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FACTS FOR THE FARMER.

AGRICULTURAL FERTILIZERS, PHOSPHATES, PHOSPHATIC MANURES.

SUPPLEMENT TO THE CANADIAN MINING REVIEW.
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Artificial Fertilizers.

By Francis Wyatt, Ph. D.

Chemistry may be described as that branch of science which investigates into the nature and properties of the elements of matter, and determines the manner in which they react upon, and combine with each other. If we hand over a grain of wheat to the botanist, he can discern in it nothing but a tiny, yellow, opaque and brittle seed, whereas, if we pass it to the chemist, he will discover by analysis that it is composed of a woody fibre, starch, gum, sugar, fat and protein. Again; ask a geologist to examine the soil, and he will designate the different ages to which it belongs and the various rocks from which it is derived, but, without the chemist, he is unable to determine the nature of its constituents, and hence cannot foretell, before any cultivation has been attempted, whether it is destined to be fertile, or of what kind of vegetation it is best able to promote the growth.

The application of chemistry to agriculture is thus naturally indicated; by its aid we obtain from the soil, from plants and from animals, at the lowest possible expenditure of time and money, the highest possible quantity of those substances indispensable to our physical well-being.

Production, in order to be cheap, must be rapid and plenteous, and we all know that the progress of unaided nature is methodical and slow.

Chemistry, by investigating the natural laws which govern the development of all living things, and by carefully observing the facts acquired by the practical experience of centuries, endeavours to provide the farmer with means by which he may assist and hasten the processes of nature. His work is, of course, still far from complete, but it has familiarized us with those elements which are essential to plant growth, taught us how those elements are distributed, shewn us what portion of them is or should be contained in our soils, and what soils are most propitious for different kinds of plants.

When our globe was launched into space, it was a liquid somewhat similar in consistency to molten glass, and, therefore, presented a vastly different appearance to that with which we are acquainted. It was made up of about sixty elementary bodies, so deposited, by order of weight or density, that the heaviest, such as gold, silver, lead and copper, were in the centre, while the lighter, such as calcium, aluminum and silicon, remained, and still exist, near the surface, where they have combined to form clays, limestones and sands.

Encircling its interior was a heavy, poisonous atmosphere, comprising all those elements which at a very high temperature assume the gaseous form—notably sulphurous, sulphuric, phosphoric, hydrochloric, nitric, boric and carbonic acids, with torrents of steam, and dense clouds of mercurial, antimonial, arsenical and other metallic vapors. When this mass began to cool, it probably resembled an immense glass ball, the solidified sides of which were uplifted by the bubblings of the intensely hot liquid mass within. These solid projections formed our mountains, and, passing from the transparent to the opaque, they gradually assumed the crystalline form. What is known as the earth's crust must have resulted from an extraordinarily forcible action consequent upon the fall of temperature. The vapors already alluded to were condensed into rain. The rain dissolved all the acid bodies, and these acids, attacking the alkaline crust, combined with its most powerful bases to form various salts. These salts soon underwent decomposition; some—such as sulphate of lime or gypsum—were deposited, while others, principally the chlorides, remained in solution and formed the seas. The neutralization of the stronger and more corrosive acids permitted the weaker carbonic acid to develop its activity, and it is this acid which has continued to play the most important part in nature in our own times. Held in solution by the running waters, it attacked and dissolved the various bases which existed in such large quantities in the mountains, and deposited them in the form of carbonates in the still warm valleys. This process of saturation, or neutralization, being entirely accomplished, chemical equilibrium may be said to have become established; the period of great geological catastrophes, therefore, came to an end, and the temperature of the earth gradually sank below the boiling point. A few volcanic disturbances continued, it is true, to occasionally convulse it; there was the upheaval, splitting asunder and complete overthrow of the most gigantic mountains, the drying up and the division of seas, and the formation of lakes of both fresh and salt water. As the temperature continued to cool, however, these disturbances became more and more rare, and there then commenced that formation of the soil which gave rise to the phenomena of vegetation.

VARIETIES OF SOIL.

It is the general custom to class arable lands according to the nature of their predominating constituents, and thus we allude to soils as sandy, clayey and limey.

Sandy soils are distinguished by their extreme porosity, and are frequently in such a fine state of division, that in the dry season the least wind will displace and scatter them in all directions. In such cases they are naturally sterile; but, when they are sufficiently moist, they facilitate and encourage the growth of an immense variety of plants of the lower order, which, by their eventual decomposition or putrefaction, form considerable deposits of that valuable substance called humus.

Such soils are more propitious than any others for the development of plants with very delicate or fine roots, such as barley, rye, oats, lucern, lupins, lentils and potatoes; but they require constant attention, and a large and regular quantity of manure, because their porosity permits them to absorb such an abundance of oxygen, that all their organic matter is rapidly burnt up.

Clayey soils are heavy and compact, and, when they contain more than fifty per cent. of pure clay, are onerous to work, and unprofitable to cultivate. It has, however, fortunately been discovered that the addition to them of so small a quantity as two per cent. of burnt lime suffices to so entirely change their nature and consistency, by transforming the silicate of alumina into a porous silicate and aluminate of lime, that it is now an easy matter in districts where lime is cheap and plentiful, to overcome this difficulty. In hot countries or in windy regions or in districts where the sub-soil is of a very permeable character, good clay lands offer great advantages, and although they periodically require the application of large quantities of reconstituents, they possess the faculty of retaining all the precious elements supplied to them, and of storing them up for the use of successive crops. When they contain a proportion of about ten per cent. of carbonate of lime, or chalk, they are the best of all soils for the extensive growth of such important plants as wheat, corn, clover, hemp, peas and beans, and of such trees as the chestnut and the oak.

Limey, or purely calcareous, are even lighter than sandy soils, and when, as is sometimes the case, they are very white and dry, they are absolutely barren. Such as these are, however, easily encountered, for we generally find them mixed with a sufficiency of clay to give them some degree of consistency, and render them available for ordinary purposes. Few soils are entirely devoid of lime, owing to the fact that all rocks contain it in greater or lesser proportion, and because it is transported in immense quantities by waters, in the form of bi-carbonate, and deposited. If it were otherwise, or if, in the absence of lime, other alkaline substances were not forthcoming, the acid principles secreted by all plants could not be saturated, and the inevitable result would be decomposition and death. In its pure form, however, lime is such an extremely strong base, that it is incompatible with life, and hence it is never allowed to exist in the soil, unless it be combined either with carbonic or silicic, or sometimes with sulphuric and nitric acids.

The general properties of every variety of soil are much influenced by colour; those which are white, and hence unable to absorb the solar rays, being invariably cold, whereas those which are dark are warm and fertile. In this regard both iron and manganese are of undisputed value, for by their transformation into ferric and manganic oxides, they produce the deep red or brown so much admired by sagacious farmers. In damp climates or in very moist soils, however, too much iron is apt to become a source of considerable danger, from the fact that, by the exclusion of air, the ferric is reduced, by its affinity for water, into ferrous oxide, and in that form exercises a highly corrosive action on vegetable life.

ELEMENTS OF PLANT LIFE.

Sixty years ago there was no such thing as what we now call scientific agriculture. In the old countries men were asking themselves the very question that faces us to day—how it is that lands which were once so fertile and productive now show signs of approaching exhaustion. The answer to this question could only be given after we had found how out-door plants live, whence they obtain their food, of what elements that food is composed; how it is conveyed to the plants and how they absorb it into their organisms. In point of fact the manner of life in plants is very similar to the manner of life in animals and man. They require certain foods in stated proportions which pass through the process of digestion; they must breathe a certain atmosphere and they are subject to the influenses of heat and cold, light and darkness.

The tissues of their bodies, like ours, are composed of carbon, hydrogen and oxygen, and contain besides nitrogenous principles, certain minerals, such as phosphoric acid, lime, potash, sulphur, magnesia and iron. It will be seen at once that if it is necessary for us to constantly absorb a sufficiency of these self-same elements to keep up our normal heat and provide us with new tissue, it must be no less essential for plants to acquire similar food, for similar purposes.

Pure atmospheric air is a mixture of nitrogen and oxygen, with a small proportion of aqueous vapor, and about 4-10,000th of carbonic acid, while water is formed by the combination of two parts of hydrogen and one part of oxygen. It is therefore apparent that the principal organic elements of plant food exist in the atmosphere as air, water and charcoal, and may be absorbed from without by the leaves, while the whole of the mineral bodies in order to be found in the soil, should be taken up from within by the roots.

How plants absorb and elaborate the inorganic matter necessary to the food of those graminiferæ which afford to man the bulk of his animal sustenance, or what process is undergone in the assimilation of carbon, hydrogen, oxygen, and nitrogen, which, in the form of carbonic acid, water and ammonia, or nitric acid. are taken from the air and the soil, we have no space to discuss; but, it will be interesting to quote a very beautiful and practical illustration of the contrast between them and ourselves, furnished by Dumas.

	Vegetables.		*Man and Animals.*
Decompose	Nitrogenous Matter, Fatty Matters, Gum, Sugar, Starch.	Consume	Nitrogenous Matter, Fatty Matters, Gum, Sugar, Starch.
Produce.	Carbonic Acid, Water, Ammonia.	Produce.	Carbonic Acid, Water, Ammonia.
	Evolve oxygen, constitute apparatus of *reduction* and are *stationary.*		*Absorb*, oxygen, constitute apparatus of *oxidation* and are *locomotive.*

The consideration of this remarkable contrast leads us to contemplate the progressive exhaustion of the soil, and the necessity for its reconstitution by the aid of chemistry, for, while admitting that *we produce those very elements* which the plants decompose, and which are so necessary to their existence, it is nevertheless a fact that *we are locomotives, and do not in practice give back to them what we have taken away.*

The elementary composition of plants being thus determined, the next step that suggested itself to investigators was the analysis of the soil, in order that comparisons might be established between virgin lands which had borne no cultivated crops and old soils which had long been tributaries to every kind of vegetable culture.

Briefly stated, it was found that good, ordinary young lands, contain in abundance most of the dominating ingredients discovered in plant organisms, and that soils which have long been under cultivation, and now show themselves incapable of their former remunerating production, only contain these dominants in minute proportions, or lack them altogether.

These data form the basis of our present science, and may be summed up in the following manner :

A. Plants require for their nourishment and prosperity a given quantity of food, composed in varying proportions and according to their different natures, of hydrogen, oxygen, nitrogen and carbon, and of phosphates, sulphates and chlorides.

B. The hydrogen and oxygen, in the form of rain or dew, are supplied as water, and the carbonic acid is mainly derived from the air.

C. Good virgin soils contain the whole of the necessary minerals, in addition to considerable quantities of nitrogenous and carbonaceous matter.

D—Long-cultivated and non-productive soils may be termed exhausted, since chemical analysis *proves their inability to furnish the needful substances in quantities equal to those found in the ashes of healthy plants.*

FERTILIZERS AND AMENDMENTS.

Having arrived at this important stage of progress we understand that, if agriculture is to continue to be the basis of national wealth and prosperity we must find means of restoring to our soils, if not in a natural in some artificial form, the chief elements yearly taken away from it by our crops—we say *chief* elements because a great number of the necessary minerals are only required in very minute proportions, and therefore generally exist in sufficient abundance. We may consequently disregard all these, and devote our attention to nitrogen, potash, phosphoric acid and lime, since these not only play the most important part in the functions of vegetation but are the most liable to complete exhaustion. The following figures representing averages compiled from the official reports of the United States Department of Agriculture extending over a series of years, will be found very *àpropos* for the purpose of illustrating the arguments already put forth.

ELEMENTS OF FERTILITY TAKEN FROM THE SOIL PER ACRE AND PER ANNUM, IN POUNDS.

——	Nitrogen.	Lime.	Phosphoric Acid.	Potash.
Wheat	25	15	30	45
Maize	55	45	80	40
Oats	30	14	18	20
Barley	35	12	18	20
Rye	25	13	25	35
Buckwheat	35	12	40	38
Hay	40	40	15	40
Tobacco	not calc'd.	160	not calc'd.	340
Turnips	do	100	45	150
Potatoes	44	60	52	185

These are, of course, only a few examples, but they will suffice for present purposes, and it is perhaps hardly necessary to add that if, according to the nature of the crop desired, at least a sufficient proportion of each of these essential elements be not present in the soil, the plants will languish, various malignant diseases will declare themselves, and death will inevitably ensue before they reach maturity.

Now, the practical question that must naturally arise, is, how may all this loss be repaired, and whence are all the elements needed to repair it to be derived? It is not so very long ago since this question would have been generally answered by the words, "farm-yard manures," and even to-day there are a large majority of farmers who depend exclusively upon this valuable fertilizer.

The fallacy of their policy is, however, made apparent by a simple calculation, which any interested reader can work out for himself, in this wise.

The necessary elements to the growth of a medium crop of hay have been put down, approximately, per acre, as :—

Nitrogen	40	pounds.
Lime	40	"
Potash	40	"
Phosphoric acid	15	"

The very best farm-yard manure is found to contain, on an average, for every hundred pounds, exclusive of water and fibre :—

Nitrogen	not quite ½	pound.
Lime	little more than ½	"
Potash	about ½	"
Phosphoric acid	(say) ¼	"

With a very moderate allowance for loss in storage, drainings, evaporations, etc., it must be conceded from these figures that to repay what has been borrowed from the soil by a single crop of hay would call for some six tons of material per acre; and there is probably only a very limited number of farmers—even if there are any—who could produce anything like this quantity. The practical answer to the question propounded, therefore, is that we must profit by the teachings of science and turn to artificial or chemical fertilizers as the only means of avoiding present loss and eventual poverty. This leads to a brief glance at the most accessible materials, and the forms in which they are most appropriate for the requirements of growing plants.

NITROGEN.

The sources and the supplies of nitrogenous elements, outside the free nitrogen and the ammonia that exist in the atmosphere, are numerous and plentiful. Every species of plant, roots, stalks, leaves and seeds yield it up in varying proportions, under the influence of decay. The refuse or waste from an average crop of clover contains about fifteen pounds of assimilable nitrogen per acre, and some of the other green crops are so rich in this element that it has become customary to occasionally grow them for the express purpose of plowing them under directly they have reached maturity. Outside the farm, we have guano, fish, wool rags, horns, hoofs, hair, blood and all other animal refuse from the slaughter-house, and, failing a sufficiency of all or any of these, there are the nitrates of soda and potash, and sulphate of ammonia.

The following are about the proportions of nitrogen contained in every 100 pounds of some of the foregoing materials :—

100 lbs.	shoddy	contain	7	lbs. nitrogen.
100 "	wool dust	"	9½	"
100 "	dried blood	"	12	"
100 "	rope cake	"	5	"
100 "	cotton	"	5½	"
100 "	sugar scum	"	3	"
100 "	leather cuttings	"	8	"
100 "	sul. ammonia	"	21¼	"
100 "	nitrate of potash	"	13¾	"
100 "	" soda	"	16½	"

POTASH.

We have seen that the quantity of potash absorbed by the most important of our crops is greatly in excess of phosphoric acid. It may consequently be assumed that continued fertility depends upon a preponderance of this important base. This, nature has in a great measure provided for, by promoting the continuous decomposition of feldspathic and other rocks, and by favouring the transfer of potash in the various forms of silicates, carbonates, and oxides from the subsoil to the surface.

When all these varieties fail, however, it is easy to secure inexhaustible supplies from the nitrates and chlorides, which are either deposited in various localities on the surface, or in the interior of the earth's crust, or held in solution by the waters of the sea.

Potash salts, to be readily assimilable, or useful to the plant, must be liable when introduced into its sap, to so easy a decomposition, that their liberated alkali may enter at once into the necessary combination with the organic compounds.

If, as it is applied, the potash be united to its acid by too strong a bond, the vegetable will be unable to effect a dissociation; and the salts will accumulate in the tissues, and become a mere burden instead of promoting healthy growth.

This question of assimilation, therefore, is one that demands very attentive study; and it is from the data collected by the most recent scientific discoveries in relation to the laws and powers of affinity, that the various salts, according to their adaptability, have been classed in the following order :

Carbonate,	Sulphate,
Nitrate,	Chlorides.

