commonly used, the retorts require about sixteen hours for carbonization.

There are so many commercial uses to which acetates and acetic acid can be applied, and such possibilities open to any process which cheapens them, that it is strange so little attention has been bestowed upon collecting the immense quantities now wasted in charcoal production, while large works for distilling these products from wood have been erected at, or near to, our cities for supplying print works, etc.

But the importance of carbonizing in closed vessels is not based alone on the value of acetic vapors collected, and the market for them may be a matter of secondary consideration. It is the possibility of obtaining a greater yield from a given amount of wood which makes retorts valuable to those using charcoal as a fuel for metallurgical processes. Liberal averages for the various methods of producing charcoal from ordinary air dried wood of medium age and size are, for meiler charring, 30 bushels per cord; for kiln charring, 45 bushels per cord; for retort charring, 66 bushels per cord. A cord of wood will, therefore, produce as much charcoal in retorts as one and one-third cords in kilns, or as two cords in meilers. The reason for this is, that, as the heat is applied extraneously, none of the wood in the retort is consumed, while in the kiln part of its content are burned to carbonize the balance, and the meiler, being more open, less controllable, and of smaller content, wastes more wood than the kiln.

The saving of a large percentage of the wood required (particularly in some of the Western States where charcoal sills are as high as thirty cents per bushel), would soon pay for a plant of retorts, even if all the acetic vapors were wasted.

The first cost of a battery of retorts is considerable, but, based on the outlay per bushel of charcoal made, it compares favorably with the expense of kilns. When placed in nests, fuel for heating the retorts is seldom required, for the uncondensable gases resulting from the carbonization are generally sufficient to maintain the temperature of the retorts at the point desired. The amount of these gases available is insufficient in some parts of the process, and in others abundant, but where a number of retorts are operated together the deficiency of one is made up by the others. The convenience of filling and emptying retorts as compared with kilns compensates for the cost of cutting the wood.

The census statistics of 1880 show that eighteen billion feet of boards were cut in that year. Of this amount there was probably a waste of one-half cord in tops and branches left to rot in the clearings, or in slabs burned at the mills, for each thousand feet of boards saved, or 9,000,000 cords. This would have produced by improved methods probably 50,000,000 bushels of charcoal, or two and one-half times the quantity annually consumed in the country. There is, therefore, an opportunity to produce, from what is now wasted, fuel to do much to advance the industries of our country, and this paper has been prepared to indicate the possibilities of manufacturing charcoal economically in locations where, if it received consideration, most satisfactory results might follow.

If the expensive and wasteful process of producing charcoal in heaps or meilers is persisted in, the practical abandonment of this fuel may easily be prophesied. But if the economics of manufacture are carefully considered, charcoal will be found to be in many locations the cheapest fuel accessible for metallurgical purposes. A number of Pennsylvania charcoal furnaces produce pig iron with no greater money expenditure for fuel per ton of metal, than their near neighbors who use mineral fuels, and in that State the more modern methods of producing charcoal are not generally adopted.

Generally where woods are felled to produce charcoal, it is considered as sacrificing timbered areas. Such is not, or should not be the case; for it is compatible with successful operations to carry on the production of charcoal in connection with lumbering, or other kindred industries. There is less merchantable timber consumed to-day, in the manufacture of charcoal, than is left in the woods by those who strip bark for tanneries, or cut railway sills and telegraph poles. The waste of the saw mills has been referred to above and needs no further comment.

An industry dependent upon charcoal as fuel must, to be permanent, maintain large forest areas, thus benefiting the surrounding country; and much of the growing timber, being suitable for other purposes than charcoal making, will be so used whenever the compensation is greater. Anomalous as it may at first appear, the probabilities are that, in the near future, the large consumers of charcoal will be among the most enthusiastic patrons of forest cultivation and preservation.

THE MANUFACTURE AND APPLICATION OF ARTIFICIAL MANURES.—By Mr. Smetham.

(A paper read before the Liverpool Polytechnic Society.)

The manufacture of artificial manures may be looked upon as a modern industry. For many generations it has been known that to produce satisfactory results in the field it was necessary for the farmer to apply to the land manures, *i. e.*, plant food, to supply the loss which had been sustained by the removal of various elements from the soil. But in those former times, the knowledge was such as was obtained by experience only, and absolutely nothing was known of the means whereby crops obtained their nourishment. With the extension of knowledge in vegetable physiology and chemistry, the barriers which had blocked the way to a rational method of manuring were one by one broken down, and with this advance, in which the name of Liebig stands pre-eminent, the way was opened to artificial manuring, and consequently to the manufacture of artificial manure.

Before treating of the methods of manufacture now in vogue, it will be necessary to give a rapid glance at the general principles which govern the growth of plants, and the methods by which they are able to assimilate the food which is placed within their reach: otherwise a just conception of the advantages of the present processes will be impossible.

It must be clear to every one, that plants in order to grow, stand as much in need of food as animals or man. Whence then does the plant obtain this food? In the first place it obtains whatever water it requires to build up its structure—principally from the soil. The carbon, the element next in importance, is obtained from the carbonic acid of the air, which is decomposed by the green colouring matter of plants (chlorophyll) and is thus assimilated. Since, in this climate at all events, there is an abundant supply of water and carbonic acid it is clear that it is quite unnecessary to artificially supply either of these. But when we come to the other elements which go to build up the structure of plants, the matter is far different. Of these nitrogen is an important element. It is absorbed by the crop chiefly in the form of ammonia or nitric acid, and it is found that although nitrogen in both these conditions exists, the quantity is by no means sufficient to supply the requirements of cultivated crop; and as plants have not the power of assimilating the free nitrogen of the air, it becomes necessary to supply nitrogen to our soils if we would obtain remunerative results. In the remaining part of plants, the mineral-matters or ash, there are a great variety of elements. The principal of these are:—lime, magnesia, phosphoric acid, sulphuric acid, potash, silica, and chlorine. Soils, almost without exception, contain these these elements in greater or less extent, but few soils, in lands which have been long cultivated, contain the whole of these constituents in sufficient quantities to supply the want of our crops. It is not necessary, however, to use the whole of the foregoing list of elements in an artificial manure, since it is found, both by practice and by the analysis of various soils, that the majority of these are already there in sufficient quantities and in an available form. In the majority of cases it is therefore found that, of the mineral constituents the only two which are required are phosphoric acid and potash, and this latter is moreover only required in certain classes of soils.

For artificial manuring, therefore, the matter resolves itself into the manufacture of manures which shall contain phosphoric acid, nitrogen, and in some instances, potash.

Fortunately there exist in nature large deposits of mineral phosphates, chiefly in the form of tribasic phosphate of lime, combined with a greater or less quantity of extraneous matter. The forms are various and found in almost every country—the most important from a commercial point of view, being Carolina phosphate, Apatite (Norwegian and Canadian), Estramadura phosphate, coprolites, and a considerable variety of so-called phosphatic guanos. Besides these mineral sources we derive a considerable quantity of the phosphate required for agricultural purposes from the bones of various animals, guano and such like animal products.

But, although phosphates are comparatively widely distributed in nature, it has been found that in the condition in which they exist they are, in the case of mineral phosphates, of little value as plant food on account of their practical insolubility in water. Before plants can avail themselves of the mineral constituents of the soil, it is necessary that these substances should be rendered soluble in water, so that they may pass by the rootlets into the plant. Some of the mineral phosphates are almost insoluble in water, and are only very slowly