr. H. L. F. Vogel, Dr. Frank said that an arrangement was now in use in all the large works to prevent nitrolim coming into the market containing carbide which would yield acetylene, or which had been damaged in course of manufacture.

The nitrogen made by the Linde process attained usually a purity of 99·8 to 100 per cent. If, through any accident or during storage while being rectified, some oxygen happened to remain in the nitrogen, it would be absorbed during the transformation of the carbide.

Concerning the remark of Mr. Leon Gaster, that the consumption of power for the preparation of equal quantities of nitrogen by the Birkeland-Eyde process was from four to five times as large as that required by the calcium cyanamide process, no objection could be raised. The proportionate cost of power to the entire cost of the preparation of calcium cyanamide depended essentially on the cost of power available for the manufacture of the carbide, as the cost of power for milling and grinding of raw and manufactured materials was only an unimportant item. On the assumption that the average cost of electrical power available at the carbide works was from £2 to £2 10s. per h.p. per annum, the cost of the carbide would amount to about 60 per cent. of the whole cost of preparing calcium cyanamide.

By the Linde process the cost of nitrogen amounted to about 4s. 10d. per cubic metre. It was owing to these conditions that the cost of power and raw materials for the preparation of carbide exercised the greatest influence on the cost of calcium cyanamide.