The amount of potash contained, in round figures, in each of these salts when puré is as follows :

100 pounds Carbonate contains 68 pounds of potash.

100 pounds Nitrate contains 46½ pounds potash.

100 pounds Sulphate contains 54 pounds potash.

With regard to the chlorides, which are compounds of chlorine and *potassium*, it is necessary before they can furnish anything available that they should undergo a preliminary decomposition in the soil, but it may be assumed that when this has taken place, every 100 pounds of the pure chloride would be equal to about 63 pounds of potash.

On the assumption that neither the sulphate of potash, nor the chloride of potassium is directly assimilable by plants, their efficacy must depend upon the composition of the soil under treatment, and the character of any other fertilizers with which they are simultaneously used.

To illustrate this it is only necessary to imagine a mixed fertilizer containing in suitable proportions, superphosphate of lime, sulphate of ammonia, and muriate of potash.

As soon as this compound reaches the soil, a reaction is commenced between the whole of the salts, resulting in the production of phosphates of ammonium and potassium, and sulphate and chloride of calcium.

The two latter will be washed down into the subsoil by the rains and carried away, while the two first will enter the roots, and be very readily decomposed in the sap, and utilized by the plant.

If, instead of the above, a mixture be chosen of nitrate of soda, and either the muriate or the sulphate of potash, a similar transformation will take place; chloride or sulphate of sodium being produced on the one hand, and nitrate of potash on the other.

Dispensing with unnecessary reiteration, these typical examples sufficiently illustrate the importance and advisability of making preliminary trials upon a small scale, with each salt, in every case where the use of potash has been determined upon, since, under the varying influences of the different elements in every soil, uncertain and unlooked-for results may be obtained.

PHOSPHORIC ACID.

This indispensable fertilizing agent is probably the one in which all cultivated soils are most deficient, and, to make matters still more complicated, its occurrence though so plentiful in nature, is found to be most unequal.

It does not exist in the atmosphere; soils of the granitic and teritiary formations are nearly deprived of it; and many other species only contain it in very slight traces.

The following are the principal and most available commercial sources of phosphates for agricultural purposes, viz.:

First, Natural phosphates, of animal or mineral origin, such as bones, bone-ash, and apatites very finely ground.

Second, Superphosphates, manufactured by treating these raw materials with a sufficient quantity of sulphuric acid to transform them from an insoluble into a soluble form.

Third, Precipitated phosphates, obtained by dissolving raw phosphates in hydrochloric instead of sulphuric acid, and adding to the liquid a milk of lime.

From which of these forms the most direct advantage is to be obtained by the farmer, is a somewhat disputed question. Accepting the generally admitted and rational theory, that no element can penetrate into the interior of a plant unless it be in the form of solution, it naturally follows that preference will be invariably given to those commercial phosphates which are most readily subject to dissociation; and this will entirely depend upon two conditions :

(a) Their own degree of aggregation.

(b) The nature and composition of the soil in which they are employed.

The first thing to be obtained is undoubtedly a fineness of pulverization, which will so divide the molecules as to render them easily decomposable by the natural action of the elements contained in the ground, and in this only partial success has been achieved by mechanical means. So long ago as 1851, Leibig recognized the difficulty, and proposed, in order to solve it, to chemically perform this operation by manufacturing superphosphates.

From the standpoint of disintegration, this method has been entirely satisfactory, and has enabled agriculture to rapidly obtain results from the use of phosphoric acid, which would otherwise have been impossible. From a chemical point of view, however, the whole theory fails. We know that superphosphates are only soluble in water so long as the sulphuric acid with which they have been manufactured retains its ascendency over the lime, and that when they reach the soil, especially where carbonates are in abundance, the sulphuric acid is at once overpowered. The phosphoric acid, being unable to exist in a free state is taken up by the lime and iron and at once reverted to a tribassic form. In other words the whole question is one of time, and of dollars and cents.

The farmer buys a ton of raw phosphatic material finely ground, and containing say twenty-five per cent of phosphoric acid for $10. If his land contains neither humus nor acid elements, nor a sufficiency of lime, the phosphate will not decompose and he will have to wait perhaps several years before obtaining any appreciable results for his outlay. On the other hand he buys a ton of superphosphates, containing only fourteen per cent. of phosphoric acid for $20 and applying it to an exhausted soil, producing the desired results on his very next crop. Hence it is apparent that the phosphoric acid of the latter is more assimilable than that of the former case; and this assimilability can only be due to the absolute state of division insured by the series of decompositions to which the raw phosphate is exposed during the manufacturing process. To define with scientific accuracy the the exact merit or intrinsic value of any specific phosphate, is a matter of very serious difficulty; since, besides that of its own physical conditions, so much depends upon the nature and composition of the soil in which it is to be employed. No better examples of this truth could possibly be found than the preliminary comparative experiments, conducted during the past two years, with raw basic slag, and various other phosphatic materials; for they have so far proved, that whereas, in some soils the effects produced by crude phosphates fairly rival those obtained with superphosphates, in other soils they are either quite inert or insignificant in their action.

LIME.

All farmers are familiar with the u-e of lime, but it is doubtful whether many of them know the exact reasons for its application or clearly understand its influence. It may therefore be broadly premised that the objects for which it is employed are two in number.

First, To exercise a chemical action upon the numerous constituents of the soil, and thereby produce a complete modification of its physical and chemical properties.

Second. To furnish it with the quality required by plants for their alimentation and growth. From the figures already given it will occur to the reflective mind that, regarded as a plant food, lime is of less direct importance from a commercial standpoint than either nitrogen, potash or phosphoric acid.

Placing the total quantity yearly removed by crops at an average of 50 pounds per acre a soil need only contain say, half of one per cent. to supply all that could be demanded of it during several hundred years.

Its true agricultural value must consequently be attributed to its qualities as an *amendment* rather than a fertilizer.

The term "amendment" has been given to substances which, when they are applied to a soil, effect a change in its general constitution, and thus lime, when mixed into strong, stiff and unworkable c offur a ten to fifteen tons to the acre induces in them a far-reaching chemical decomposition, which, in addition to partially transforming them into the more porous silicates and aluminates of lime, sets free large quantities of alkaline salts that were previously unable to co-operate in the phenomena of vegetation because bound up in insoluble combinations.

This marvellous effect would of itself create for lime a very high place in the estimation of farmers; but it by no means represents the total scope of its usefulness, as will be clear to those who recall its properties as a generator and promotor of combustion. The accumulation of vegetable remains in various stages of decay and putrefaction, left in the ground by the crops or intentionally plowed under for the purpose, results in the production of a body known as humus. If left to itself this body would so acidify the soil as to destroy its normal basic or alkaline reaction. It could consequently no longer afford nourishment to any of those plants which generate the elements of animal food. In order to successfully cultivate such lands it is therefore necessary to neutralize their acidity; render them alkaline, and remove the excess of these organic matters.

All these conditions are perfectly fulfilled by burnt lime. The word "combustion" designates that process by which an organic body principally composed of carbon and hydrogen, with traces of nitrogen, unites with the oxygen of the air to form oxides. Thus, coal, coke, wood and vegetable refuse, although burnt to create heat, and apparently thereby destroyed, in reality merely undergo a chemical change, arising out of that scheme of nature which has provided for the restoration of all their constituents to the atmosphere and the soil.

The carbon continues with the oxygen of the air to form carbonic acid gas; the hydrogen and nitrogen, momentarily set free by this action, unite themselves together to form ammonia; while the ash consists of oxidized mineral matters.

With the exception of fluorine, every element combines with oxygen to form oxides, and in doing so develops more or less heat. The warmth of the animal body is created and sustained by the oxidation of the starchy or fatty or carbonaceous elements of food; and, hence, while animals breathe in oxygen, they breathe out carbonic acid, gas and steam. When this natural chemical process is stopped, the animal dies; or, to speak more forcibly, when no more food is provided, or no more oxygen inhaled, the internal fire ceases to burn, and everything grows cold.

This is but a brief definition of combustion. It, however, suffices to establish that oxygen is the promoter of the phenomenon, and hence to explain that, if great masses of decaying humiferous matters sometimes linger in soils, it is because the latter are cold and wet and have become so choked up and cohesive as to preclude a proper circulation of air.

Oxygen is thus unable to reach them until they have been warmed, dried and made porous. Burnt lime, when properly administered, accomplishes all these objects.

By its great affinity for water and the intense heat of its combination, all moisture is absorbed. The rapidly drying soil cracks and opens up in every direction, and free ingress being thus afforded to the air, a vigorous and permanent combustion sets in.

Attacked in its turn by the carbonic acid gas resulting from the combustion process, it is converted into carbonate of lime, and, alkalinity being thus gradually restored, the plough completes the conquest, and barren wildernesses become fertile plains.

Reviewing these effects and briefly summing up its advantages, it will be seen that, independently of its power to impart porosity and to facilitate combustion, lime sets free various alkaline salts from useless combinations, and renders them available as plant-food. It also decomposes certain injurious salts of iron, magnesium and manganese, counteracts the evil influences of all kinds of sulphurous emanations, and, before being transformed into carbonate, destroys, by its causticity, vast quantities of ravaging insects and their eggs.

Despite these great advantages, it must be noted that the indiscriminate use of this powerful oxidizing agent on good ordinary cultivated soils would be productive of disaster.

Lest this statement be regarded as conflicting, it is explained that a good soil is what has been described as a mixture containing all the elements required for plant-food, in a proper physical condition, and with a due proportion of humus or organic matter. This humus is of the utmost importance.

First. Because, by its very slow oxidation or combustion it helps to maintain the warmth of the soil.

Second. Because it contains a considerable quantity of nitrogen, which is gradually transformed by this slow combustion into ammonia or nitric acid and nitrates.

Third. Because it has the invaluable property of always retaining moisture, and thus can enable plants to withstand periods of drought which would otherwise kill them.

However rich it may otherwise be, it has been demonstrated, by experiment, that no soil is perfect which contains less than two per cent. of humiferous matter.

This is why scientists untiringly urge upon farmers to provide for its maintenance by using in addition to artificial fertilizers all the farmyard manure they can scrape together and to carefully plough under, instead of burning, as they are so prone to do, all the refuse from their crops.

The imperative necessity of this duty is intimately connected with the most complicated

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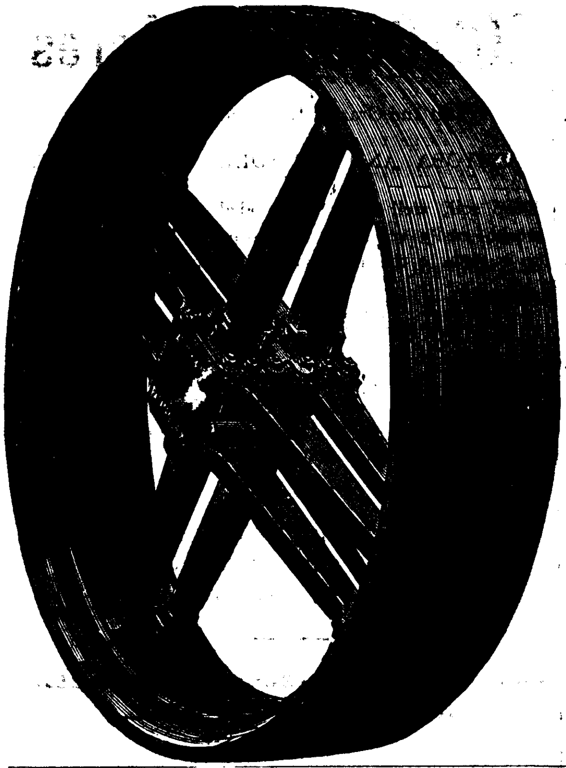

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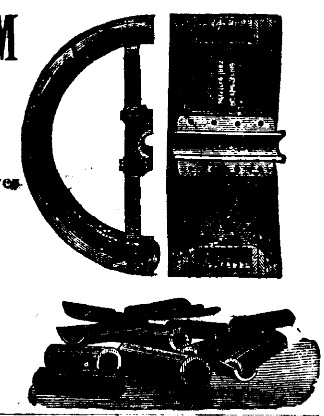

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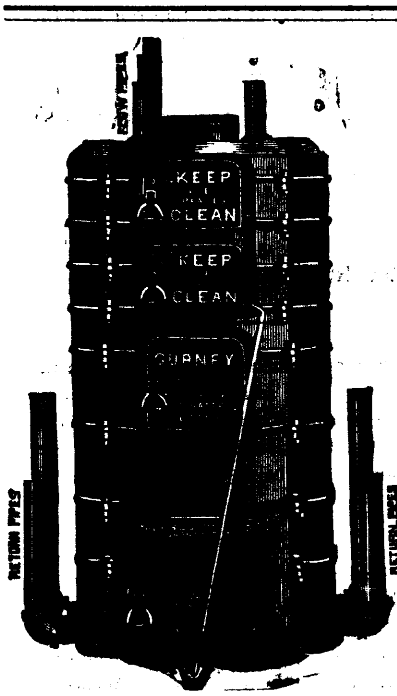

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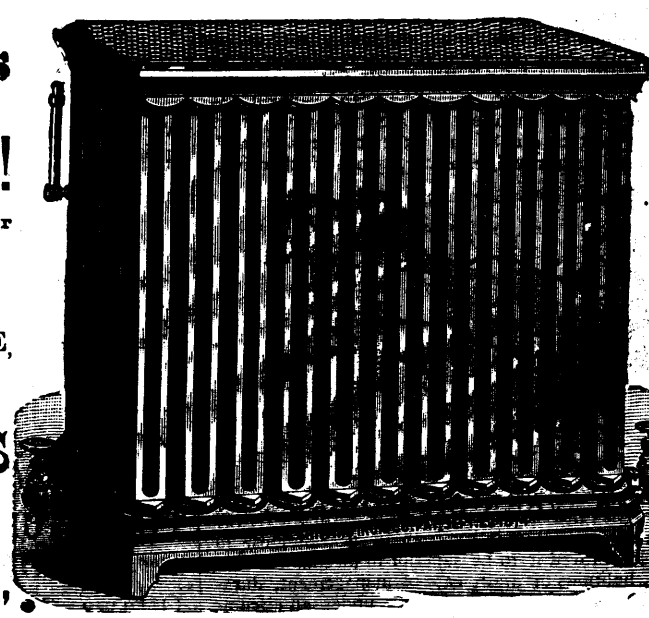

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problem yet remaining to be solved by agriculturalists, (i.e.) whence to obtain sufficient assimilable nitrogen to integrally replace what is taken from the soil by the crops, and exported with them to foreign countries every year, without having recourse to any of the costly commercial substances already enumerated.

The pet theory—so beautiful as a theory—of obtaining it directly from the air, in a suitable form, and at a fabulously cheap price, continues to occupy many clever brains in many scientific laboratories, but is still as far as ever from a practical solution; on the other hand since it has been proved that nitrification chiefly results from the extremely slow oxidation of organic matter in alkaline soils, it naturally follows that so long as there exists a sufficiency of humus under favourable conditions, no dearth of available nitrogenous plant food need be apprehended.

Unfortunately, the immense amount of exportation, combined with misconceived notions of sanitation, prohibit all hope of restoring to the lands the whole of the required nitrogen in an organic form. It is consequently all the more necessary to manipulate what remains in a spirit of economy; to handle the soil with delicacy, care and intelligence, and above all things, to avoid introducing into them any substance which may interfere with their normal, regular, and natural functions.

The Application of Ground Phosphates.

Prof. Arthur R. Guerard.

