made by many of the leading German factories. Very interesting exhibits are made by the following:

Schmidt & Haensch, Berlin.
A. Krüss, Hamburg.
Karl Zeiss, Jena.
Steeg & Reuter, Hamburg.
Staudinger's successor, Giessen.
Bunge's successor, Hamburg.
Grossherzoglich saechsische Pruefungsanstalt für Glas Instrumente, Ilmenau.

The other important exhibit here is made by the Physikalisch-Technische Reichsanstalt, Charlottenburg, near Berlin, and consists of normal and standard instruments for various purposes, samples of material, diagrams, publications, etc., which are interesting to anyone acquainted with the work of the institution.

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## THE DEVELOPMENT AND EXTENT OF THE FERTILIZER INDUSTRY.[1]

BY CHARLES U. SHEPARD, M. D., CHARLESTON, S. C.

THE fertilizer industry pre-eminently owes its origin to the scientific recognition of the indispensability of phosphoric acid as an element of plant food; its steady growth has reflected the agricultural appreciation of its use, while the stupendous strides in this branch of trade have especially followed the development of new phosphatic deposits, whose yield has furnished the basis of most artificial manures.

As powerful coadjutors in building up the fertilizer industry to its present dimensions, may be mentioned the development of the Stassfurt potash mines and the South American nitrate of soda beds, the utilization of pyrites (chiefly from Spain and Portugal), the Thomas slag from the steel works, ammonium sulphate, cotton-seed and other meals, and the valuable side products from the enormous slaughter houses of the present day. All of these agencies have contributed largely to the modern growth of the fertilizer industry; nevertheless a brief study of the history of the manufacture and trade in commercial manures

[1] Read before the World's Chemical Congress, August 25, 1893.

will show that its inception and expansion are chiefly due to the demand for and supply of phosphoric acid for agricultural purposes.

Bone and ivory clippings from the knife and button factories of Sheffield, England, were probably the first purely phosphatic manures. This material, amounting to about 1000 tons annually, was regarded as waste until the middle of the last century. Neighboring farmers began to use it on their lands, and so convincing were the results of its application, they soon became willing to meet the constantly advancing price of an article which, originally, was considered barely worth the trouble of hauling to their fields. The same experience was had at a similar factory near Puy-de-Dome, France, although the good results from the utilization of bone-waste do not appear to have been as thoroughly appreciated as in England. In 1774, Hunter first openly advocated the agricultural use of bones. The first experiments with bone meal, on beets, were made in 1775, in Lincolnshire.[1]

From such feeble beginnings, and so comparatively recently dated the consumption of phosphatic manures; they failed, however, to assume any great commercial or agricultural importance until after 1820.

Very naturally the effect of bones on crops received an erroneous interpretation in the days when agricultural chemistry was hardly dreamed of. Thus, Albrecht Thaer, the great agricultural writer, at the close of the last century and in his introduction to the study of English agriculture, observed, "Burnt bones have the effect of lime." And again in 1833, in his *Principles of Rational Agriculture*, he attributed to the gelatine contained in bones, the good results from their use. About the same time John Nepomuk von Schwerz wrote in his *Introduction to Practical Agriculture*: "The effect of bone-meal is not inconsiderable, even after the extraction of the fatty matter." Fawtier in writing of the value of the several components of bones, observed: "We can neglect one of the earthy components, *viz.*, phosphate of lime, because it is indestructible and insoluble. It cannot

[1] "Die Natürlichen Phosphate," by Dr. L. Meyn, and "Chimie Agricole," by Prof. P. P. Dehérain, have afforded me many of these historical data.

serve as manure." If later the beneficial action of bones was acknowledged, it was almost wholly attributed to their gelatin by such writers as Payen.

But another and the true significance of bone manure soon obtained foothold. The presence of phosphorus in seeds had been discovered by Polt, and afterwards verified by Margraff, Vauquelin and Th. de Saussure. Basing his opinions on their researches, Justus von Liebig attributed the agricultural effect of bones to their content of phosphate of lime. The Duke of Richmond's direct field experiments on the use of bones were instituted in 1843. They apparently demonstrated that the action of calcined or boiled bones (*i. e.*, deprived in whole or in part of their grease and gelatin) is not inferior to that of crude and fresh bones. His conclusion, which controverted the prevailing opinion, was that the fertilizing principle of bones lies neither in grease nor in gelatin, but rather in phosphate of lime, and more particularly in phosphoric acid and not lime.

Meanwhile the agricultural application of and consequent demand for bones outran the scientific investigations as to their mode of action. Factories for grinding bones were established in England, France, and Germany. The cultivation of the sugar beet and the manufacture of sugar on the Continent enormously increased the demand for bones. They were no longer regarded as refuse; but, on the contrary, they were everywhere carefully collected and shipped to great commercial centers or locally applied to the crops. In 1859, Great Britain imported 84,000 tons; in 1872, 97,778 tons, worth £642,715. But a substitute was at hand, which should relieve the farmer in his competition with the sugar refiner. Coprolites had been discovered in France and England, and their composition ascertained. These discoveries remained inoperative until after the experimental investigations of the Duke of Richmond, before alluded to, and those of Justus von Liebig with superphosphates.

Liebig recommended in 1840, the employment of sulphuric acid to dissolve osseous phosphate of lime, and, thus to render it more subservient to the wants of vegetation. Shortly thereafter, John Bennett Lawes, the great English manufacturer of chemical manures and yet more distinguished experimenter in

agricultural chemistry, erected a factory for the treatment of coprolites and similar phosphates according to Liebig's plan for utilizing bones.

