

the lime originally dissolved, but hardly any phosphoric acid, now has added to it the remainder of the cathode solution, whereupon the greatest part of the lime in the solution is precipitated as hydrate; by the introduction of some carbonic acid the rest is precipitated as carbonate; the lime precipitation is allowed to settle. The solution remaining above it is then drawn off. The original electrolyte is regenerated by its means and enters again the electrolyzing apparatus.

II.—The Raw Material and Its Utilization.

In applying the method, both phosphorites and apatites of very varying origin (e.g. those obtainable from Sweden, Norway and France, and also insular phosphate) have been employed. The percentage of phosphoric acid has varied between 9 and 40, corresponding to a variation of from 20 per cent. to 88 per cent. of tricalcic phosphate, without that, however, having any effect upon the course of the process. The raw material may be in a finely pulverized state, but not necessarily so, for raw phosphate has been used in lumps of a diameter of as much as 5 cm. The phosphate of lime present in the raw material is completely dissolved, provided, that is to say, that no grains of phosphate are embedded in silicates or other insoluble minerals, which may occur if the crushing has not reduced the raw material to fairly small-sized lumps.

Out of the amount of acid generated per ampere-hour, 1.33 grammes of tricalcic phosphate is dissolved. The voltage required is about 5 volts per cell. The phosphoric acid remaining in the solution, on the precipitation of bicalcic phosphate, is about 1 per cent. of that present originally in the raw material.

Of the silicates or iron ore (oxides of iron) mingled in the raw phosphate no appreciable quantity is dissolved.

If the raw phosphate contains carbonate of lime, it is dissolved by the acid simultaneously with the phosphate, chlorate (perchlorate) of lime, and carbonic acid being formed and the latter disappearing; consequently, the consumption of acid is rendered greater by the presence of the carbonate of lime, which is, from an economical point of view, a disadvantage. In this process, 1 per cent. of carbonic acid in the raw material involves practically the same amount of consumption of acid, or of energy, as 1 per cent. of phosphoric acid. On the subsequent addition, however, of the alkaline cathode solution, the same high-percentage bicalcic phosphate is precipitated. Consequently, an equally excellent fertilizer is obtainable out of raw phosphate containing carbonate as out of that free from it, though at an expenditure of more acid or of more electric current. In any case, by the electrolytic

method it will be possible to make use of raw phosphates containing more carbonate than is the case in the manufacture of superphosphate; on the other hand, they are not the most suited to be first resorted to.

III.—The Nature of the Electrolyte.

With reference to the electrolyte, the salt used should be of such a nature that its acid may yield in conjunction with lime an easily soluble salt and of a kind which is not subject to change during electrolysis. As electrolytes solution of perchlorate of sodium or chlorate of sodium are suitable, or else mixtures of those salts, the presence of other salts, for instance chloride, in small quantities is of no account.

Both these salts are thoroughly suited to the purpose, perchlorate of sodium being the best that could be desired. Both chlorate and perchlorate of sodium are exceedingly easily soluble salts—1 part of chlorate of sodium being soluble in 1.05 parts of water at an ordinary temperature, while perchlorate of sodium is still more easily soluble: that is of importance, inasmuch as the washing of the precipitated bicalcic phosphate is thereby rendered considerably easier.

A slight loss of the electrolyte by spilling in the process of washing, etc., always occurs. The amount of that loss will not exceed a value of \$1.50 per ton of the finished article, if perchlorate is employed.

IV.—The Composition of the Phosphate and Its Value as a Fertilizer.

The normal percentage of phosphoric acid (P_2O_5) soluble by citrate, contained in the bicalcic phosphate produced by the electrolytic method, is about 34, irrespective of the character of the raw material. The quantity of the phosphoric acid soluble by citrate has been determined in accordance with the method officially recognized for that purpose in Germany. As the quantity of phosphoric acid soluble by citrate in the bicalcic phosphate obtained constitutes about 95 per cent. of all the phosphoric acid in the product the total percentage of phosphoric acid in the bicalcic phosphate works out at 35.8 on an average.

Extensive experiments in cultivation with the aid of bicalcic phosphate, prepared by the electrolytic method, have been carried out by Professor H. G. Soderbaum, Chemist to the Swedish Royal Academy of Agriculture. Exhaustive reports of the results of these experiments are to be found in "Meddelanden från K. Lantbruksakademiens Experimentalfält," Nos. 75 and 78 (1902 and 1903), and a report of experiments in the cultivation of oats is given in "The Experiment Station Record," edited by the United States Department of Agri-