With the appearance of Liebig's book, "Chemmistry in its applications to Agriculture and Physiology" (1840), may be said to have begun a new era in the art of culture. To Liebig we are indebted for the right understanding of exhaustion and restoration in agriculture, the neglect of which had converted many once fruitful districts into hopeless deserts. It was Liebig who pointed out that the inorganic elements of plant-food in the soil were the most important, the easiest exhausted, and that their constant removal in the harvest was, notwithstanding the rotation of crops, and the then usual system of manuring, a robbery of the soil, which enriched the present at the expense of the future. This was the so-called "mineral" theory, to which was opposed the "nitrogen" theory, giving the chief value in the nourishments of plants to the organic substances, the nitrogen products. In the controversy which ensued, the results obtained under Liebig's system at the numerous experimental stations and confirmed in general farm practice eventually drove the nitrogen theorists out of the field. The re toration to the soil, upon scientific principles, of the constituents taken from it thus founded a new and increasing industry, the manufacture of commercial fertilizers, in which the opening up of extensive deposits of potash, salts, and phosphate of lime took an important part. Justus Von Liebig may, therefore be rightly called the founder of the high art of culture.

But in acknowledging all that is due to this illustrious chemist, and admitting that his views were generally correct, it cannot be denied that he was sometimes more suggestive than conclusive, while his principles, having unfortunately been accepted on faith, have led, in some instances at least, to false conclusions. Remarkably has this been the case with the application of vitriolated or superphosphate of lime, the manufacture and employment of which have now assumed such vast proportions, that it is fitting some investigations were made into the principles which govern its use. But before entering into this subject perhaps it may be well, for the sake of clearness, to give some general idea of the food requirements of plants and the nature of manure, in which I crave indulgence of those whom I may take over old ground.

Plants require for their complete development organic and inorganic elements, of which they consist. One part of these is afforded by the atmosphere, the other by the soil. The The latter are left as ashes on burning, while the former go off in gaseous form. The inorganic, incombustible elements are: potash, soda, lime, magnesia, phosphoric acid, sulphuric acid, and iron; the organic, volatile elements are carbon and nitrogen. Plants receive carbon in the form of carbonic acid and nitrogen in the form of nitric acid and ammonia; these last being furnished directly or indirectly from the atmosphere, while the soil must contain all the necessary mineral constituents in a proper physical condition for plants to grow and thrive upon it. The fundamental conditions, therefore, for plant production are given in the air and soil.

The circumambient air is the mediator of heat from the sun, climate being the first factor in plant growth. The other no less important factor, is the soil. Soil is formed from the disintegration of the rock masses in the earth's crust in various ways, by the action of the air and meterological appearances—weathering; by the force of water and ice, and finally by volcanic causes, as they are still active in some countries. In general, the formation of soil is not to be considered as complete, but on the contrary as continuing unceasingly and evident everywhere. The soil for the most part consists of inorganic with a small proportion of organic constituents, such as vegetable and animal remains. Formerly these last, so called *humus* were considered to be the active agents in the nourishment of plants and a soil was valued according to the quantity of *humus* it contained. But this view has been abandoned. We now know that the inorganic elements in the soil are the essentials of plant food.

All kinds of soil contain a certain number of chemical bodies, which may be considered as constant parts in soil, such as silica, alumina, lime, magnesia, potash, soda, iron, and partly combined with these, carbonic acid, phosphoric acid, sulphuric acid and ammonia; finally water, which occurs both in chemical as well as mechanical combination. Besides these we find other chemical bodies in soil, but in smaller quantity and without special importance for vegetation. But it is only with the upper layer of soil and under certain conditions with the sub-soil that the agriculturist is concerned.

This vegetable layer contains a certain amount of plant food, which, by the continued removal in the harvest, is gradually but entirely extracted. It is for this reason, therefore, in order to keep up the productive power of arable soil, that the renewal of such substances as serve the purpose, and which the harvest has removed, is necessary. This restoration is manuring. Now, when a plant is burnt, a great portion of its elements passes off in gaseous form, while a part remains as ashes. The most important ash elements are lime, potash and phosphoric acid; volatile elemen's, carbonic acid and ammonia. The soil must contain, or be able to develop, all these to be fruitful. Not every plant, however, demands one and the same quantity of nourishment; one requires more potash, another more lime, a third more phosphoric acid, but all plants need a portion of all of these elements together, and if one of them only is wanting the plant cannot thrive. Thus, it may be that so great a quantity of the most of these nutritive elements is present in a soil that a continued cultivation is not able to exhaust it; but of others, on the other hand, particularly phosphoric acid and potash, the quantity may be so small that it may well be consumed by repeated harvests. At the same time it is necessary that the manurial plant food should be present in such a form in the soil that it is accessible to the plant; that is, not only in chemical, but in suitable physical combination. Thus, in supplying the nutritive elements of plants in the form most favorable for absorption and assimilation consists the whole art of manuring.

As a matter of course, the restoration must be made in such a manner that the results warrant the outlay; in other words the object is to return to the soil as manure, in the form of worthless or cheap material, these elements which, in the form of valuable, saleable, or useful materials, have been taken away in harvest. The experience of 2,000 years has taught that this restoration cannot be better made than in animal and human excrements. Especially is this the case with stable manure, in which such excrements are mixed with straw, which has generally fulfilled the demands so completely that no substitute of like value has as yet been discovered. It contains the mineral elements of plant food in a condition most favorable for this absorption and assimilation by the plant; the fermentation which takes place in the soil is the fountain of ammonia and carbonic acid, which serve not only as food in themselves, but assist in decomposing other elements found in the soil. By means of this decomposition, accompanied by the generation of gas, heat is produced, and also a favorable mechanical condition of the particles of soil. Yet, nevertheless, stable manure, together with its liquid portion, does not return to the soil in sufficient quantity all the nutritive elements which have been extracted from it, as long as its production is confined to the farm-yard, and not supported from without Moreover, stable manure does not always contain the two most important inorganic elements of plant food, phosphoric acid and potash, in the right relation for plant production. Upon these grounds the increasing cultivation of the soil and the needs of mankind demand the employment of artificial fertilizers along with, or as a substitute for, farm-yard manure. The important plant food elements act always together; that is to say, each one helps toward the increased power of assimilation of the other by the plant; so that by the employment of one, and one only, by no means will the effect produced upon the plant be in proportion to the quantity of this element used. For example, if a potash fertilizer be used on a soil poor in potash the plants growing on that soil would take up not only a greater percentage of potash, but they would also take up all the other elements in proportion to the addition of potash. The harvest, therefore, from a soil to which potash had thus been added extracts more of the necessary nutritive elements altogether than a harvest from a soil to which no potash at all had been added would do. If, then, a field, and the plant life on it, be always supplied with one and the same food element all the others, consequently, by the help of its action, would be gradually consumed and the field become unfruitful; that is, it would no more possess all the mineral substances out of which the plant body is built up. This condition lasts until efficient manuring or a renewed decomposition of some undecomposed mineral by the action of the atmosphere furnishes a sufficient quantity of available plant food. But it is not possible in all kinds of soil, by this last means alone, that is, by letting the land rest or fallow, to effect a restoration. Many elements, as phosphoric acid and potash, may be so entirely absorbed out of the soil that a natural restoration is not to be thought off at least only after an indefinite period. This is the cause to which the desolation and barrenness of so many regions is to be attributed, and not to imaginary climate changes or decrease of population. The careless indifference to the relation between exhaustion and restoration may, therefore, be well called a robbery of the soil; for here the present lives on the capital which a long past has heaped up in the soil, but which without or within sufficient restoration must, in a short time, be entirely consumed. To prevent this in a judicious manner, to keep the land ever in a uniform condition of fertility, and to win from it a satisfactory interest, is the duty of the agriculturist. He can only solve this problem in a cultivated land by a rational and scientific system of manuring. Turning now to the main subject of my essay, if any of the delicate membraneous parts of plants—the leaves, the stems, the roots—be examined under the microscope they will be found to consist of innumerable small hollow spaces, called cells. These cells are inclosed by a thin skin or membrane, and contain a fluid giving an acid reaction. This is a well-known fact; but it may be easily proved by pressing the root-fibres of any fresh young plant on a bit of blue litmus paper. The paper will be reddened, owing to the disengagement of malic, acetic, citric, or other vegetable acid. Now, by the laws of chemical affinity, this acid demands and combines with a base.

Hence when any of the necessary nutritive elements of plants, as phosphate of lime, in a sufficiently fine state of division, are brought into contact with the cells of the root, the acid in the cells will strive to overcome the obstacle presented by the inclosing membrane, and unite with the base. And this can be visibly demonstrated; for if a glass vessel be filled with the juices of the plant or, which is the same thing, with distilled water containing acetic or other vegetable acid, and a bladder tied over it in such a manner that it touches the liquid, and then a little finely powdered phosphate of lime placed upon it, in the course of a short time the powder will be seen to have disappeared in solution through the pores of the membrane. But if this can be shown in the laboritary, how much more powerful must be the action of the living plant in nature when such powder is brought into contact with the membrane of the cells of the root in search for food! Consider the powerful ramifications of roots sending out their fibres and hairs in every direction, encompassing the soil, penetrating often several feet into the ground; conceive the countless myriads of these living, plant-feeding organs, which must be in contact with the particles of soil in a proper physical condition, and we have an idea of the enormous forces which are here at work.

Admitting then, that the roots of plants have the power of extracting their food immediately from those portions of the soil which are in direct contact with their absorbent surfaces, that is, when the necessary nutritive elements are present in suitable physical combination, I maintain that the assumption originated by Liebig, that it was only from a watery solution in the soil that mineral plant-food could be assimilated, that in order to be available it must be soluble in water—this assumption, I say, is entirely ungrounded. And yet this is the view which has been almost universally accepted by agricultural chemists. Thus in the manufacture of superphosphates of lime from mineral phosphates, at the suggestion of laws, the object was to render the neutral or insoluble phosphate, by the action of sulphuric acid, soluble in water. Thus the commercial and manurial value of phosphate manures has been estimated by the amount of phosphate of lime present which is soluble in water, that portion which has become reduced or reverted (that is, which has lost its solubility in water), and that which has remained insoluble being considered nearly if not absolutely useless as a fertilizer. Nay some have assumed such authority on the subject, that they have even caused laws to be enacted to prevent the sale of phosphate manures containing less than a certain percentage of soluble phosphate. Assuredly it is time to take up the matter in the interest of the public; for if it is true that finely-ground unvitriolated phosphate of lime is equal in manurial effect to superphosphate, why then should the farmer buy acid to perform a function for which nature has already amply provided? Why should we pay two prices for our phosphate manures, not only in manufacture for so much vitrol which we do not want, and indeed would rather be without, but also in transportation for two tons to get one tone of useful material?

I hold that the insoluble, non-crystalline mineral phosphates (such as Canadian phosphate), as found abundantly in nature, need only to be mixed in fine powder with the soil under suitable conditions. The plant, then, assisted by the action of the weather, will convert with acid from nature's own acid chambers as much of the insoluble into soluble or superphosphate as it requires.

These views have been held by the late Dr. St. Julien Ravenel, of Charleston, since shortly after the discovery of the South Carolina Phosphate deposits in 1867, but although circulated to some extent among his personal friends they did not come before the public until 1877, when the Agricultural Society of South Carolina, struck by their originality and force, appointed a committee to investigate the subject.

The special reasons which prompted the society were the impoverished condition of the low country of South Carolina after the war, the small crops which were made from exhausted land, and the necessity of home production. A series of field experiments were thus instituted under Dr. Ravenel's supervision to test the practical value of his views as applied to the production of cereals and grass, with the object of ascertaining if these crops could be grown at a moderate cost on the poor coast land of the State.

Dr. Ravenel was led to the belief that this could be accomplished by the following considerations expressed forcibly in his own words:

"1. When a sheaf of wheat weighing one hundred ounces is carefully burned, ninety-five ounces disappear; five ounces remain as ashes. The gaseous matter gone off consists of the elements of air and water; the ashes left of mineral matter existing in small quantity in all soil. Ninety-five per cent then of the material which plants are composed is superabundant, while the five per cent. of mineral matter needed is cheaper in Charleston than anywhere on the globe. Heat and sunlight supply the force by which the germ or seed works this material into the mature plant. Our geographical position secures us an ample rainfall, equally distributed through all the months of the year; bright sunlight, a winter temperature high enough for the growth of important crops, a summer heat heat not too great for the full development of semi-trophical plants, secure us, in effect, two seed times and two harvests in one year.

"2. As among animals some feed on grass and others require more highly organized matter for their nourishment, so among plants some form their substance from the air, water and mineral matter of the soil directly, while others cannot do so, but live upon the remains of a vegetation which has previously flourished and decayed upon the land. For example, a sheep confined to a good pasture thrives; a dog under the same circumstances starves. The grass must be converted into matter before it can support the dog.

"Wheat will not grow upon poor land supplied merely with mineral matter, but pea-vines will, and when these have decayed upon the land wheat will flourish there. Here the leguminous* plant does for the graminaceous one what the herbiverous animal does for the carniverous.

We have many leguminous plants, some of which grow from spring to fall, others from fall to spring. By supplying the necessary mineral matter and using those plants which grow during the summer to prepare food for small grain, and those that grow during the winter to do the same for grass, there is good reason to hope that the coast lands may be made to produce remunerative crops, and those of a kind which are sowed and reaped by the efficient labor-saving machines of the day." In order to test the system thus proposed several experimental stations were formed in the neighborhood of Charleston. They were placed under the direction of practical men and conducted with scientific accuracy, reports being made by the committee on coast lands to the Agricultural Society of South Caroline. These reports show an average yield, from a series of years, of twenty-five bushels of wheat, forty-five bushels of oats and four tons of good hay to the acre. The lands on which these results were obtained consisted of poor sandy loam, so exhausted previously that without manure they could not produce eight bushels of oats or five bushels of corn to the acre.

For those who are interested in details I subjoin the following report of results for season of of 1878, and give the manner of conducting the experiments:

OATS.			WHEAT.		
No. of Acres.	Am't. Bush.	Per Acre. Bush.	No. of Acres.	Am't. Bu. Lbs	Per Acre. Bu. Lbs
(a) 3½	130	40	(d) ¼	7 43	30 52
(b) 1¾	78¼	45	(e) ¼	6 27	25 48
(c) 1	60	60	(f) ¼	5 26	21 44

These six fields were planted under Dr. Ravenel's system, no other manure being used, and all treated in the same manner, except that fields c and d were planted with the drill.

*There are many members of the family of plants called legumes (leguminosæ), which may be used as fallow crops, that is, by not extracting the alkalies of the soil, and only a small quantity of phosphates, they exercise no injurious influence on crops which are cultivated immediately after them. They act also as carriers of nitrogen. Such plants are beans, peas, vetch, clover, lucern, buckwheat, &c.

The following is the formula for cultivating cereals and grass as practiced at the experimental farms:

GRASS TO MAKE A MEADOW.

"1. *The kind of grass.*—The Bermuda* (as being particularly suited to that coast) is recommended. It is best to select for a meadow-land well-set in this grass, because it does not seed, and is propagated only by transplanting.

"2. *The manner of cultivating grass.*—Plough the land thoroughly in the spring or early summer, next scatter together broadcast over it two bushels of cow-peas and 500 pounds of ash element to the acre, with seed of the vetch, if the vetch is not already on the land, and harrow and roll it until it is even and smooth enough for the mower.

The peas must not be used as food for man or beast. Suffer them to die on the land in the fall; it is believed unnecessary to turn them in.† The vetch comes up in December, lives through the winter, and dies in the spring and early summer. Then the grass shoots and must be cut from time to time in the course of the summer, when ripe for the mower. The meadow is then established.

"3. *The Manner of Maintaining the Fertility of the Meadow.*—This is managed through means of the ash element and vetch. Every autumn, when the grass has died down, scatter over the meadow 500 to 1,000 pounds of ash element per acre, the quantity being determined by the weight of hay taken from the land; if under four tons, 500 pounds will be sufficient. The vetch having sodded itself, as it always does, appears again spontaneously in December, and the two, ash element and the vetch, combine to fertilize the land for the crops of the following summer.

"4. Experience thus far at these farms indicates that the meadow, when so established, must not again be touched with the plow.

THE SMALL GRAINS.