Immediately the interest in phosphatic material of every kind was stimulated by the promulgation of their value. The search for phosphatic deposits extended to all accessible parts of the world. A vast number and variety of phosphates were discovered and developed. Nevertheless it was not until the South Carolina beds had been opened to commerce and manufacture, that the treatment and manipulation of mineral phosphates, which thus far has constituted the main function of the fertilizer industry, began to assume the rapid expansion which has latterly characterized it.

The inauguration of the South Carolina phosphate industry occurred in the winter of 1867-68.

At a time when the prostration following an exhausting war and a social revolution had depressed all the former commercial and agricultural industries of the Carolina seaboard, and men were casting about for the means to rehabilitate their broken fortunes; when the deposits of Peruvian guano and West Indian phosphates had begun to exhibit signs of their ultimate, perhaps speedy, exhaustion, and remaining sources were proving entirely inadequate to supply the rapidly increasing demand for mineral phosphate of lime, which had been shown to be susceptible of conversion into a substitute for the phosphates contained in guano and bone ; then, and as a generally appreciated relief, began the practical utilization of the Carolina phosphate beds.

The necessity of the restitution to enfeebled lands of the mineral constituents of plant food, so ably presented by Justus von Liebig, had duly impressed the minds of all enlightened farmers, particularly those in the older countries. The settlement of the vast plains of the American northwest and the active shipment from its virgin soil of cereals and animal products at prices which defied competition by the old system of agrarian operations, necessitated intensive agriculture. A stricter study into every detail of cost on the farm and the practice of rigid economy throughout had well nigh dethroned bulky

domestic manures from their long vaunted supremacy. The use of quickly-acting fertilizers for shortening the period of plant growth, and especially to permit of the successful raising of money-crops beyond their natural thermal belts, had become established.

Simultaneously with the development of the Carolina deposits, occurred that of the Stassfurt potash salts, and shortly thereafter that of the nitrate of soda beds on the Pacific coast of South America. Meanwhile the substitution of sulphur from pyrites—often obtained as a side product—for the more expensive Sicilian brimstone, and the introduction of great improvements in the methods of manufacturing chemical manures, combined to cheapen the cost of their production. With a ready supply of the other mineral constituents of plant food, a greater demand has naturally followed for what has been long regarded as the very foundation of artificial fertilizers, *viz.*, phosphate of lime.

Thus were afforded, and at a time of their greatest need, to the people of the Carolina seaboard, the manifold blessings which flow from a great and comparatively remunerative industry; and to farmers at large commercial manures of better quality and at cheaper cost than they had before enjoyed. Possessing about the same content of phosphoric acid as the best coprolites and the various bone articles which had previously served for the manufacture of superphosphates, and mixing very kindly with sulphuric acid, the South Carolina phosphates were gladly utilized by all the trade in artificial fertilizers, except by those engaged in making the high grade goods sold in Germany. The growth of the South Carolina industry has been fairly steady, as the yearly production of the mines prove:

| | Tons. |
|---|---|
| 1868, year ending May 31 | 12,262 |
| 1871, " " " " | 74,188 |
| 1874, " " " " | 109,340 |
| 1878, " " " " | 210,322 |
| 1885, " " " " | 395,403 |
| 1889, " " Dec. " | 541,645 |
| 1891, " " Aug. " | 572,949 |
| 1892, " " " " | 548,396 |

According to Maj. E. Willis the production of South Carolina phosphates for the years 1891–2 and 1892–3, ending August 31, was as follows:

| | From Charleston, 1891–92, tons. | From Beaufort, 1891–92, tons. | From Charleston, 1892–93, tons. | From Beaufort, 1892–93, tons. | |
|---|---|---|---|---|---|
| Foreign shipments... | 4,396 | 120,058 | 175 | 177,893 | |
| Coastwise " ... | 143,627 | 30,602 | 121,939 | 96,720 | |
| Interior ..... | 58,713 | 10,000 | 39,342 | 12,500 | |
| Consumed ..... | 165,000 | 16,000 | 155,000 | 15,000 | |
| | 371,736 | 176,660 | 316,456 | 302,113 | |
| Grand total..... | | | | | 1,166,965 |

The shipments from the State's territory, almost wholly confined to the Beaufort district, were for the same year (ending August 31, 1892), 156,095 tons; they promise to approximate 250,000 tons for the present year.

THE AMOUNT OF PHOSPHATE ROCK MINED AND REMOVED FROM THE RIVERS OF SOUTH CAROLINA, BEING THE PROPERTY OF THE STATE, FROM SEPTEMBER 1, 1892, TO SEPTEMBER 1, 1893, ACCORDING TO STATE INSPECTOR JONES, "THE NEWS AND COURIER," SEPTEMBER 19, 1893.

| | Tons on hand first of year, estimated. | Tons mined during year, estimated. | Tons removed during year. | Tons on hand last day of year, estimated. |
|---|---|---|---|---|
| Coosaw Co ..... | 40,370.00 | 98,631.00 | 110,719.99 | 15,411.00 |
| Carolina Mining Co.... | 11,631.00 | 56,500.00 | 63,521.60 | 6,826.00 |
| Farmers' Mining Co... | 15,675.00 | 36,576.00 | 46,093.95 | 4,000.00 |
| Beaufort Phosphate Co. | 11,048.00 | 21,184.00 | 27,613.96 | 4,927.00 |
| Ashley Phosphate Co.. | ..... | 169.67 | 169.67 | ..... |
| J. C. Nelson ..... | 305.75 | 579.25 | 487.00 | 407.00 |
| James O'Hear ..... | 455.25 | 177.74 | ..... | 623.00 |
| James Reed..... | 60.00 | 487.00 | 630.00 | ..... |
| F. W. Wagener & Co.. | 12.00 | 122.54 | 122.54 | ..... |
| Total..... | 79,557.00* | 214,427.20* | 249,358.71 | 32,194.00 |

*Corrected.