"The land is to be prepared for small grain through a crop of cow peas ‡ as for grass. Having been thoroughly ploughed two bushels of peas and 500 pounds of ash element are sowed broadcast per acre, and harrowed in with a heavy harrow. If, when the peas have matured, there is time to allow them to die on the land, it is more economical, and just as well in other respects that they should. In this case plough the land and sow the grain. But if there is not time the vines must be turned in with a heavy plough and the land harrowed for the grain. The use of the drill in planting these crops is recommended. If it is intended to put the land in grain a second year, &c., &c., as soon as the crop is harvested turn the stubble under with a two-horse plough, and repeat the process of preparation by sowing cow peas and ash element as already described.

"The peas have been sowed broadcast at these farms, but every one will sow and cultivate them in the manner experience teaches him to be the best.

"The 'ash element' mentioned above consists, as the name indicates, of the most important element of the ashes of plants, viz: lime, potash, and phosphoric acid. It is prepared simply by mixing in equal proportions, calcined marl, of the great eocene marl beds of the coast; South Carolina phosphate ground to *an impalpable powder* (showing under the microscope 30,000 particles to the linear inch), and alkaline salts (kainit) from the mines of Stanfurt, Germany.

These experiments have attracted the attention of many intelligent farmers in the State and elsewhere. In many instances they have been tried on a larger scale, and in every case when fairly tested, so far as I have been able to learn, with like success. Indeed, evidence goes to show, by the gradual improvement on land year by year to which the system has been applied, that the process is cumulative rather than exhaustive. Nor has it been confined only to small grain and grass crops, but has been equally successful when applied to cotton, corn, potatoes, turnips, etc.

Would it not seem worth while, then, in the face of these results, for farmers everywhere to put these principles practically to the test? These are not theories, or speculations, or laboratory experiments only; they are facts proved in the field under the most trying circumstances. I am aware that they contradict the assertions of many acknowledged authorities on agricultural chemistry. There are, however, some exceptions to the rule.

Dr. Charles Graham, professor of chemical technology, University College, London, in an exposition of his views on the use of unvitriolated phosphate of lime, published in the *North British Agriculturalist*, February. 1881, writes:

"The suggestion of Liebig and Lawes that the slow-acting, half-inch bones should be submitted to the vitriolating process, whereby soluble phosphate is formed, was at one time of some value, since it gave agriculture a convenient means of distributing over the land an easily soluble substance in the place of the pieces of bone previously used, and which were slowly decomposed and dissolved, owing to the size, the gelatine, and the fatty matters. With coprolites the suggestion was readily adopted, and, as years rolled on, acid was more and more used in the preparation of phosphatic materials, until at last these indeed became rather vitriol carriers to the profit of the manure manufacturers than to the benefit of agriculture.

"Analytical chemists attached so high a value to the soluble phosphate that the factor 30 became with many the multiplier in calculating the commercial value from the centesimal composition of superphosphates. Some, indeed, went beyond this, and in time analytical chemists came to think of soluble phosphate as the only test of vitriolated phosphatic minerals, the insoluble being regarded as of little or no use. The vitrol makers had good cause to rejoice at Liebig's suggestion and its extravagant valuation by those who followed him. As chamber acid may be profitably made at £2 10*s*. ($12.50) a ton, there was every inducement to saturate manure with it, and analytical chemists stimulated this abuse. Now, more than twenty years ago I wrote to the *North British Agriculturist*, attacking the highest valuation of soluble phosphate. A manufacturer in reply attempted to controvert my arguments by allusion to the cost of his plant, and by the, to him, cogent argument that analytical chemists should be the last to attack manufacturers who gave them employment."

In another communication addressed to the *North British Agriculturist*, January, 1869, Dr. Graham explains his views as follows:

"The employment of sulphuric or hydrochloric acid with phosphate of lime, dating from the time of Liebig's and Lawes' recommendation, has led agriculturists and chemists in a great measure to ignore, firstly, the real use of the acid, and secondly, the mode in which plants take up phosphate of lime. At first it was very generally assumed that the acid phosphate in the manufactured superphosphate remained in a soluble state in the soil until absorbed by the plant. There are, however, few who now doubt that the acid superphosphate when mixed with moist soil becomes again insoluble, either from the action of lime in the soil or of the clay. Clay is the more general agent in this change.

It is, however, beyond my present purpose to consider the chemical compounds formed by this reinsolubility of superphosphates in the soil. This change is a rapid one, a few days, or at most a few weeks, sufficing to destroy the solubility (*i.e.*, in pure water) of the manure. It may be asked: How, then, account for the great benefit to agriculture which was undoubtedly experienced by the adoption of Liebig's superphosphating principles? The answer to this is simple. Before Liebig's recommendations green bones, the size varying from quarter of an inch to half an inch, were used for grass, turnips and other crops.

"Of course, in such a mechanical state the action was slow, hence it was found that by treating them with acid the action was quicker, or, in other words, that a much less quantity would suffice for a given crop. The action was chiefly a mechanical one. The sulphuric or hydrochloric acid employed acted as a grinder, hence the bones were distributed more evenly in the soil, and presented to the solvent agencies therein an enormously increased surface of action. This, setting aside for the moment the value of the gypsum formed in the supherphosphate, and which, when desired as manure, may be had cheapest as gypsum, is the solution of the benefit experienced in the adoption of the superphosphating theory. The real solvent before absorption by the plant is in all cases carbonic acid water; the humic, ulmic, and other organic acids arising from the oxidation of the vegetable matter, more or less found in all soils, may or may not form solutions of phosphate of lime, and be taken up as such by the plant.

"Be this as it may, carbonic acid is the final product of the oxidation of vegetable matter, and is sufficient for explaining our present need. Limiting ourselves, therefore, to the consideration of carbonic acid water we see that the whole process may be explained in the absorption by the capillaries of the solution of the neutral phosphate in carbonic acid water, and the subsequent deposition in the cells of the plant of the phosphate and carbon, the oxygen and the water being for the most part exhaled.

"This absorption of phosphate of lime is, of course, coeval with the origin of vegetation, and therefore prior to the use of superphosphate of lime. It seems, to me, that agriculturists should now consider whether this expensive vitrol process may not be with advantage superseded by the older and simpler methods of nature."

*The Bermuda is a perennial grass, whose roots take complete possession of the soil and hold it, to the exclusion of all summer plants, even of broom-sedge. It requires, however, a very rich soil to make it grow thick and high enough to cut. Under favorable circumstances it makes two heavy crops of delicate grass during the summer, which dries easily, keeps well, and is second to none in feeding value.—Dr. R.

† To determine whether it were necessary to turn in the green vines, always a difficult and troublesome operation, some of the dried vines were washed in a filter with water, the water tested, and found to contain all the valuable constituents of the vine, showing that no loss of fertilizing material had been occasioned by the plant dying on the surface of the land, and proving the turning in which has greatly prevented the general adoption of this mode of fertilizing to be unnecessary.—Dr. R.

‡The dried vines of the cow-peas sowed with ash element were found by Dr. Ravenel to contain nitrogenous matter capable of producing 2½ per cent of ammonia, and 10 per cent of mineral matter or ash. The continuous use of the pea as a fertilizer has not proved satisfactory where a liberal supply of mineral matter has been omitted.

Dr. Graham then goes on to suggest the composting of the finely-ground mineral or bone phosphate with farm-yard manure as the cheapest carbonic acid manufactory, or where that is scarce, with turf, leaf-mould, sawdust, &c. Employed thus, or added in a ground state to a highly vegetable soil without previous preparation, he maintains that mineral or bone phosphate in a fine state of division will act as quickly as ground, boiled, or green bones, or even as superphosphate itself. In France, and more particularly in the lands of Brittany, mineral phosphates have been largely used without any previous preparation for years on poor, miserable land and yielding now large and profitable crops of cereals and roots. But in all ordinary cases he recommends composting with vegetable matter, such as dung, turf, &c., before spreading on the land.

An important consideration for the farmer, "says Dr. Graham," is that the present supherphosphating method is not only unnecessary but expensive. For an equal outlay he may obtain three or four times as much phosphoric acid when purchased in the raw-ground state as in the ordinary superphosphated condition. The former would, in my opinion, do better were he to employ the money saved in the purchase of the cheaper article by expending it, not in vitrol, for which he pays so dearly in superphosphates, but in the purchase of nitrogen, and especially as regards root crops in the purchase of potash."

From the foregoing it will be seen that Dr. Graham not only advocated the use of finely-ground phosphates of lime, but suggested a method of employing them as manure as early as 1867. Experiments were made at his suggestion in Germany and on a larger scale on the borders of England and Scotland, and his views were published in foreign journals, which have been translated, or re-appeared in English agricultural journals, and in pamphlet form by Messrs. Crossmand & Paulin, fertilizer manufacturers of Berwick-on-Tweed, who have done much to introduce Dr. Graham's views into England.

Many thousand tons were thus used in this way without the addition of any acid in France, Germany, England and Scotland, and have continued to be so used in spite of the efforts of grasping monopolists who avail themselves of the generally assumed high value of soluble phosphates to increase their high profits by drenching dear phosphates with cheap acids, and selling the products at the same or even at an enhanced price as a better article.

More recently, and following in Dr. Graham's footsteps, Professor Thomas Jamieson, University of Aberdeen, and chemist of the Aberdeenshire Agricultural Association, has been conducting a series of elaborate experiments to test the value of the nitrogenous matter in bare manure, and the comparative value of soluble and insoluble phosphates, mineral and animal, as a manure for turnips. Writing the 13th of May last, and enclosing a complete series of his reports from 1875 to 1881, inclusive, Mr. Jamieson remarks that during the past season his experiments have been so conclusive that his interest in the phosphate question as a question has ceased to exist.

In the last report for season, 1881, which is the unfinished proof not yet issued to the public, he reproduces for the sixth time his conclusions now final as follows :

"1. Non-crystalline phosphate of lime, ground to a floury state, applied to soil deficient in phosphate, greatly increases the turnip crop, to a less extent the cereal and grass crops, but always with equal effect, whether it be derived from animal or mineral matter.

"2. Soluble phosphate is not superior in effect to insoluble phosphate, if the latter be in a finely disaggregated form, (e.g., disaggregation effected by precipitation from solution or by grinding bones after being steamed at high pressure).

"3. Nitrogenous manures used alone have little effect on root crops (unless the soil is in the unusual state of poverty of nitrogen and wealth of available phosphate).

"Nitrogenous manures used with phosphate give a visible increase of root crop, but this increase is due mostly or entirely to excess of water in the bulbs.

"Nitrogenous manures exert a great influence on cereals, the effect of phosphate on such crops being subordinate. The increase of nitrogen in this case is not accounted for by excess of water.

"As to the relative efficiency of different forms of nitrogen, the ultimate effect ef nitrogen in sulphate of ammonia, in guano and steamed bone flour is nearly identical, whether used with soluble or insoluble phosphate. Nitrate of soda, when used with soluble phosphate, is identical also with the above forms, but is of less efficacy when used with insoluble phosphate.

"4. Fine division (or perfect disaggregation) of phosphate assists the braird nearly as effectively and fully as healthily as does the simultaneous application of nitrogenous manures.

"The most economical phosphatic manure is probably non-crystalline, floury, insoluble phosphate of lime, the cheapest form being mixed with an equal quantity of the form in which the highest degree of disaggregation is reached. At present these two forms are respectively ground coprolite and steamed bone flour."

Mr. Jamieson, moreover, notices in his report the conclusions of the International Congress of the Directors of Agricultural Experimental Stations, which was held in Paris, June, 1881. Here the subject of phosphates received much attention also, and general approval of the efficacy of the undissolved forms was the result.

From the records of the Congress it appears evident that the French and German agricultural chemists are now in accord in regard to the comparative value of soluble and precipitated phosphates (*i.e.*, those which had once been soluble but have returned to the insoluble state in fine division), which French chemists have for some time held should be on an equal footing. The French chemists in Congress, therefore, as Mr. Jamieson remarks, assented all the more readily to the doctrine of the value of raw ground phosphate of lime, as in so far as precipitated phosphate was concerned they themselves had been travelling on the same line.

The words of the declaration of the Congress are as follows :

"The Congress is of opinion that in reports of analyses the directors of stations should state the solubility of phosphates by the expressions, phosphoric acid soluble in cold citrate of ammonia, or soluble in water, and not that of 'assimilable phosphoric acid.' The Congress believing that to apply the term assimilable to the phosphate soluble in the citrate would be to class implicitly and necessarily in the category of substances not assimilable the phosphates which are evidently soluble in the soil, such as those in bone ash, guano, bone powder, farm-yard manure and fossil phosphates."

In commenting on Mr. Jamieson's experiments in Scotland, Mr. L. Grandeau, commissary general of the Congress and dean of faculty of science, University of Nancy, records :

"These conclusions generally resemble, it will be seen, those which I have made from my eight years' experiments. They confirm notably the important fact of the identity almost of soluble and of precipitated phosphate. The general conclusion of the Aberdeenshire experiments is that the tribasic phosphate in fine powder is the most economical source of phosphoric acid to the cultivator. We are then, Mr. Jamieson and myself, absolutely in accord upon this very important economical fact, that it is necessary to substitute in cultivation on the large scale the raw mineral phosphate in fine powder for the infinitely dearer supherphosphates.

Among other chemists who have experimented in England may be mentioned Drs. Lawes, Provost, Cameron, Vœlcker, Baldwin and Aitken, all of whom have confirmed the value of fine-ground phesphates as far as under the circumstances was to be expected, though some of these have been reluctant to abandon the old land marks. In a paper on "Co-operative Experimenting as a Means of Studying the Effects of Fertilizers and the Feeding Capacity of Plants."

Professor O. W. Atwater says: "Treating the insoluble phosphate of bone or mineral phosphate with acid to make supherphosphate is expensive. Soluble phosphoric acid costs us from twelve to fifteen or more cents per pound. While we can buy it in the mineral forms for from four to six or seven cents. The general theory is that superphosphate is necessary, but still, some how or ohter, many of us have the feeling that, in many cases at least, the cheaper insoluble phosphates would do as well, that fine grinding might serve instead of supherphosphating. and that there are many cases in which the cheap rock phosphate might replace the dearer bone manure. If, so, the saving would be immense."

Such then are the views and conclusions of some of the leading chemists and agriculturists abroad and at home, who concur in the use of fine-ground unvitriolated phosphates in place of the superphosphates. We are therefore not alone in our views on the subject, the question is not one which is confined to any one locality or soil, but is of high economical importance to agriculture in general, and may well agitate the whole world.

Now, it must not be supposed that in expounding Dr. Ravenel's views I claim for him that he was the first to suggest the use of unvitriolated phosphates, for long before the discovery of phosphates in South Carolina, and prior to Dr. Graham's experiments or even Liebig's recommendations, it is well known that bone phosphate in a powdered condition was largely used as a fertilizer. But as some misconception may arise in regard to the originality of Dr. Ravenel's suggestions I deem it necessary to state wherein he differed from Dr. Graham or any other chemist. Dr. Graham, as we have seen, gives the solution of tricalcic phosphate in carbonic acid water as the true explanation of the nourishment of plants. Dr. Ravenel believed that the acid contained in the root of the plant itself was the active agent in dissolving the plant food. These two theories of the same result are comparatively of little practical importance to the farmer.

The vital feature, however, of Dr. Ravenel's system, of which we must not loose sight, is the employment of the leguminoids along with the necessary mineral matter not only to assist in preparing the soil for future crops by furnishing the vegetable acids, but also to act as cheap carriers of nitrogen. Farm-yard manure is often scarce, but in any case when applied on a large scale the legumes effect the same end in a very much simpler and cheaper way. In like manner clover, together with "land-plaster," has been used to some extent in Virginia, and some recent experiments of Sir J. B. Lawes in England seem to indicate a similar employment of legumes' but this systematic method of applying different legumes with all the mineral matter needed at different seasons to suit the various crops of grass, of grain, of cotton, &c., is entirely the suggestion of the late Dr. St. Julien Ravenel.

In conclusion there are some points about the economy and application of raw-ground phosphates which I wish to make clear.

In writing to me on the subject some farmers have expressed surprise at the comparative cost of soluble and fine-ground phosphates, both being sold, I believe, at very much the same price. What they ask is the economy of the one over the other? The answer is this: In the acid article the farmer gets in a ton of fertilizer only about half a ton of phosphate of lime, whereas in the raw-ground rock he gets a whole ton. At the present price of crude rock the finely-ground product is certainly dear enough, that is to say, as much or more is charged for grinding as the rock originally cost.

But as the acid in the superphosphate acts chiefly as a grinder, and a ton of superphosphate costs as much or more than a ton of ground phosphate, and yields but half the quantity of fertilizing material; there is no doubt as to the economy of the fine-ground rock.

There is no one word since the introduction of artificial fertilizers which has so misled farmers or cost them more money than the word *soluble*. For what does soluble or superphosphate mean practically to the farmer? It means that his phosphate is in such a condition that it may be washed out in the drainage waters, and that at a time when the plants most need it, viz: in the later stages of their growth it has disappeared; or it means that the possible liberation of a quantity of acid in the soil, owing to the chemical action taking place, is liable rather to exhaust than improve his land. And yet this is the article for which two prices are paid; instead of using the simpler and cheaper raw-ground phosphates which remain always stored up as in a bank in the soil for nature to draw checks on as required. But it must be understood that the finer ground the plain phosphate is, and the more uniform the powder, the more complete will be the manurial effect. Again, as I have already pointed out, the use of phosphates, or of any one element of plant food alone will not have the desired effect, unless the other necessary elements are present in sufficient quantity in the soil. Therefore, the phosphate ground to the finest possible state of division (an impalpable powder) is to be mixed with the mineral matter needed, lime and potash, and then composted with farm-yard dung or other vegetable material, or better still, and along with the legumes, which furnish also the necessary ammonia. If farmers will apply the finely-ground mineral phosphates *under these conditions*, I am convinced that they will find them efficacious as well as economical. I do not expect any one to adopt these views all at once or without a trial. I have a greater respect for the farmer's proverbial common sense; but I do expect all to try this thing for themselves. Do not ask your would-be experienced neighbor, do not ask your chemist or fertilizer dealer, but go the land and ask it the question!

And especially I urge our southern farmers to give the matter their earnest consideration. We are an agricultural people. The two essentials for plant growth are force and material. The forces are light, heat and water; the materials, lime, phosphate and potash, carbonic acid and ammonia. Our climate affords the forces in the highest dégree of perfection; the materials are most of them at our very doors. There is no reason why we should not make this one of the most blest regions on the globe, if we will only make use in a rational manner of the means with which nature has provided us.

The Value and Importance of Canadian Phosphates as a Fertilizing Agent.

(Excerpted from the Blue Books of the Hon. John Carling, Minister of Agriculture.)

The farming community of Canada, as a whole, seem to be very backward in applying artificial fertilizers to their soil, contenting themselves with the simple old time barnyard manure. With the annual exhaustion resulting from continuous yield, this is not sufficient of itself to produce the results in Canadian grain that the present system of farming might be expected to yield.

The Dominion Government has by no means neglected to bring this matter before the public, as the following extracts from its blue-books show. The Minister of Agriculture, in his Report to Parliament for the year 1878, commenced to call attention to the application of phosphate as a fertilizer in the following remarks:—

"The fact of the ascertained existence of phosphate of lime in very large quantities in the Provinces of Quebec and Ontario, is of very great importance for the agricultural interests of the Dominion."........

"Canada is really now emerging—at least the old Provinces of the Dominion are—from the position of what may be called new-land farming, a system to a great extent dependent on the unused resources of the virgin soil, which contain the requisites for producing the cereals and grasses without resort to artificial manures. While this state of things has existed in Canada, the Old World has drawn from Peru and other countries, guano and other manures, to enable it to get returns from the soil which the old Provinces of Canada have been drawing from decayed vegetable and other deposits, everywhere found in land recently cleared of the forests. But while this virgin soil enables the new-land farmer to obtain the cereal and other crops without the expense of purchasing artificial manures for a considerable length of time, it happens in Canada, as in other countries, that the necessary properties for the production of wheat and other crops will become exhausted in the proportion that they are taken from the soil, without the return to it of the necessary fertilizers to counterbalance the exhaustion from the crop......In many of the old parts of Canada, it has been found in places where wheat was at one time easily and profitably raised for export, the soil has become so much exhausted from cropping, that grain can now only be profitably grown by the use of artificial and other manures, in the same way as in the Old World, by a very careful system of farming and the use of such manures.

"Peruvian guano, which has been so largely used for this purpose, seems to be diminishing in quantity, and it is, therefore, fortunate that the fact of the existence of immense deposits of phosphate of lime in Canada has become known. This occurs, also, at a time when the necessity for a change in our system of agriculture has become apparent. It is not, however, the agriculturists of Canada alone who are to be benefitted by the discovery which has been made.

"Already the phosphates of Canada are being used in England, Germany and the United States. English, German, and Canadian companies are engaged in the mining, and the trade bids fair to become a large and profitable one. So important, in fact, is this trade likely to be, that it is desirable to ascertain how it can be fostered and utilized to the greatest advantage to this country.

"The percentage of purity of the ascertained large deposits of phosphate of lime is from 70 as high as 95, and this coupled with the proximity of iron pyrites appears to afford the conditions necessary for an easy and cheap manufacture of superphosphates. Such manufacture would employ the labour of our own country."

In 1880 he again alludes to it as follows:— "The necessity for the use of artificial manure in the production of wheat and other crops, becomes yearly more and more apparent, and especially on this continent where the virgin soil is becoming exhausted by continual cropping, and a return to it of the requisite fertilizers is absolutely necessary for profitable cultivation.

"Practical experience has shown how some of the older States, whose soil was considered inexhaustible for wheat growing, are now far behind the Western States and Manitoba, against the products of which, from virgin soil, they can only compete by heavy use of artificial and other manures.

"From the fact of a fertilizer in our midst, only requiring to be manufactured, it can readily be seen what facilities are afforded Canadian agriculturalists for its use, compared with Europeans, who have to pay the freight and other charges on the same material even in a crude state.

"I strongly call the attention of our farming community to the use of this native product, a demand for which, in a manufactured state, would soon call into existence works for the same amongst us; and such manufacture would employ the labour of our own country."......

"It is to be hoped that increased attention will be paid to the phosphate industries, and the results of experiments in the use of this fertilizer be noted and made public."

In 1881 is found as follows: "The percentage of purity of native Canadian phosphate ranging from 70 to 95 per cent, affords a condition well calculated to induce our agriculturalists to use it. Even in its raw state, when reduced to a fine powder, experiments have shown that it produces valuable results. The production of wheat and other crops exhaust from the soil the necessary properties for their growth, and this can be only counterbalanced by a return to the soil of suitable fertilizers. As the virgin soil turned up by the early settler has year by year had drawn from it its requisites for producing cereals and grasses, so the time has now arrived when it will no longer produce remuneratively without resort to artificial manures. Prof. Hoffman, the analyst to the Geological Survey staff, considers that from its usual high percentage Canadian phosphate may be regarded as 'most eligible.'".........."I would again, as in my last Report, urge the attention of our farming community to the use of this native product, a demand for which would necessarily call into existence works for its manufacture at our very doors."

Again in 1882: "Considerable attention is being paid in various quarters to its use in the raw state pulverized, but the beneficial effects are said not to be visible during the first year. Experiments to test its appliance in this state have been made at the Agricultural College, Guelph, but the result has not been made known. From present indications considerable attention will be paid to phosphate mining and shipment during 1883."

"There has been a tendency in some of the old provinces to cultivate continuously the cereals on rich virgin soils, and this process, whatever may be the natural wealth of the soils, conduces to deterioriation. This may be obviated by the application of artificial manure, cadable of imparting recuperative properties to the soil. Experiments have shown that phosphates, especially when chemically prepared, possess these qualities in a very high degree. I would strongly urge a trial of its effects, and the comparison of the yield of grain afforded by land thus treated, with that on land without this stimulant. If an active demand were created for manufactured phosphate, its preparation would also largely aid in employing the labour of our country."

In 1883 he says: "When Canadian phosphate first came on the market, some eight years ago, practical men shook their heads at the hard and unpromising looking material. Many of the mills then in use in fertilizer-works were the buhrstones used to pulverize coprolite and other comparatively soft material. The difficulty of grinding has now been overcome, and it is no longer a source of danger to workmen, and of perplexity to manufacturers. Instead of using it as they did coprolite, it is mixed largely with other softer materials, which enables the operating chemist to first saturate the raw phosphate with sulphuric acid, and use Canadian phosphate as a drier.

"Being a more concentrated phosphate than any other in the world, it has very naturally been sought for to bring up the acid phosphate fertilizer to high percentages of phosphoric acid." ...."I have in previous reports, remarked that the removal by crops impoverishes the soil, and prevents it from yielding as abundantly as formerly, unless the loss is compensated by supplying phosphate fertilizers. In the districts where cattle raising is not carried on, the absence of ordinary manure must be compensated for by some artificial stimulant and experience goes to prove that for the production of cereals of every description as well as for the strengthening and renewal of worn out lands, no available fertilizer is known that can produce such beneficial results as phosphate when subjected to a chemical process, and known to the trade as super-phosphates.

"The grain exported from the port of Montreal in a single year, has been estimated to contain 2,574 tons of phosphoric acid, which implies the total exhaustion, as far as phosphates are concerned, of 75,000 acres, the renewal of which necessitates the application of some 6,000 tons of phosphates."

In 1884 he still more strongly points out the benefits to be obtained from its use—"The use of Phosphate as a fertilizer, when converted into Super-phosphate, cannot be too strongly urged on our farming population, and the advantages it offers in renewing lands worn out by perpetual cropping, in the absence of ordinary manure, the want of which is too often apparent in districts where cattle-raising is not carried on, cannot be too often impressed. In those parts of Europe where the sugar beet is largely grown—Belgium and Denmark for instance—no fertilizer has been found equal to phosphate, and the same remark might well be applied to the grain producing farms of our older provinces. The rigid inspection to which the crude material is subjected in England tends greatly to keep up the standard of our shipments, and the high percentage of Canadian phosphates will always secure for it a foremost place and an eager demand. Prof. Dawkins, comparing the phosphate obtained from various countries, states the percentage that Canada yields out of a mean of analyses, is 87-52 of tribasic phosphate of lime."

"The question has not yet been solved whether the raw material pulverized will give beneficial results to the soil by its application, and till this fact has been ascertained, the crude phosphate will continue to be shipped to the place of manufacture. The establishment of works for its conversion into Super-phosphate, contiguous to the natural deposits, would prove of immense advantage, as the material thus converted would be far more likely to be made use of by our resident agriculturists, and transport of bulky phosphate would be resolved into shipments of a substance commanding a far higher price. The advantages obtained by foreign manfacturers would in that case be gained by Canada, and an industry might be added to those already existing which would materially add to our prosperity." . . . . "It seems to me a matter of regret that no definite action has yet been taken in regard to the conversion of crude phosphate, into superphosphate ready for use. If the manufacture of the prepared fertilizer was carried on in Canada, much larger returns would be obtained for the shipments of it made to Europe, and a considerable saving would occur in the cost of freight, as, under the present conditions, however carefully the system of collecting the crude material is carried on, there are still quantities of foreign matter associated with it, which are valueless when separated by the manufacturer. I have ascertained that the mineral from which the acid requisite for converting phosphate into superphosphate could be extracted, is present in proximity to the phosphate itself, but no steps appear to have been taken towards the manufacture of this commodity, either for home use, or for foreign export. I am, however, in hopes that with the attention the phosphate mines have received within the past year, both from members of the British Association who visited them, as well as from capitalists with a view to investment, and as the output of the crude material increases with the development of new mines, this important question of its conversion into a form ready at once for the use to which it is to be applied, will occupy the serious attention either of those at present engaged in phosphate mining, or of those who might make its manufacture a separate branch of industry."

In 1885, he again calls attention to it, and in the appendices to the Report for that year, on page 204, an instructive report on "Canadian Phosphates" in relation to agricultural use is furnished by Mr. H. B. Small, which goes very fully into the history of phosphate and contains much valuable information on the subject.

"During the past two years, owing to the attention that has been given to it, the product of Canadian mines has increased in favour with manufacturers of superphosphates. I would particularly call attention to the use of this natural product as a fertilizer to be used by our farming population. It is an established fact that wheat contains about $\frac{8}{10}$ per cent. of phosphoric acid, or about 16 pounds to each ton, and when the total shipments of wheat from this country are taken into consideration, the amount of phosphoric acid taken from Canadian soil and sent away in the wheat can easily be estimated. This loss to the soil requires the most powerful fertilizer to replace or compensate for it, and the only fertilizer known of a sufficiently high grade to effect this is phosphate of lime, when converted into superphosphate. Diversity of opinion prevails respecting the beneficial result to the soil by the application of the material in a raw pulverised state. The experience of agriculturists in the Southern States, where this fertilizer is largely used, both in the raw and prepared conditions, is largely in favor of the latter form for immediate returns, and that when the raw substance is used it should be in combination with some other fertilizer of pronounced condition and fertility. From experiments made in the States referred to, the following deductions may be informed:—For prompt and immediate results, superphosphates, and for slow and continued results, ground phosphates are respectively valuable."

In 1886, the Minister again calls the attention of the agricultural community to the necessity of the use of fertilizers:—"When Liebeg, in 1840, compelled the agricultural community to accept his views of exhaustion and restoration of the soil, and that the constant removal therefrom in harvest of the inorganic elements of plant food, notwithstanding the rotation of crops and the old system of manuring, was a robbery of the soil, which gave a present increase at the expense of the future, he founded an industry which has assumed constantly increasing proportions ever since. That industry is the manufacture of fertilizers or superphosphates, and the demand for materials with which it can be manufactured has led to a search for, and consequent working of, natural deposits in which phosphate of lime preponderates. The whole art of manuring consists in supplying the natural elements of plants in a form most favourable for absorption and assimilation, and, as ordinary manure does not always contain the most important inorganic elements required, phosphoric acid, and potash sufficient for plant use, the needs of mankind demand the employment of artificial fertilizers along with, or as a substitute for, barnyard manure.

"The attention of our agricultural community cannot be too strongly drawn to the necessity for the use of fertilizers, although the chief portion of the phosphate of lime which is produced in Canada is shipped in its crude state to Great Britain and the Continent, there to be manufactured into superphosphates, a considerable portion of which is shipped to the United States..........

In 1887 he further says— . . . . . "The question of using ground phosphate in the raw state is attracting considerable attention, and a series of tests will be made at the Experimental Farm during the coming season, the results of which will be made public. The manure question is one of the most important connected with agriculture, and whatever will tend to an increased production of crops must necessarily demand the attention of the agricultural community. Phosphate rock has now, to a great extent, been substituted in place of bones in the manufacture of superphosphate and commercial fertilizers, by treatment with sulphuric acid, for the purpose of rendering it soluble. Phosphoric acid, as contained in crude phosphate, has been considered insoluable in water, but water containing carbonic acid, ammonia, or common salt, has the power slowly of liberating the phosphoric acid from its basic lime, and rendering it soluble for plant food. But the slower operations of water to render the phosphoric acid available for crops, can be largely increased by mixing the pulverized material with fermented manure, or peat. This system has for several years been carried on in the United States, in connection with cotton and tobacco plants, both of which being very exhaustive to the soil, require very stimulating fertilizers to restore the growing properties essential for plant life to the land. It is to be hoped that our farming community will see the necessity of adopting some measures for keeping the land required for the use of cereals, up to its standard, by using fertilizers, and it does seem anomalous that this rich natural product at our very door, should be shipped away to the United States and Great Britain without its value being recognized by our own farming community." . . . . . .