The Florida phosphate beds have recently attracted great attention not only from capitalists seeking suitable investments, but also from all phosphate miners and those engaged in the fertilizer trade.

In view of the many publications on this subject which have latterly appeared and because I do not feel at liberty to digress

from the topic which I have chosen, I will content myself with simply quoting the production for the past few years of Florida phosphates of all varieties, *viz.*:

| | Tons. |
|---|---|
| 1888 | 3,000 |
| 1889 | 4,100 |
| 1890 | 46,501 |
| 1891 | 112,482 |
| 1892 (about) | 290,000 |

The shipments for 1892 consisted of about two-thirds "hard rock" and one-third "pebble" phosphates. They comprised 283,221 tons, of which 225,090 tons were exported to foreign ports. (Letter of Mr. E. W. Bailey, of Fernandina.) The local consumption of phosphates in Florida is estimated at a few thousand tons.

FLORIDA HARD ROCK AND PEBBLE PHOSPHATE, 1892 (E. WILLIS).

| | Hard rock | | | Pebble rock | | |
|---|---|---|---|---|---|---|
| | Domestic. | Foreign. | | Domestic. | Foreign. | |
| Punta Gorda .. | ..... | ..... | | 21,809 | 44,314 | |
| Fernandina ... | 5,520 | 119,492 | | ..... | ..... | |
| Tampa ..... | 1,000 | 45,590 | | 20,816 | 2,808 | |
| Savannah ..... | ..... | 7,412 | | ..... | ..... | |
| Brunswick .... | ..... | 18,061 | | ..... | ..... | |
| Jacksonville .. | ..... | ..... | | ..... | ..... | |
| Rail ..... | 4,000 | ..... | | 19,300 | ..... | |
| Consumed..... | 1,000 | ..... | | 3,000 | ..... | |
| | 11,520 | 190,555 | 202,075 | 64,925 | 47,122 | 112,047 |
| Total tons... | | | | | | 314,122 |

I have hesitated about discussing before so intelligent and professional an audience the necessity of the fertilizer industry. But there may be some present who, while admitting the general proposition that a restitution of the elements of plant food should accompany the steady depletion which continued cropping entails, have not considered the extent of this drain—that enormous waste which even now the utmost energies of the trade in commercial manures cannot compensate for. Centuries of harvesting in the ancient grain producing countries of the world have reduced the original stock of assimilable phosphoric acid to a point where the cereals may no longer be profitably culti-

vated. A natural recuperation, if possible, involves cycles of time. Nations recover from the effects of disastrous and sanguinary warfare; but no human endurance can withstand widespread sterility in a land. The population must seek other and more fertile regions, or be doomed to abject poverty or slow extinction. Man is essentially a squanderer of phosphoric acid. To his agency, pre-eminently, may be ascribed its exhaustion in the soil. The greater part of this precious ingredient which enters so largely into his own frame and the composition of his food, as also of the animals subservient to him, is allowed to flow into the sea; where at the greatest depths of ocean-dredging it has been discovered, apparently now building new phosphatic deposits, some nodular and others as a replacement of old animal forms.

Delhérain has valued the phosphoric acid annually contained in the solid and fluid dejections of the French population (thirty-six million souls) at nearly $4,000,000. Johnson has calculated that the liquid manures carried off each day by the sewers of London would fertilize near 60,000 acres of sterile land, and thus might support 125,000 individuals for one year.

Delagarde has calculated the annual waste of plant food in rural France at the enormous sum of $400,000,000, that being the commercial value of the material adequate to replace the dissipated ingredients.

China offers an example to the world in the care with which all animal remains and manures are restored to the soil. It is unquestionably due to this economy that its territory can support two human beings to the acre. In some of its provinces the ratio is greater, as in Pekin and Tchenkon, where one acre subsists six to eight.

If fecal matter were saved in France to the extent of only twenty per cent. more than is now the case, it should not be compelled to import in some years ten million dollars worth of grain; it might, on the contrary, export nearly twenty millions worth per annum (Bobierre). The use of domestic manure extends back to the earliest times in much the same manner and to the same effect as at present; and yet it has not prevented the exhaustion of many fertile lands nor averted the gradual

decline in productiveness of European and other lands now cultivated for a long period.

The report of the international jury at the Universal Exposition of 1889 by M. Grandeau, shows the amount of the most important constituents of plant food annually abstracted from French soils, and their value. The yearly depletion is of

| | Tons (metrical). | Value per ton. | Total value. |
|---|---|---|---|
| Nitrogen | 600,000 | at 1600 francs | 960,000,000 francs |
| Phosphoric acid | 300,000 | " 300 " | 90,000,000 " |
| Potash | 775,000 | " 450 " | 348,000,000 " |
| | | ($279,600,000) | 1,398,000,000 " |

The production of farm manure for 1892 was estimated at 84,000,000 tons, containing of

| | Tons. |
|---|---|
| Nitrogen | 327,600 |
| Phosphoric acid | 151,200 |
| Potash | 378,000 |

Without allowing for any waste in the stable and other manure of the farm, the deficit for the year should stand:

| | Tons. | | Per cent. | |
|---|---|---|---|---|
| Nitrogen | 272,400 | or | 45.4 | Per cent. of the yearly depletion. |
| Phosphoric acid | 148,800 | " | 49.6 | |
| Potash | 397,000 | " | 51.2 | |

To restore this deficit would be required of the following chemical manures:

| | Tons. | | Tons. |
|---|---|---|---|
| Nitrate of soda | 1,747,000 | Superphosphate | 1,240,000 |
| Sulphate of ammonia | 1,463,000 | Potassium chloride | 1,985,000 |
| Tribasic phosphate | 876,000 | Kainite | 3,300,000 |

Robert Hasenclever has calculated that the yearly crops abstract from the soil of Germany 640,276 tons of phosphoric acid; that the entire animal excreta together with the litter contain 553,572 tons of phosphoric acid, but that fully one-half of it is lost to agricultural use, which would leave an annual deficit of 363,490 tons. Against these figures are to be put 156,020 tons phosphoric acid contained in the yearly application of chemical manures; the result is an annual abstraction of over 200,000 tons phosphoric acid from German fields.