Last year, 1888, he not only still more strongly brings the matter before the public, but quotes from the "London *Times*" and "*Morning Post*," important references to the subject, made by those papers. . . . . . . "I continue to hope that the time is not far distant when our own farmers will see the advisability of using this fertilizer at home, which would have the effect of largely increasing this mining industry. Late advices from Great Britain show that Canadian phosphate is prominently engaging the attention of superphosphate manufacturers in that country, and the enormous deposits in this vicinity may be expected to receive thereby still more attention than has been the case in the past. I am informed that British agriculturists have been discussing of late the present position of their supplies of phosphate, that most essential element of plant food. It appears, from the inquiries of the Chemical Manure Manufacturers' Association, that the great guano beds of Peru and Chili are approaching exhaustion, and the British farmer seems timid lest the growing home demand for the phosphates of the United States and Canada, in those countries, should greatly curtail the British supply from these sources, and leave the British farmer without an adequate quantity of artificial manures at anything like reasonable prices. At this moment, therefore, special attention is being drawn to the Canadian deposits.". .

Facts like the above show that the farming community have been very strongly urged to remedy the impoverishment of the soil, which naturally takes place by continuous cropping, by the application of a fertilizer produced almost at their own doors, and the results of a want of action in this matter are only due to their own lack of interest, and not to any inaction on the part of the Government.

From the above extracts, the Canadian public will see that the Minister of Agriculture has done his share towards calling attention to the need of artificial fertilizers.

Nitrates v. Phosphates.

The frequently-quoted simile referring to the respective merits of nitrates and phosphates, as a plant food, that "the nitrate is like a glass of spirits, the phosphate like a plate of beef," is an exceedingly terse way of putting a generally acknowledged fact that, while the former is a mere stimulant, the application of phosphate adds permanently to the fertility of the soil. The simile, however, might with equal accuracy be continued as follows :—"But a combination of the two is like a substantial dinner."

The application of science to agriculture is of comparatively recent date, but, nevertheless, the progress in agricultural chemistry has wrought, as was to be expected, a corresponding advantage in the art of farming. It was soon ascertained that the artificial barrenness produced by exhaustion yields, under proper conditions, to the touch of science. Certain constituents, it was found, are indispensable for plant growth, and of these the largest quantities were continually being withdrawn. Chief among these constituents are phosphoric acid, nitrate of potash or soda, and ammonia. Most agricultural soils contain sufficient iron, magnesium, calcium, chlorine, sodium, and sulphur to last for ages, but the disproportion between the amount of the three former ingredients required by plants and the amount replaced in the soil by nature is so great that exhaustion of these elements follows as the necessary consequences of continuous cropping.

The application of science to agriculture resulted in nothing more and nothing less than the creation of a new industry, namely, the production of "commercial fertilizers."

The introduction of artificial fertilizers marks, therefore, a new epoch in the history of agriculture. Their general acceptance in common farm practice is equivalent to the introduction of a new force. They have revolutionised the mode of agriculture as thoroughly as steam and electricity have revolutionised transportation and commerce. By their judicious application a barren soil can be changed into one of great productiveness. Therefore the principal functions of a good fertilizer are to supply to the soil the three elements of plant-food usually wanting in poor or exhausted lands, viz., phosphoric acid, ammonia, and nitrate of potash or soda.

The application of scientifically prepared concentrated plant-food to the soil forms a means of estimating the progress which a country is making in the domain of agriculture. The marvellous ease and rapidity with which France paid off the enormous war indemnity of five milliards of francs has justly taken the world by surprise. Yet to a great extent it was due only to the wealth Frenchmen knew how to derive from the land they live on by a generous and intelligent method of farming, and to nothing else can this be ascribed but a practical recognition of the value of artificial manure.

Is it not strange, therefore, in the year 1889, when it has been clearly and repeatedly proved by all the leading scientists of the day, as well as by practical demonstration, that each and all of the three elements enumerated above are requisite and necessary to form the basis of a satisfactory and practical fertilizer, that men of intelligence can be found antagonistically debating the respective merits of phosphoric acid, as represented by the general term of "phosphates," and nitrates of soda and potash, usually designated "nitrates"? This is clearly attributable, however, not to a lack of knowledge of the scientific facts as they exist, but because of the different financial interest involved in the two industries, thereby causing an undue advocacy of the particular chemical ingredient in which the several parties have embarked their capital.

The time is rapidly approaching when such a state of things must end; already those most largely interested in the nitrate industry have accepted the teachings of science in regard to this question of superiority or inferiority of the respective elements, and—appreciating the certainty of an almost universal demand in the future for a concentrated fertilizer containing all the beneficial qualities to be derived from a judicious combination of phosphoric acid and nitrate of potash—are alive to the necessity of securing a substantial interest in the comparatively limited supply of the crude phosphate rock.

The average farmer's knowledge of plant, physiology, and agricultural chemistry is, as a rule, of a very limited nature. He is not able to determine for himself what are, or what are not, those essential elements of food plants which he desires to procure for his land; but he is rapidly becoming educated up to a proper understanding of the various elements, and their relative value to the soil.

The literature published by the Royal Agricultural Society of England and the Bath and West of England Society is having a very beneficial effect in this direction, and the statistics and results of experiments therein published have in the past, and will still more in the future, clearly demonstrate that the very best results are to be derived, not from the use of nitrates or superphosphates alone, but by an intelligent use of the two in combination.

As evidence of this, Mr. J. E. Knowles, the chairman of the Experimental Committee of the Bath and West of England Agricultural Society (1888 89) states in his report that the results of twenty-four experiments in relation to wheat-growing showed "that nitrate of soda and sulphate of ammonia, when combined with superphosphate, have each given a larger produce both in corn and straw than either used alone." In the same publication the same satisfactory results were noted in reference to the oat crop. Experiments were made on ½-acre plots with the following results :—"The unmanured plots produced at the rate of 21 bushels per acre. By spending £1 1s. an acre in nitrate of soda (70 lbs.) and superphosphates (168 lbs.) the produce of grain was exactly doubled, and there was an increase of straw of 864 lbs, this increase in corn and straw being equal in money value to 2*l*. 10*s*., or a clear gain, after deducting cost of manure, say, 30*s*. per ocre."

"In the plots where sulphate of ammonia alone and nitrate of soda alone were used there was a small gain of about 6*s*. per acre."

Similar experiments on "grass" resulted as follows :—Uumanured, 4 cwt. 1 qr. per acre of hay; sulphate of ammonia, 5 cwt. 2 qrs. of hay; nitrate of soda, 5 cwt. 1 qr. 7 lbs. hay; nitrate of soda and superphosphates combined, 6 cwt. hay.

No clearer proof can be required to demonstrate beyond a doubt the unquestionable advantage of this combination, and it will be unnecessary, therefore, to trouble the reader with detailed results of the numerous other trials made.

That both the nitrate and phosphate industries have reached gigantic proportions, notwithstanding unreasonable opposition, may be gleaned from the following figures :—

	Tons.
Nitrates used annually in the United Kingdom and Continent........	600,000
Nitrates used in United States (about)	90,000
Phosphates imported into United Kingdom alone (1887)...........	283,415
Superphosphates and fertilizers mainly based on phosphates, used in the United States (1886)...........	Tons. 1,006,631

Of this quantity 616,631 tons were used in the Southern States in the cotton districts.

It is difficult to estimate to what proportions this business may grow when a loyal combination is once established between the two interests, which, as we have pointed out above, must be the inevitable and speedy result of the march of progress and intelligent agricultural enterprise.

The question then arises—and it is a question which has given great concern to the manufacturers of fertilizers both in Europe and America during the past year—Where are we to look for our future supplies of crude phosphate rock which the satisfaction of this ever-increasing demand for plant-food necessitates? That the question is one of great moment for the consideration of manufacturers is evidenced by the serious anxiety evinced on this point by Mr. Herman Voss—himself the manager of one of the largest fertilizer manufacturing companies in the world—in his admirable paper read before the Chemical Manures Manufacturers' Association on 10th December, 1888. He therein stated :—"The consumption of phosphatic manures, partly owing to the use of large quantities of nitrate of soda and ammonical manures, is rapidly increasing all over the world, and our supply is at present dependent upon so few sources that I consider it necessary and advisable to change our mode of selling superphosphate in such a way that we could also draw from other sources which would strengthen our hands as manufacturers."

It will be noted that Mr. Voss not only expresses anxiety as to the present limited sources of supply of the crude phosphate, but strongly emphasises the fact we have demonstrated above, that any increased use of nitrate of soda, as a matter of course, will increase comparatively the demand for phosphatic manures.

The present imports of crude phosphate rock into Great Britain, as stated by Mr. Voss, are derived from the following sources (1887):—

	Tons.
United States	165,275
Canada	19,194
Dutch West Indies	9,505
British West Indies	6,451
Spain and Portugal	15,612
Belgium	45,322
Holland	4,778
France	11,140
Australia	350
Hayti	3,044
Brazil	1,200
Other countries	1,544
Total	283,415

From these figures it will be seen that to supply the requirements of Great Britain alone for the next ten years, provided the demand does not increase, will require an output of about 2,834,150 tons, and it is but reasonable to assume that long before the expiration of that time many of the older sources of supply, from which there has been a continuous drain for many years past, will be completely exhausted. On the other hand, it will be noted that the Canadian supply up to the present has only amounted to about 8 per cent. of the British consumption, notwithstanding the well-established fact that the phosphate deposits in the Dominion cover such an enormous area as to warrant the assumption that in the near future Canada will take a foremost place in the world's supply of this invaluable mineral.

It will be noticed that the largest producing countries at the present time are the United States and Belgium. A reference to Mr. Voss's admirable paper shows that the average percentage of phosphate of lime in the Belgian product is not more than 50 per cent., while that of the United States contains about 60 per cent. The Canadian mineral, as imported into Great Britain averages, however, from 80 to 85 per cent. of phosphate of lime, and may at once be set down as one of the highest grades of phosphate rock the world produces.

When we take into consideration that, in order to produce a really high-grade phosphatic manure compound (for which intelligent agriculturists are year by year becoming more exacting in their demands), it is a necessity that manufacturers should procure a correspondingly higher grade of the raw material—and, if proof of this is necessary, it is to be found in the fact that makers are willing to pay a much higher price per unit of phosphate of lime for the richer minerals than they are for that of poorer quality; thus, for example, while a manufacturer is paying, say, 7*d.* per unit for a 50 per cent. phosphate, or 29*s.* 2*d.* per ton and 9*d.* per unit for one of 60 per cent., or 45*s.* per ton, he is willing to pay about 1*s.* per unit for the higher-grade Canadian, or 4*l.* per ton for an 80 per cent. grade, and 4*l.* 5*s.* for one of 85 per cent.—it must readily be seen that the Canadian miner must always be in a position to produce his material at a decided advantage over any of his foreign rivals

The question then naturally arises, if this be the case, how is it that the present output is so limited?

The reply is to be found in Mr. Voss' remarks under the head of "Canadian Phosphates," as follows:—

The Canadian mines commenced to be worked some ten years ago, and the output now amounts to about 25,000 tons per annum. Our imports from Canada were:—

Years.	Tons.
1881	8,187
1882	16,531
1883	15,716
1884	21,484
1885	18,069
1886	19,194

So that it will be seen that in six years the output has increased about 250 per cent.

Capital is the agent most required in Canada to build up and develop her mining industries. With it much more could be accomplished; without it Canadians are unable to avail themselves to the full extent of their rich phosphate territory.

Canada offers to the British capitalist a large and profitable field for investment in her phosphate properties. As the great and vital question of the future supplies of fertilizing materials becomes more widely discussed capital will assuredly flow into Canada for the purpose of of developing this profitable industry; but it behoves every Canadian, every man interested in the great future of this business, to see that the interests of the British investor are safeguarded by countenancing only those mining schemes which can bear honest investigation, and that will provide a fair and reasonable expectation of returning to those who invest their money in these properties a good and permanent interest on their capital. Otherwise, notwithstanding the glorious future opening out for those at present engaged in the business, capital will seek investment elsewhere, and the advancement of the colony, as well as its mining industries, will be permanently impeded.

Phosphate of lime (apatite) was first discovered in Burgess, Ontario, in 1847. In 1860 the first shipment of the mineral was made, amounting to about 100 tons.

The earliest discovery of apatite in the County of Ottawa was made in 1829 by Lieut. Ingall, of the 15th Regiment, while engaged in certain geological explorations. Mining operations were not engaged in until 1873.

The entire phosphate beds of South Carolina, so far as discovered and defined, have been estimated to cover an area of 240,000 acres. It was not known that the rock possessed any commercial value until the year 1865.

In those parts of Europe where the sugar beet is largely grown—Belgium and Denmark, for instance—no fertilizer has been found equal to phosphate, and the same remark might well be applied to the grain producing farms of our older provinces. The rigid inspection to which the crude material is subject in England tends greatly to keep up the standard of our shipments, and the high percentage of Canadian phosphate will always secure for it a foremost place and an eager demand. Prof. Dawkins, comparing the phosphate obtained from various countries, states the percentage that Canada yields, out of a mean analysis, is 87·52 of tribassic phosphate of lime.

Our Fertilizer Trade.

As has been pointed out in these columns, farms are constantly being abandoned in Ontario and Quebec, and families are compelled to emigrate to a life of comparative hardship for the sake of newer soils when a knowledge of the means of enriching the old lands, and where these may be obtained, would preserve their homes in comfort and affluence. It is no exaggeration to say that the agriculture of the future depends upon the growth and development of this industry. Already works have been established in various parts of Canada.

The largest now in operation is owned by Messrs. G. H. Nichols & Co., the well known manufacturing chemists of New York. Some years ago, they purchased what are known as the Capelton mines, situate at Capelton, Province of Quebec, and have worked them on a very extensive scale up to the present time. The ores mined, being a sulphuret of copper and iron, were shipped to Laurel Hill Chemical Works, New Jersey (also owned by Messrs. G. H. Nichols & Co.), where they were treated and prepared for market. About two years ago, they decided to erect a large chemical manufacturing plant at Capelton, contiguous to their mines, for making sulphuric acid and other chemicals, also superphosphates. In the manufacture of the latter the apatites from the Ottawa Valley are largely used, being regarded by this firm (who are most competent judges) as the finest quality known for the manufacture of mineral manures.

Messrs. G. H. Nichols & Co, with their various works, manufacture more sulphuric acid than any other concern on this side of the Atlantic Ocean; they have everything known to modern science (together with many things not generally known) wherewith to manufacture, not only economically, but of great purity.

Their works at Capelton are well and conveniently located on the Possumpsic Division of the Boston and Maine Railroad, and at only a very short distance from the Canadian Pacific and Grand Trunk Railways, thus making them accessible to every part of the Dominion of Canada. In answer to our enquiries, the firm writes:

"This spring we decided to commence the manufacture of chemical fertilizers for Canadian farmers, feeling that up to that time they had been at a great disadvantage as compared with their American neighbors, in that fertilizers furnished them had not only been in many instances improperly made, but almost universally at much too high a price to enable them to use them advantageously. We constructed a small experimental works, manufacturing the grades referred to in our advertisement, and while the outlet has not been as large as we could have desired, we have found, on the whole, the farmers to take hold of it with a good deal of intelligence. We have been sufficiently encouraged to believe that our policy of high grade goods at the lowest possible prices was correct, so that we are now preparing to erect in time for the winter trade a large and complete fertilizer works at Capelton, in which we expect to be able to manufacture fertilizers to the extent of several thousand tons per annum by the most approved modern machinery. It is our expectation to distribute this fertilizer through agents in various parts of the country, who will be controlled from our central office, so that there will be no danger of their overcharging farmers. The prices mentioned in our advertisement are what we expect the farmers to pay, any commission for agents being paid by us. If the trade warrants, we are prepared to extend the fertilizer department to any necessary degree, so that Canadian farmers may be certain that they may get all of the fertilizer they want at the lowest possible margin of profit. We simply need their co-operation to make the enterprise a success both for ourselves and for them."

The next manufactory of importance is located at Smith's Falls, Ontario. The works are much older than those above referred to, but not as large. Mr. R. J. Brodie, a graduate of McGill College, has charge of these works. Mr.

DEPARTMENT OF Inland Revenue.

AN ACT RESPECTING AGRICULTURAL FERTILIZERS.

The public is hereby notified that the provisions of the Act respecting AGRICULTURAL FERTILIZERS came into force on the 1st of January, 1886 and that all Ferlizers sold thereafter require to be sold subject to the conditions and restrictions therein contained—the main features of which are as follows:

The expression "fertilizer" means and includes all fertilizers which are sold at more than TEN DOLLARS per ton, and which contains ammonia, or its equivalent of nitrogen, or phosphoric acid.

Every manufacturer or importer of fertilizers for sale, shall, in the course of the month of January in each year, and before offering the same fertilizer for sale, transmit to the Minister of Inland Revenue, carriage paid, a sealed glass jar, containing at least two pounds of the fertilizer manufactured or imported by him, with the certificate of analysis of the same, together with an affidavit setting forth that each jar contains a fair average sample of the fertilizer manufactured or imported by him; and such sample shall be preserved by the Minister of Inland Revenue for the purpose of comparison with any sample of fertilizer which is obtained in the course of the twelve months then next ensuing from such manufacturer or importer, or collected under the provisions of the Adulteration Act, or is transmitted to the chief analyst for analysis.

If the fertilizer is put up in packages, every such package intended for sale or distribution within Canada shall have the manufacturer's certificate of analysis placed upon or securely attached to each package by the manufacturer; if the fertilizer is in bags, it shall be distinctly stamped or printed upon each bag; if it is in barrels, it shall be either branded, stamped or printed upon the head of each barrel or distinctly printed upon good paper and securely pasted upon the head of each barrel, or upon a tag securely attached to the head of each barrel; if it is in bulk, the manufacturer's certicate shall be produced and a copy given to each purchaser.

No fertilizer shall be sold or offered or exposed for sale unless a certificate of analysis and sample of the same shall have been transmitted to the Minister of Inland Revenue and the provisions of the foregoing sub-section have been complied with.

Every person who sells or offers or exposes for sale any fertilizer, in respect of which the provisions of this Act have not been complied with—or who permits a certificate of analysis to be attached to any package, bag or barrel of such fertilizer, or to be produced to the inspectors to accompany the bill of inspection of such inspector, stating that the fertilizer contains a larger percentage of the constituents mentionod in sub-section No. 11 of the Act than is contained therein —or who sells, offers or exposes for sale any fertilizer purporting to have been inspected, and which does not contain the percentage of constituents mentioned in the next preceding section—or who sells or offers or exposes for sale any fertilizer which does not contain the percentage of constituents mentioned in the manufacturer's certificate accompanying the same, shall be liable in each case to a penalty not exceeding fifty dollars for the first offence, and for each subsequent offence to a penalty not exceeding one hundred dollars. Provided always that deficiency of one *per centum* of the ammonia, or its equivalent of nitrogen, or of the phosphoric acid, claimed to be contained, shall not be considered as evidence of fraudulent intent.

The Act passed in the forty-seventh year of Her Majesty's reign, chaptered thirty-seven and entitled, "*An Act to prevent fraud in the manufacture and sale of agricultural fertilizers,*" is by this Act repealed, except in regard to any offence committed against it or any prosecution or other act commenced and not concluded or completed, and any payment of money due in respect of any provision thereof.

A copy of the Act may be obtained upon application to the Department of Inland Revenue, as well as a copy of a Bulletin which it is proposed to issue in April, 1888, concerning the fertilizers

E. MIALL,
Commissioner.

January, 1889.

NOTICE

Is hereby given that all communications in respect to matters affecting the Department of Indian Affairs should be addressed to the Honorable E. Dewdney as Superintendent General of Indian Affairs, and not as Minister of the Interior, or to the undersigned. All Officers of the Department should address their official letters to the undersigned.

L. VANKOUGHNET,
Deputy Superintendent-General of Indian Affairs.

Department of Indian Affairs, Ottawa, 11th May, 1889.

MONEY ORDERS.

MONEY ORDERS may be obtained at any Money Order Office in Canada, payable in the Dominion; also in the United States, the United Kingdom, France, Germany, Italy, Belgium, Switzerland, Sweden, Norway, Denmark, the Netherlands, India, the Australian Colonies, and other countries and British Colonies generally.

On Money Orders payable within Canada the commission is as follows:

If not exceeding $4	2c.
Over $4, not exceeding $10	5c.
" 10, " " 20	10c.
" 20, " " 40	20c.
" 40, " " 60	30c.
" 60, " " 80	40c.
" 80, " " 100	50c.

On Money Orders payable abroad the commission is:

If not exceeding $10	10c.
Over $10, not exceeding $20	20c.
" 20, " " 30	30c.
" 30, " " 40	40c.
" 40, " " 50	50c.

For further information see OFFICIAL POSTAL GUIDE.

Post Office Department, Ottawa, 15th Sept., 1888.

Brodie states that he makes the sulphuric acid from the pure sulphur. He gets rid of the hydro-flouric acid gas—which is produced by the action of the sulphur acid on the apatite—by a simple arrangement of wooden chimnies, thus solving a difficulty which has embarrassed many persons in their efforts to use Canadian phosphates. He makes a "complete fertilizer," that is, a mixture of the three principal ingredients of plant food, namely, phosphate, potash and ammonia. The demand is growing in a very encouraging manner, for when a *farmer* tries it once, he generally comes back for more. Mr. Brodie says he could sell many thousand tons during the coming year if he could make it, but the factory is small and the facilities not very great.

The advantages to the agricultural community in having such important enterprises as these is simply incalculable, for the farmer knows this important fact better than anyone—that the soils of the older settled provinces have become impoverished by years of cropping without replenishment, and districts that once yielded great stores of grain now only afford the scantiest pasturage or produce.

There is evidently a large and extending field in the Dominion of Canada for both the manufacture and use of fertilizers, which, if properly and judiciously nurtured, must tend to both profit and usefulness. As a well-known writer has said, "Our agricultural future must depend upon supplies of plant-food brought from sources outside the farm, and prepared for the farmer's use by those who make it their business to do so, and who must, in order to succeed, bring to it not only a large capital, but likewise science as a handmaid, skill and talent as absolute requisites. The progress of this industry measures the true progress of Canada, and promises results which it is impossible to foresee at this day. It opens up a wide vista of changes and improvements. It heralds the awakening of agricultural thought, and has partly awakened it. And with thinking comes improvement, comes better tillage of the soil, comes better stock, comes larger crops, better profits, and lastly, a higher moral and intellectual standard."

Exports of Canadian Phosphate.

The exports of Canadian phosphate from 1877 to 1888, as per official returns, may be stated to have been as follows:—

Year.	Tons.	Est'd value.
1877	2,823	$ 47,084
1878	10,743	208,109
1879	8,446	122,035
1880	13,060	190,086
1881	11,968	218,456
1882	17,153	338,357
1883	19,716	427,668
1884	21,709	424,240
1885	28,969	496,293
1886	20,440	343,007
1887	23,690	319,815
1888	22,485	242,285

The exports for 1889 promise to exceed those of the last two years.

On the Occurrence of Phosphates in Nature.*

D. G. M. Dawson, F. R. S., R. S. M. N.

In proposing to review, in so short a paper as this must necessarily be, a subject so extensive as that indicated by the title, a difficult task has been undertaken, and I cannot hope to do more than touch upon its main points.

In the first place it may be proper to enquire why phosphate materials are now so much sought for as fertilizers.

It has been said laconically that "Phosphorus is life," but this, like most bold generalizations, is but a partial, and even a misleading statement of the fact. Certain it is, however, that this element, variously combined, is present in all living tissues, whether vegetable or animal, and though in small quantity only, is absolutely essential to these tissues, and, therefore, to the manifestation of life. Animals, depending ultimately for their subsistence on plants, derive from these their supplies of phosphorus, together with the other substances necessary for their nutrition.

Unlike the animal, the plant is capable of living, ultimately, on inorganic substances, and while deriving a large part of its food from the air, is absolutely dependent on the soil for those incombustible constituents which, when the plant is burnt, remain as ash. Without these the growth of the plant is impossible, and it is therefore necessary to ensure a sufficient supply of them in the soil. Phosphorus, in a state of combination, is one of these, and that to which I wish particularly to refer.

In following this substance from the soil to the plant, from the plant to the animal, and from the animal again to the plant, we find a system of circulation which, under certain conditions might go on indefinitely. In a state of nature, this cycle is generally complete, but it is interfered with and broken by the present organization of humanity, and more particularly by those arrangements which have resulted in the massing of population in large towns.

In these it is found necessary to remove the effete and excrementitious matters by a system of sewage, which results in draining the phosphates and other substances valuable from an agricultural point of view, into the sea, where they may be considered as absolutely lost. Victor Hugo, in a well-known passage, contrasts the wealth to be seen rolling through the streets of Paris to that which is silently but steadily flowing away by the sewers beneath, which he maintains is greater. Be this as it may, in this particular case there is a continuous process on a large scale in action, by which the land is deprived of its phosphates, and particularly in a country like this, which exports great quantities of food material, with their contained phosphates, to be consumed abroad.

Some years ago (1869) Mr. Gordon Brown calculated the amount of phosphorus actually contained in grains annually shipped from the port of Montreal, estimating it for this purpose in the form of phosphoric acid. Wheat contains about $\frac{8}{10}$ (eight tenths) per cent. of phosphoric acid, or about 16 pounds to each ton, and as the total shipments of wheat amounted to 292,534 tons, the quantity of phosphoric acid sent away in it equalled 2,340 tons. Taking the average quantity of this substance contained in good soils, he found that this meant the total exhaustion to a depth of 12 inches, in so far as phosphates are concerned, of 70,320 acres, and would require the use of 5,850 tons of apatite of good quality as manure to maintain the fertility of the fields. Adding to this the amount of phosphoric acid contained in other grains exported, he found the total loss in the year to be 2,574 tons of phosphoric acid, representing a value of over $500,000.

With such statistics in evidence it will not be necessary to enlarge further on the necessity of discovering a source of supply of phosphates for our fields, and for this we must have recourse to some specially concentrated natural deposits. What, therefore, is the nature of these, how have they been found, and where do they occur?

In answering these questions, it must be remembered that soils have been produced by the decay and disintegration of rocks, and have derived their contained phosphates from the rocky crust of the earth.

Good soils contain say about $\frac{2}{10}$ (two-tenths) per cent. of phosphoric acid, and on analyzing rocks chemically or microscopically we find phosphates—generally calcic phosphate—present in them in similar small proportions. In some crystalline rocks we find apatite, or crystalline calcic phosphate so abundant that it can easily be recognized under the microscope. It is needless to say, however, that the percentage of phosphate present in ordinary rock masses is quite too small to suit them to be used as fertilizers for exhausted soils. We must have recourse to some richer sources of supply, and the concentration of phosphates in nature is generally found to have been brought about by organic agency. Of these concentrated deposits of phosphatic matter we may first glance at those known as Guanos. These are essentially composed of excrements of sea birds. Extensive accumulations of this character can occur only in dry climates, for though formed wherever sea birds congregate in great numbers, the rain fall is usually sufficient to remove them before they reach important dimensions. Guanos are naturally divided into two classes, though between the extremes of these there are many intermediate varieties.

These classes have been named respectively nitrogenous and phosphatic. Those of the first class occur in exceptionally dry climates, such as are found on the coast and adjacent islands of Peru, Bolivia and Chili, where rain seldom or never falls. In these the nitrogenous constituents of the organic matter—converted by decomposition into ammonia salts—remain as a part of the mass. In phosphate guanos, on the contrary, the rainfall has been sufficient to remove the whole or nearly the whole of the very soluble ammonia salts, while not enough to wash away the phosphatic material. Guanos of this class are of common occurrence in the West Indian Islands, and in some of these in which the subjacent coral rock is penetrated by caverns, only such part of the phosphatic accumulations are preserved as have been washed into these subterranean hollows through fissures, or have penetrated to them in solution through the porous coral rock.

In the Ardennes region of the south of France, phosphatic deposits occur which, in my opinion, are very similar in origin to those just alluded to. These, however, are very much older, and, in fact, include fossils of Tertiary age, and, so far as known, none of modern forms. They fill irregular cavernous fissures which traverse the surface of plateaus composed of Jurassic limestone, and it would appear that the higher parts of these plateaus have at one time formed an archipelago of bird-frequented islands in a Tertiary sea. The phosphate or phosphorite from these deposits is known commercially as

* Read before the Field Naturalists' Club, Otta

Bordeaux phosphate—from its place of shipment,—and though very irregular in its occurrence, is largely worked and exported.

Phosphatic deposits like these, however, directly referable to surface accumulations by sea-birds, are, as a rule, quite modern. With rare local exceptions, any which may have been found in the earlier geologial periods have been washed away and lost; the very process of submersion, necessary as a preliminary step to the preservation by burial in the strata, causing their dissipation. Most of the truly fossil phosphates found in connection with the older rocks have been found in a quite different manner. To understand this we may examine first such modern deposits as the "mussel muds" of Prince Edward Island. These are accumulations produced in shallow tidal estuaries where great numbers of molluscs and other marine organisms are going to decay, so rich in phosphates and organic matters as to be of great value locally as a manure. Deposits more or less closely resembling these are found in many parts of the modern sea bottom and along the coast, and where just such deposits have been buried deeply, and included in some of the older formations, they produce what are known as "coprolite beds." This term, however, it must be explained, is in general very loosely applied. It should be restricted to the fossil excrements of various animals, which are occasionally found in the rocks, and often in such beds as those just referred to, but seldom even then constitute more than a small part of the phosphatic matter, most of which usually occurs as concretions or nodules. These have resulted from that slow process of drawing together of like particles in the mass, which is usually designated concretionary action, but is not in all cases fully understood. A fragment of shell or bone, or a tooth frequently serves as the nucleus of such a concretion, and when the material is abundant such concretions frequently coalesce and form almost continuous layers. The so-called *coprolite beds* of Cambridgeshire, Bedfordshire and other localities in England, and those of Carolina, in the Southern States are of this nature.

The last-named deposit dates no farther back than the Tertiary, and consists of a layer, usually from six to fifteen inches in thickness charged with nodules of calcic phosphate and containing also bones, teeth and shells, the pores of which have been more or less completely filled with the same material. This deposit lies at no great depth below the surface, and is still nearly horizontal. In some places it is below high-water mark, and large quantities of the phosphatic nodules are obtained by dredging in some of the estuaries and channels which penetrate the low alluvial country. Where the nodule-bed occurs above the sea-level it is worked by a system of trenching, the finer material being washed away on gratings, and the nodules then dried—generally by artificial heat—before being sent to the mill.

A long way farther back in time are the "Coprolite" beds of the south of England, which date in fact from the Cretaceous period. Where this deposit occurs at an inconsiderable depth below the surface, it is worked by a system of trenching similar to that employed in Carolina, the soil being carefully put to one side and subsequently restored, and the land again brought under tillage. As the deposits are thin it does not pay to follow them to any great depth, but some years ago the annual production was as much as 25,000 tons.

These can be considered only as instances of the mode of occurrence of phosphatic materials in the geological series. Deposits more or less closely analogous, to those described and sufficiently rich to work are found in a number of other localities, which we have not now time to consider. There is reason to believe that phosphatic or "coprolitic" nodular deposits have been found wherever the local conditions were favourable and large quantities of animal matter were in process of accumulation and decay, throughout the entire geological series. Going a great way back in geological history, we find instances of this in Canada in parts of the Chazy subdivision of the Silurian, in the Graptolitic shales of the Quebec group, and even in the Cambrian rocks of St. John. It is true that none of these deposits are of importance from an economic point of view, for instances of workable deposits in these palæozoic rocks we must turn elsewhere.

They are merely mentioned here for the purpose of connecting the occurrence of naturally concentrated phosphatic materials as found in the newer rocks, with the deposits of the same material found in the oldest known rocks—those of the Laurentian period.