In view of modern experience and for the needs of a general agriculture, there appears to be more necessity of replacing phosphoric acid than either nitrogen, which by natural agencies may be restored from the atmosphere, if slowly (Dehérain), or potash, of which there is usually a practically greater supply in the soil and which may be replaced by soda, at least to a slight extent under favorable conditions.

As to the requisite amount of restitution, Drechsler arrived at the following conclusions:

"1. All cultivated plants require for their best development a greater supply of assimilable nutritive principles in the soil than what they abstract during the period of growth. Their yield is proportionate to the amount of the ingredient which offers to the plant the smallest quantity in an assimilable condition.

"2. If a soil contains less plant food than is requisite for the production of the crop, it can reproduce an equal harvest of the same kind only when the ingredients abstracted from it are restored.

"3. It is necessary to restore in quantities sufficient to re-establish the productiveness of lands, the ingredients abstracted in the produce which the soil does not contain in excess or are not in a proper state of division (for assimilation).

"4. At each manuring it is necessary to so augment the fund of assimilable food in the soil that the available amount of each ingredient shall be sufficient for the production of normal agricultural crops until the occurrence of the next fertilization."

That without abundant restitution, it is simply a question of time until all soils must become practically exhausted, our own short American experience amply teaches. A century ago the farmers about Albany and New York, produced thirty to forty bushels of wheat, where their successors now obtain only ten or twelve. A recent correspondence with agricultural authorities throughout the now central states and those lying to the west of them, has clearly demonstrated how comparatively soon the necessity for using commercial manures occurs even in our briefly occupied and originally fertile central territory. A western state will indignantly reply to a question as to the condition of the commercial manure-trade within its borders, with the

statement that so great is its fertility that absolutely no restitution to its fields is required. Its neighbor to the east admits the use of stable manure, as a supplement to the original fertility, at least for some crops. Yet to the eastward, and there come vague reports of artificial manures being used, if only in small quantities. But as soon as the north and south line is reached which divides our population into the eastern and western halves, statistics of consumption become attainable, and their testimony proves an ever increasing trade in these commodities.

The fertilizer industry stands no longer on the defensive; except in ignorant communities, its tone is no longer apologetic. Its mission is noble, if simple, *viz.*, to make two ears of corn where now there is only one and soon there may be none. Its functions are to provide an adequate supply of food for man, animal and plant; to enable the farmer to carry out the old saying, "Feed your land and it will feed you." Its importance must be weighed not only by its actual achievements, but by the effects of its absence. A signal proof of its necessity, lies in its stupendous development during the past twenty-five years. No statesman can afford to underrate its influence or antagonize its activity, since they serve to invigorate agriculture, whether for the direct support of animal life or for the production of money crops, thus enhancing the value of lands which otherwise might soon be worthless.

## THE SOURCES OF THE CHIEF INGREDIENTS OF COMMERCIAL FERTILIZERS.

*Peruvian Guano.*—The dimensions of the trade in Peruvian and similar guanos in times past have an additional value for us as they reveal the void which its present shriveled size has left, and they indicate the necessity for providing a substitute at least in quantity. A real equivalent has never been found; nor is it probable that so efficacious and abundant a combination of plant food will be discovered in the future.

The extent of the trade in these natural bird guanos was enormous so long as the supply was unimpaired, but one by one the deposits yielded to the eager demand for the precious and costly material. The quantity of guano exported from Peru from February 19, 1842, to December 21, 1867, amounted to

7,175,194 tons, valued at $218,693,625; and in 1871 and 1872, to 1,181.327 tons, valued at $44,915,451. The United States imported in the period 1848 to 1858 707,408 tons.

By no means all bird guano came from Peru, as the following table of the shipments to Europe during the years 1841 to 1857 will show:

| | Tons. |
|---|---|
| From Peru | 1,664,662 |
| " west coast of Africa | 305,807 |
| " South Africa | 76,042 |
| " Chili | 106,602 |
| " Patagonia | 73,485 |
| " Bolivia | 24,667 |
| " other localities | 122,383 |
| | 2,373,648 |

Great Britain received in the period 1884 to 1888, 188,421 tons of bird guano, worth £1,596,020, and exported 41,840 tons, valued at £343,562. The present exportation of Peruvian guano does not probably exceed 50,000[1] tons annually, of which one-half goes to the United Kingdom. After manipulation it is largely shipped to the colonies.

*Nitrate of Soda.*—The nitrate of soda trade from the Pacific coast of South America has assumed gigantic proportions ever since the shipments of Peruvian guano began to wane, as may be seen from the following table which exhibits the exportation and consumption during the past few years.

| | Exportation from South America, tons. | Consumption in Europe, tons. | Consumption in America, tons. | Total consumption, tons. |
|---|---|---|---|---|
| 1888 | 754,000 | 637,000 | 68,000 | 705,000 |
| 1889 | 930,000 | 655,000 | 79,000 | 734,000 |
| 1890 | 1,035,000 | 780,000 | 104,000 | 884,000 |
| 1891 | 753,000 | 830,000 | 98,000 | 928,000 |
| 1892 | 795,000 | 785,000 | 97,000 | 882,000 |

These figures also show the preponderance of the supply over the demand, which caused a fall in price and later brought about an agreement among the producers to reduce the shipments to 800,000 tons in 1891 and 900,000 tons in 1892.

[1] Voss and others reckon it higher, even to 100,000 tons.

The present (1892) consumption of nitrate of soda by countries is approximately as follows:

| | Tons. |
|---|---|
| Germany | 330,000 |
| France | 200,000 |
| Great Britain | 110,000 |
| Belgium | 100,000 |
| Holland | 40,000 |
| Spain and Italy | 10,000 |
| United States | 100,000 |
| | 890,000 |

By no means all of this vast supply is directly employed by agriculture, very considerable parts being used in the manufacture of gunpowder, sulphuric acid, and chemicals. Nevertheless, the greater portion of the importation finds agricultural use in Germany and other countries.

*Sulphate of Ammonia.*—This began to find considerable employment in agriculture in the sixties. Its present production in Europe has been given as follows:

| | Tons. |
|---|---|
| England | 143,000 |
| France | 25,000 |
| Belgium | 10,000 |
| Germany | 30,000 |
| Other countries | 10,000 |
| | 218,000 |

According to another authority, Bradbury & Hirsch, of Liverpool, the production in and exportation from Great Britain for 1892 was:

| | Tons. |
|---|---|
| Exportation to Germany, Denmark, Sweden, and Russia | 33,000 |
| " " France, Spain, and Italy | 36,000 |
| " " Belgium and Holland | 24,000 |
| " " America and colonies | 18,000 |
| Consumed in Great Britain | 43,500 |
| Stock on hand | 3,500 |
| 1892 total production in Great Britain | 157,000 |

*Stassfurt Potash Salts.*—The total production of the syndicate of Stassfurt miners for 1891 was as follows:

| | Gross Tons. |
|---|---|
| Chloride of potassium | 134,162 |
| Sulphate of potash | 17,980 |
| Double sulphate of potash and magnesia, calcined | 11,398 |
| " " " " " " crystallized | 1,052 |
| Manure salts, calcined | 3,076 |
| Kieserite | 28,559 |
| Kainite and sylvinite | 413,507 |
| Carnallite | 39,441 |

The industrial and agricultural use of the chloride of potassium, eighty per cent., and sulphate of potash, ninety per cent., is as follows:

| | Industrial | | Agricultural | |
|---|---|---|---|---|
| | Germany, tons. | Foreign, tons. | Germany, tons. | Foreign, tons. |
| Chloride | 42,498 | 38,115 | 1,300 | 49,430 |
| Sulphate | 4,648 | 4,500 | 110 | 8,722 |

According to Hasenclever the following quantities of kainite were used in Germany in the years mentioned:

| | Tons. |
|---|---|
| 1880 | 23,763 |
| 1885 | 55,320 |
| 1888 | 105,231 |
| 1889 | 150,341 |
| 1890 | 178,031 |

The consumption of Stassfurt potash salts for the year 1891 was as follows:

| Countries. | 80 per cent. chloride of potassium, gross tons. | 90 per cent. sulphate of potash, gross tons. | Kainite and sylvinite, gross tons. |
|---|---|---|---|
| Germany | 43,798 | 4,758 | 240,000 |
| Austria | 2,550 | 60 | .... |
| England | 12,310 | 1,650 | .... |
| Scotland | 8,150 | 1,385 | .... |
| France | 15,110 | 2,170 | .... |
| Belgium and Holland | 8,500 | 250 | .... |
| Italy | 4,640 | 140 | .... |
| North America | 35,670 | 5,200 | 115,245 |
| Scandinavia | 550 | 50 | .... |
| Denmark | 1,794 | | |
| Spain, Portugal, etc. | 1,090 | 2,317 | .... |
| Other lands | .... | .... | 58,262 |
| | 134,162 | 17,980 | 413,507 |

Very recently another deposit of potash salts has been found in the Wipper valley, near Sonderhausen, Germany, which promises to prove an important rival to the Stassfurt beds. Difficulty of transportation has thus far interfered with the utilization of the East Austrian potash deposits.

*Nitrate of Potash.*—Extensive beds of this valuable material are claimed to have been found in Mashonaland, near Mt. Darwin, in the direction of the Hunyani river, by Mr. Griffiths, engineer to the South African Co. They are said to be from three inches to twenty feet in thickness and to underlie twenty square miles.

*Mineral Phosphates.*—The sources of the world's supply of phosphates with the amount furnished by each was estimated at the close of 1890 by Mr. Hermann Voss as follows:

| | Tons. |
|---|---|
| England | 20,000 |
| Germany | 40,000 |
| Norway | 20,000 |
| Belgium | 200,000 |
| France | 400,000 |
| United States | 600,000 |
| Canada | 30,000 |
| West Indies | 50,000 |
| Other countries | 100,000 |
| | 1,460,000 |

Since then the Florida beds have been developed with extraordinary rapidity, and their output has increased from about 50,000 tons in 1890 to nearly 300,000 tons in 1892. But as this increment has been to a certain degree at the expense of other phosphate mining communities, especially under the combined influence of depressed business and diminished agricultural profits both at home and abroad, it is improbable that the total production of mineral phosphate for 1892 has largely exceeded 1,600,000 tons.

France enjoys the possession of phosphatic deposits of greater extent than any other European country, unless it be the undeveloped beds in Russia. They are practically of two sorts, those of higher grade and adapted for conversion into super-

phosphates (industrial), and those of lower types, which are ground and directly applied to the soil (agricultural).

According to *L'Engrais*, the estimate of May 1, 1892, of the French phosphatic deposits in the departments of Somme, Pas de Calais, and Aisne is as follows:

| | |
|---|---|
| Area underlaid by deposits | 185 hectares (457 acres) |
| Average yield per hectare | 8,557 tons (French) |

The quantity and quality are estimated at:

| | Tons. |
|---|---|
| 70–80 per cent. tricalcium phosphate | 158,000 |
| 60–70 " " " " | 222,500 |
| 50–60 " " " " | 301,500 |
| 40–50 " " " " | 428,500 |
| 30–40 " " " " | 366,500 |
| Total | 1,477,000 |
| 25–40 per cent. phosphate chalk | 636,500 |
| Daily extraction from mines | 955 |
| Actual monthly production of works | 29,125 |

The same authority has given the following estimate of the total productions of mineral phosphates for all France in the years 1891 and 1892.

| | Industrial phosphates. | | Agricultural phosphates. | |
|---|---|---|---|---|
| | 1891, tons. | 1892, tons. | 1891, tons. | 1892, tons. |
| Region Somme | 278,000 | 407,000 | 56,000 | 52,000 |
| Boulonnais Pernes-Cambresis, etc. | ..... | ..... | 35,000 | 30,000 |
| Ardennes | ..... | ..... | 17,500 | 17,500 |
| Meuse | ..... | ..... | 45,000 | 45,000 |
| Auxosis | 16,000 | 9,000 | 2,000 | 1,000 |
| Indre | ..... | ..... | 6,000 | 6,000 |
| Region du Midi | 12,000 | 10,000 | 3,000 | 2,000 |
| Algerie et divers | 2,000 | 2,000 | 2,000 | 2,000 |
| Total | 308,000 | 428,000 | 166,500 | 155,500 |

The French exportation and importation of phosphates for the years 1889–91 were as follows:

| | 1889, tons. | 1890, tons. | 1891, tons. |
|---|---|---|---|
| Exportation | 150,963 | 122,002 | 91,246 |
| Importation | 6,914 | 21,452 | 17,069 |

The diminished exportation and increased importation during 1890–91 may have been due to the increasing activity of the Carolina and Florida phosphate mines in the same period.

*The Thomas Slag*.—The Thomas Slag has thus far defied my efforts to reach a satisfactory conclusion as to the extent of its agricultural use.

Hasenclever calculated the production of this article for 1891 as follows:

| Production of | Thomas slag, tons. | Containing of phosphoric acid, tons. |
|---|---|---|
| Germany, Austria, and Luxemburg | 617,600 | 105,000 |
| England | 178,700 | 30,390 |
| France | 84,500 | 14,360 |
| Other countries | 65,000 | 11,050 |
| | 945,800 | 160,800 |

While Rieman estimates the annual consumption of Thomas slag meal in Germany at 200,000 to 250,000 tons; Voss quotes it at over 300,000 tons; and other authorities at 450,000 tons. Recent commercial depression has reduced the output of the steel works, and consequently of the Thomas slag.

There is naturally great difference of opinion as to its agricultural value, although enormous quantities continue to be directly employed on German fields, and, that too, without interfering with the ever increasing application of acidulated and otherwise manipulated phosphates.

The report of the International Agricultural and Forestry Congress in Vienna (1891) on the availability of the Thomas slag, shows that the action of the Thomas meal is dependant on the amount of *matière noire* in the soil, which hastens the decomposition of the tetracalcium phosphate not only by its property of holding fast to moisture, but also by the influence of its ulmic and humic acids. Under favorable agricultural conditions it is necessary to employ only fifty per cent. more of the *active* phosphoric acid contained in the meal than is commonly used of water soluble phosphoric acid; but where the soil and conditions are not favorable, it is necessary to use two or three times as much. At recent prices of phosphoric acid in Germany, *viz*., say, $2\frac{3}{4}$ to 3 cents per pound for the active acid in Thomas meal, and six cents per pound for water soluble, there does not appear to be any great profit in the use of the meal instead of acidulated phosphates.

## THE FERTILIZER INDUSTRY IN GREAT BRITAIN.

The trade in commercial manures in the United Kingdom whether for home consumption or exportation, has necessitated large importations of crude materials and the erection of vast works for their manufacture. In 1889 there were registered in Great Britain 281 manure works, of all sizes; but among that number were eight of a capacity of 30,000 to 50,000 tons annually and twenty of 10,000 to 20,000 tons. The direction of these extensive plants has produced men of great business and scientific attainments; their operation gives employment to £5,000,000 of capital and thousands of workmen; their output serves to maintain the high fertility of British farms. In no other country have the effects of artificial manuring been so carefully studied; and wherever agricultural chemistry extends, thither the fame and achievements of the Rothamsted farm have spread.

The growth of the trade has fully kept up with that of other countries. The artificial manures manufactured in 1862 amounted to 200,000 tons, and in 1890 to 800,000 tons in addition to the sale of about 200,000 tons of nitrate of soda and similar manures (Voss).

The following table is very instructive as exhibiting the increment in the consumption of phosphatic material, whether in bones or mineral phosphates, as compared with the importation of guano. If the modern agricultural opinion holds good that the liberal application of nitrate of soda is almost imperative, but that it involves the greater use of phosphatic manures, whether it be that the former stimulates the leaching out of the phosphoric acid from the soil or that it causes the plant to assimilate more of the latter; in either case the tendency of the present day requires a greater employment of phosphates, and it is encouraged by an extraordinarily cheap market of those goods.

IMPORTATIONS INTO GREAT BRITAIN, ACCORDING TO THE BOARD OF TRADE RETURNS.

| | 1867. | | 1889. | | 1890. | |
|---|---|---|---|---|---|---|
| | Tons. | £. | Tons. | £. | Tons. | £. |
| Bones | 83,814 | 457,436 | 62,435 | 308,212 | 69,949 | 372,048 |
| Nitrate of soda | 60,887 | 667,356 | 117,565 | 1,102,583 | 108,892 | 903,632 |
| Phosphates | * | * | 304,953 | 703,794 | 343,501 | ..... |
| Guano | 192,308 | 2,109,506 | 28,604 | 199,783 | 28,005 | 167,181 |
| Total | 337,009 | 3,234,298 | 513,557 | 2,314,282 | 550,347 | ..... |
| Chemical manures exported. | ..... | 196,183 | 320,181 | 2,049,765 | 318,511 | 2,070,246 |

* None reported.

IMPORTATIONS INTO GREAT BRITAIN, ACCORDING TO THE BOARD OF TRADE RETURNS.—*Continued.*

| | 1891. | | 1892. | |
|---|---|---|---|---|
| | Tons. | £. | Tons. | £. |
| Bones | 82,945 | 416,849 | 63,008 | 286,452 |
| Nitrate of soda | 122,032 | 1,049,818 | 118,642 | 1,012,549 |
| Phosphates | ..... | ..... | ..... | ..... |
| Guano | 23,623 | 138,642 | 27,874 | 189,433 |
| Total | 485,372 | ..... | 548,649 | ..... |
| Chemical manures exported | 322,166 | 2,112,563 | 329,125 | 2,136,000 |

For first six months of 1892 importations of phosphates were .....146,156 tons.
" " " 1893 " " " " .....154,328 "

The importation of phosphates into Great Britain has been as follows, according to the Anglo-Continental Guano Company:

| Sources. | 1888. Tons. | 1889. Tons. | 1890. Tons. | 1891. Tons. |
|---|---|---|---|---|
| South Carolina | 111,369 | 122,511 | 177,283 | 35,200 |
| Florida | ..... | ..... | ..... | 96,881 |
| English Antilles | 11,010 | 1,880 | 3,970 | 1,960 |
| Dutch " | 10,736 | 14,730 | 11,763 | 8,851 |
| Hayti and San Domingo | 6,238 | 4,094 | 992 | 1,639 |
| Venezuela and Guinea | ..... | ..... | ..... | 540 |
| Australia | ..... | 1,250 | ..... | ..... |
| Canada | 12,423 | 24,297 | 21,089 | 15,918 |
| Portugal | 6,979 | 1,326 | ..... | 320 |
| France | 39,059 | 64,490 | 25,659 | 18,325 |
| Belgium | 54,261 | 64,643 | 82,096 | 70,723 |
| Holland | 4,137 | 2,210 | 2,428 | 3,434 |
| Norway | ..... | ..... | 4,151 | 1,495 |
| Other countries | 1,675 | 390 | 1,070 | 1,483 |
| Total | 257,886 | 304,953 | 343,501 | 256,769 |
| *Exportations:* | | | | |
| To Sweden | ..... | 1,305 | 1,587 | ..... |
| " Germany | 3,747 | 9,716 | 6,235 | ..... |
| " Holland | 985 | 1,535 | ..... | ..... |
| " Other countries | 891 | 1,510 | 489 | ..... |
| | 5,623 | 14,660 | 8,314 | ..... |

The exportation of artificial manures from Great Britain for the year 1891, was as follows:

| Countries. | Tons. | £ value. |
|---|---|---|
| To Germany | 75,549 | 400,201 |
| " Belgium | 17,015 | 187,420 |
| " France | 43,651 | 275,016 |
| " Spain | 34,274 | 324,892 |
| " West Indies | 21,266 | 210,659 |
| " Otherwise | 130,411 | 714,375 |
| | 322,166 | 2,112,563 |

A material change has been induced in English agriculture by the development of the vast grain fields of the American North-

west. To-day England grows more clover, grass, and root crops, and less wheat, because of the greater profit in the former. Hence there is greater demand for phosphates and less for nitrogen (Voss).

*France.*—The annual importations and exportations of manures have been as follows:

| | Importations. | | Exportations. | |
|---|---|---|---|---|
| | 1891. Tons. | 1892. Tons. | 1891. Tons. | 1892. Tons. |
| Nitrate of potash | 1,600 | 1,605 | 836 | 588 |
| Nitrate of soda | 180,278 | 205,887 | 6,501 | 7,673 |
| Phosphates | 17,644 | 41,185 | 91,821 | 83,885 |
| Peruvian guano | 2,999 | ..... | 1,559 | 1,355 |
| Other guano | 1,990 | 3,427 | | |
| Acid phosphates | 98,521 | 97,660 | 36,068 | 43,308 |
| Chemical manures | | 21,462 | | 14,655 |
| Other manures | 45,330 | 35,658 | 40,220 | 34,857 |

M. Joulie has reported to the Society of Agriculture of France the following table as the annual consumption of artificial manures in that country:

| | Tons. |
|---|---|
| Nitrate of soda | 215,000 |
| Sulphate of ammonia | 30,000 |
| Natural phosphates (direct application) | 150,000 |
| Thomas slag meal | 70,000 |
| Superphosphates | 500,000 |
| | 965,000 |

France employs, additionally, potash salts to the value of 500,000,000 francs, and of other fertilizers to the value of 19,000,000 francs, making a total annual outlay of 120,000,000 francs, or $24,000,000 (Joulie). The trade in commercial manures has trebled in the past twenty years.

*Germany.*—The importations of commercial manures for 1892 are as follows, according to *L'Engrais*:

| | | Tons. | |
|---|---|---|---|
| Nitrate of soda | | | 379,898 |
| Sulphate of ammonia | | | 34,206 |
| Phosphates *via* Hamburg. | from Florida | 48,928 | |
| | " Canada | 2,251 | |
| | " South Carolina | 20,286 | |
| | " Aruba | 430 | |
| | " France | 6,181 | |
| | " Belgium | 1,340 | |
| | " Norway | 385 | |
| | " Mexico | 2,014 | |
| By other ports than Hamburg | | 26,357 | |
| By rail | | 150,000 | 248,172 |
| *Carried forward* | | | 662,276 |

| | |
|---|---|
| *Brought forward* | 662,276 |
| Bone ash | 14,620 |
| Bone black refuse | 10,973 |
| Bone flour | 24,551 |
| Phosphatic guano | 12,528 |
| Nitrogenized " | 3,665 |
| Fish | 5,458 |
| Meat | 5,037 |
| Total | 739,108 |

A conservative estimate of the consumption of artificial manures in Germany gives the following results:

| | Tons. |
|---|---|
| Acid phosphates | 450,000 |
| Thomas slag meal | 300,000 |
| Bone meal, etc. | 75,000 |
| Precipitated phosphate | 5,000 |
| Nitrate of soda | 250,000 |
| Sulphate of ammonia | 50,000 |
| Potash salts | 200,000 |
| | 1,330,000 |

By others the consumption of acid phosphates is placed at 600,000 tons; of Thomas slag meal at 450,000 tons; of nitrate of soda at 300,000 tons; thus aggregating a total of at least 1,500,000 tons annually.

M. Maizieres (*L'Engrais*, 18th of August, 1893) estimates the average production of acid phosphates in Europe as follows:

| | Tons. |
|---|---|
| France | 440,000 |
| England | 500,000 |
| Belgium | 275,000 |
| Germany | 550,000 |
| Holland, Sweden, and Norway | 150,000 |
| Italy and Switzerland | 100,000 |
| Other countries | 100,000 |
| Total | 2,115,000 |

The production oscillates between 2,000,000 and 2,400,000 tons. It is derived from the consumption of about 1,000,000 tons each of mineral and other phosphates and sulphuric acid of 53° B.

*The United States.*—The consumption of commercial manures has grown very rapidly during the past twenty years in the

Atlantic, and especially the South Atlantic states. Their use is steadily on the increase in the central and gulf states. Gradually they are being sought after in the less distant and more thickly populated of the western ones.

In many of the states it is possible to obtain official figures as to the consumption of artificial manures within their borders, and I would herewith express my thanks to the many commissioners of agriculture and experimental station officers who have kindly assisted me in procuring the results given in the following table. I am also indebted to many friends who have given me estimates for the states that do not possess an official record of the quantity of commercial manures sold and used in them.

Consumption of commercial manures:

| | Tons. |
|---|---|
| Vermont | 4,000 |
| Maine, New Hampshire, Massachusetts, and Rhode Island | 40,000 |
| Connecticut | 20,000 |
| New York | 92,000 |
| New Jersey (estimated)* | 60,000 |
| Pennsylvania | 450,000 |
| Delaware and Maryland (estimated)* | 75,000 |
| Virginia | 140,000 |
| West Virginia | 15,000 |
| North Carolina | 145,000 |
| South Carolina | 200,000 |
| Georgia | 280,000 |
| Florida | 40,000 |
| Alabama | 90,000 |
| Mississippi | 25,000 |
| Louisiana | 15,000 |
| Ohio | 50,000 |
| Indiana | 35,000 |
| Kentucky | 12,000 |
| Tennessee | 15,000 |
| Other states (estimated) | 47,000 |
| Total | 1,550,000 |

*Those marked as "estimated," have been given their quota by myself.

As the commercial center of the South Carolina phosphate deposits, and as the seat of probably the largest manufacture of phosphatic manures in this country or even in the world, the following figures as to the extent of the industry at Charleston—

which have been kindly gathered for me by an experienced manufacturer of that city—may prove interesting.

"The aggregate capacity of the Charleston fertilizer works when they are running full would be, say, 350,000 to 400,000 tons per annum. The incorporated capital of the works plus their surplus is about $4,000,000. But this does not include the amount of money necessary for the companies to borrow in order to go on manufacturing, as the bulk of their capital is largely invested in plant. The borrowed money would vary in accordance with production and would be anywhere from three to seven millions. The sum of money expended for labor in a fair average year would amount to from $350,000 to $500,000."

The world's consumption of commercial manures may be estimated at the following figures.

| | Tons. |
|---|---|
| The United States | 1,550,000 |
| Germany | 1,300,000 |
| France | 1,000,000 |
| Great Britain | 1,000,000 |
| Belgium and Holland (estimated) 300,000 | |
| Scandinavia (estimated) 100,000 | 650,000 |
| Spain, Italy, and Austria | |
| Total | 5,500,000 |

Mr. Hermann Voss' table of the world's consumption of artificial manures arrives at a total of 5,400,000 tons, although differently arranged and distributed.

I will close my remarks with the preceding statement of what the fertilizer industry of to-day is contributing to the welfare of man. It is, truly for a suitable compensation, trying to feed and clothe him better, and to enable him and his posterity to continue to live at the old home instead of emigrating after having exhausted the fertility of his fields. I have endeavored to show to what extent the trade in commercial manures may be relied upon to meet these great exigencies.