In the Laurentian rocks—which are those characterizing the great country to the north of the Ottawa, and elsewhere very largely developed in Canada—we have a great volume of sediments, deposited in an ocean of vast antiquity, the earliest in fact of which we find any traces. These sediments which, no doubt, originally resembled in their main features those of later ages, have since been so completely metamorphosed that their materials have entered into new combinations among themselves and become entirely crystalline. While, therefore, still consisting of the *materials* originally deposited, they resemble them as little in appearance as do the crude ingredients of glass the finished product. There can, however, be no doubt of the original sedimentary origin of these Laurentian rocks and the change from muds and sands—and I would also include contemporaneous volcanic materials—to wholly crystalline rocks such as these, is seen in less metamorphosed formations in various parts of the earth's crust, and has been traced in all its stages. If, therefore, ordinary limestones were originally present in these old rocks, we would expect them now to have assumed a wholly crystalline character, and to appear as marbles. Contained beds of a peaty or coaly nature might be expected to pass into crystalline carbon or graphite, and phosphatic nodular or coprolitic layers could appear only as crystalline calcic phosphate or apatite. As a matter of fact we find all three of these substances in the Laurentian, and though the proof may not be absolute that their origin and appearance was at first the same as that of analogous materials in the newer rocks, the evidence is all in that direction. The main facts in regard to the mode of occurrence of these deposits of apatite in Canada, so far as our knowledge goes, must be very briefly presented. Some of the beds in the Laurentian series are found to be comparatively rich in apatite, crystals and crystalline masses of this mineral being scattered through them. This is the case in some of the marbles, occasionally in the iron ores, and also particularly in connection with the pyroxenic rocks. In addition to these in which the apatite may be considered as generally distributed, certain layers, apparently of the character of beds, occur, consisting of nearly pure apatite, or containing so large a proportion of the minerals as to pay for working. Still further, we find distinct veins and fissures which have been filled with apatite by processes of segregation in which the mineral is found either nearly pure, or more frequently, mingled with crystals of other substances.

Though the exportation of these Canadian deposits may, I believe, be considered as still in its infancy, it has already assumed considerable proportions. Quoting from an interesting paper read a few days ago by Dr. Sterry Hunt, before the American Institute of Mining Engineers, we find that the amount shipped from Montreal, in 1883, was 17,840 tons (see quantities exported in 1888 as quoted in another portion of this issue), of which a portion was delivered in Hamburg and Stockholm, but the greater part went to British ports. Of this amount, 15,000 were from Quebec, the remainder from Ontario. It is estimated, according to Dr. Hunt, that the shipments during the present year will amount to 24,000 tons.

Besides the very widespread distribution of these apatite deposits and their great economic importance, one of the most striking facts so far developed is their great irregularity. Taking into consideration the extremely disturbed character of the Laurentian rocks, this is easily understood. Layers and veins which may, before the great folding and kneading together of these rocks, have possessed considerable regularity and uniformity, have been, as a consequence of the excessive disturbance folded and dislocated in every sense, leading to the production of large pockets and irregular masses of apatite which may now be connected only by narrow and twisted seams, or may occupy what appear to be completely isolated positions.

This being the case, it may be asked, can a Geological Survey do anything to aid in the discovery of apatite and the development of this mining industry? Fortunately we are not quite without a clue in the matter. It has already been discovered (largely by Mr. Vernor's work) that certain broad zones of the Laurentian series (in part already traced out and mapped), contain most of the workable deposits of apatite, while extensive intervening belts of country show comparatively little apatite and offer little encouragement to the miner. These zones are pretty clearly recognizable by their composition and character, and though much has already been done in the matter of deffning them, much more yet remains to do. They can, it would appear, be mapped down with a degree of certainty, nearly as great as regions capable of yielding good lumber, or lands suitable for farming can be defined by explorations with these particular ends in view. The further question involved in the utilization and working of special local deposits is also one requiring sagacity and special knowledge, but cannot be considered as within the province of a public survey. Like the enquiry as to how many feet of sawn lumber a given tree will afford, or how best to lay out a certain plot of a couple of hundred acres for farming purposes, this remains to be determined by the person who wishes to utilize these for his own pecuniary benefit.

Barnyard Manure.

Mr. Thomas Macfarlane, F.R.C.S., Dominion Analyst, again calls attention to the large amount of money which farmers pay for the ammonia in fertilizers, which might be saved if sufficient care was taken to preserve that contained in barnyard manure. Nearly the whole of the nitrogen in the fodder fed to farm stock is to be found in the excrements of the animals, and one-half of it is contained in the urine. It is further the fact that 95 per cent. of the potash contained in the food of oxen and sheep may be recovered by carefully saving the liquid manure only. To secure the nitrogen, or ammonia, and the potash, the means are very simple. The dung from the different animals should be brought together and kept under cover at a lower level than the stable floor, so that the liquid manure may flow upon, over and down through it. In this way all the different sorts and both parts of the manure are properly blended, the solid part and the bedding kept moist, and none of the urine escapes. It is further necessary to strew the stable floor, below and behind the animals, with 2 lbs. per 1,000 lbs. live weight, daily, of ground plaster or sulphate of lime, which has the effect of retaining the ammonia resulting from the decomposition of the liquid, and the fermentation of the solid manure. It has recently been proposed to obtain these results by the use of superphosphates in place of ground plaster, and experiments by Heiden, Dietzell and others in that direction have been entirely successful. Deitzell mentions that $1\frac{1}{4}$ lbs. of phosphoric acid only are required for the treatment of 1,000 lbs. of stable manure. The use of "plain superphosphate" in this way must result in the production of a manure of every excellent quality.

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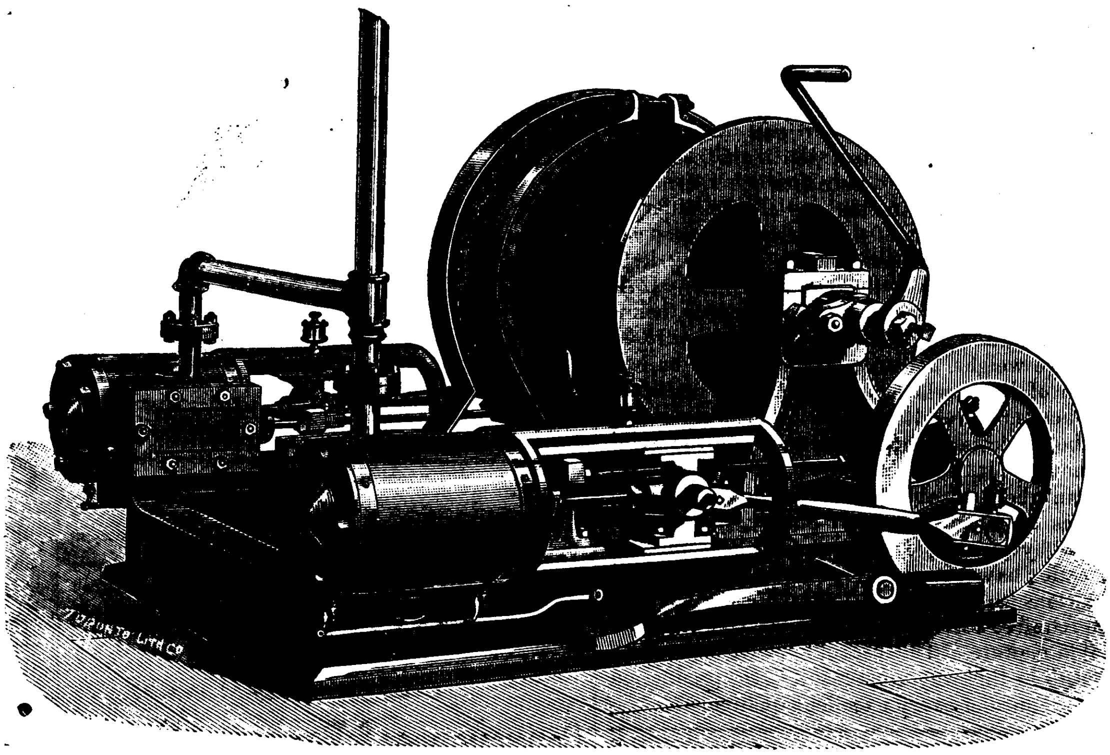

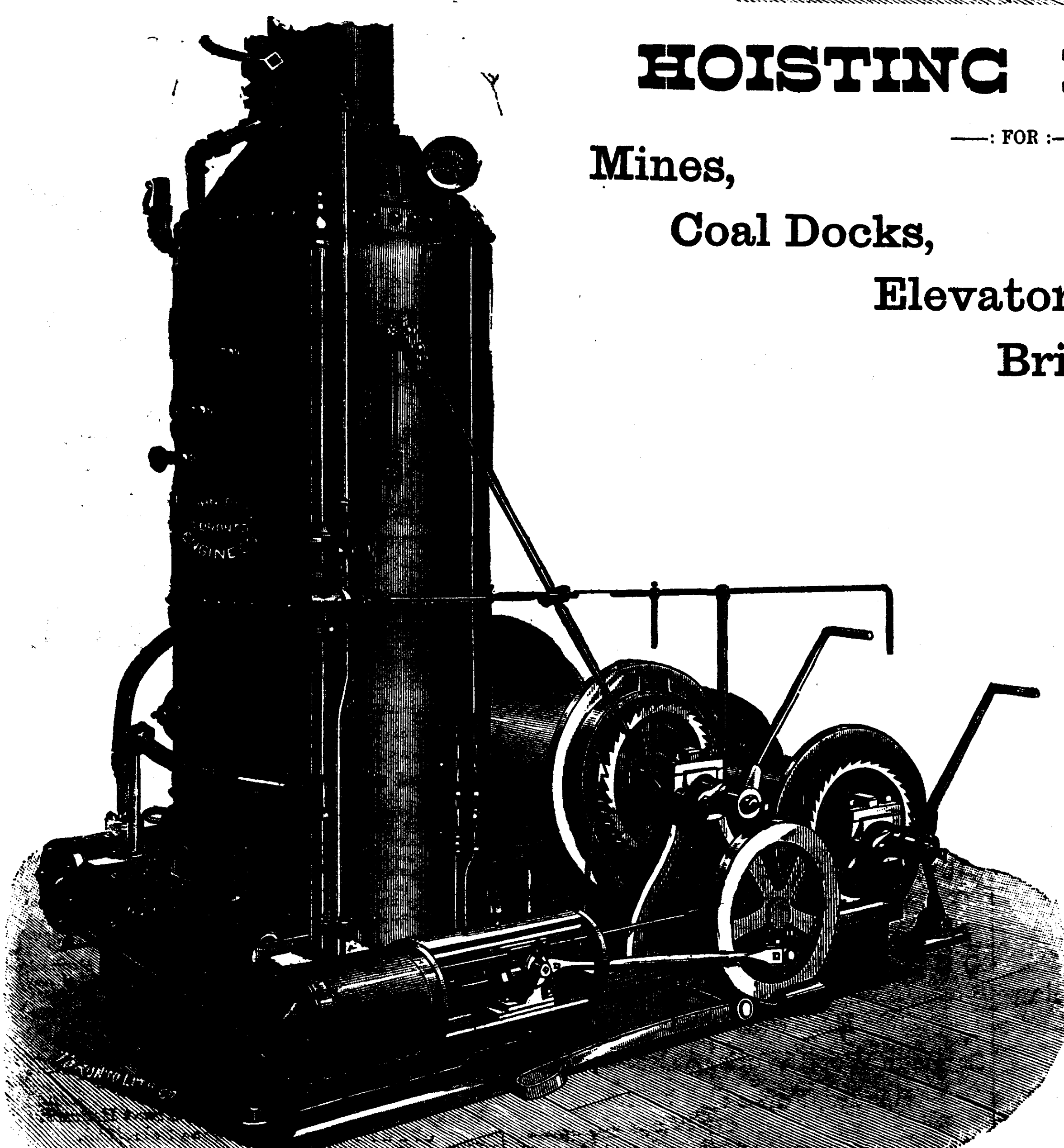

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Mining Regulations

TO GOVERN THE DISPOSAL OF

Mineral Lands other than Coal Lands, 1886.

THESE REGULATIONS shall be applicable to all Dominion Lands containing gold, silver cinnabar, lead, tin, copper, petroleum, iron or other mineral deposits of economic value, with the exception of coal.

Any person may explore vacant Dominion Lands not appropriated or reserved by Government for other purposes, and may search therein, either by surface or subterranean prospecting for mineral deposits, with a view to obtaining under the Regulations a mining location for the same but no mining location or mining claim shall be granted until the discovery of the vein, lode or deposit of mineral or metal within the limits of the location or claim.

QUARTZ MINING

A location for mining, except for iron on veins, lodes or ledges of quartz or other rock in place, shall not exceed forty acres in area. Its length shall not be more than three times its breadth and its surface boundary shall be four straight lines, the opposite sides of which shall be parallel, except where prior locations would prevent, in which case it may be of such a shape as may be approved of by the Superintendent of Mining.

Any person having discovered a mineral deposit may obtain a mining location therefor, in the manner set forth in the Regulations which provides for the character of the survey and the marks necessary to designate the location on the ground.

When the location has been marked conformably to the requirements of the Regulations, the claimant shall within sixty days thereafter, file with the local agent in the Dominion Land Office for the district in which the location is situated, a declaration or oath setting forth the circumstances of his discovery, and describing, as nearly as may be, the locality and dimensions of the claim marked out by him as aforesaid; and shall, along with such declaration, pay to the said agent an entry fee of FIVE DOLLARS. The agent's receipt for such fee will be the claimant's authority to enter into possession of the location applied for.

At any time before the expiration of FIVE years from the date of his obtaining the agent's receipt it shall be open to the claimant to purchase the location on filing with the local agent proof that he has expended not less than FIVE HUNDRED DOLLARS in actual mining operations on the same; but the claimant is required, before the expiration of each of the five years, to prove that he has performed not less than ONE HUNDRED DOLLARS' worth of labor during the year in the actual development of his claim, and at the same time obtain a renewal of his location receipt, for which he is required to pay a fee of FIVE DOLLARS.

The price to be paid for a mining location shall be at the rate of FIVE DOLLARS PER ACRE, cash, and the sum of FIFTY DOLLARS extra for the survey of the same.

No more than one mining location shall be granted to any individual claimant upon the same lode or vein.

IRON.

The Minister of the Interior may grant a location for the mining of iron, not exceeding 160 acres in area, which shall be bounded by north and south and east and west lines astronomically, and its breadth shall equal it length. Provided that should any person making an application purporting to be for the purpose of mining iron thus obtain, whether in good faith or fraudulently, possession of a valuable mineral deposit other than iron, his right in such deposit shall be restricted to the area prescribed by the Regulations for other minerals, and the rest of the location shall revert to the Crown for such disposition as the Minister may direct.

The regulations also provide for the manner in which land may by acquired for milling purposes, reduction works or other works incidental to mining operations.

Locations taken up prior to this date may, until the 1st of August, 1886, be re-marked and re-entered in conformity with the Regulations without payment of new fees in cases where no existing interests would thereby be prejudicially affected.

PLACER MINING.

The Regulations laid down in respect to quartz mining shall be applicable to placer mining as far as they relate to entries, entry fees, assignments, marking of localities, agents' receipts, and generally where they can be applied.

The nature and size of placer mining claims are provided for in the Regulations including bar, dry bench, creek or hill diggings, and the RIGHTS AND DUTIES OF MINERS are fully set forth.

The Regulations apply also to

BED-ROCK FLUMES, DRAINAGE OF MINES AND DITCHES.

The GENERAL PROVISIONS of the Regulations include the interpretation of expressions used therein; how disputes shall be heard and adjudicated upon; under what circumstances miners shall be entitled to absent themselves from their locations or diggings, etc., etc.

THE SCHEDULE OF MINING REGULATIONS

Contains the *forms* to be observed in the drawing up of all documents such as:—"Application and affidavit of discoverer of quartz mine." "Receipt for fee paid by applicant for mining location." "Receipt for fee on extension of time for purchase of a mining location." "Patent of a mining location." "Certificate of the assignment of a mining location." "Application for grant for placer mining and affidavit of applicant." "Grant for placer mining." "Certificate of the assignment of a placer mining claim." "Grant to a bed rock flume company." "Grant for drainage." "Grant of right to divert water and construct ditches."

Since the publication, in 1884, of the Mining Regulations to govern the disposal of Dominian Mineral Lands the same have been carefully and thoroughly revised with a view to ensure ample protection to the public interests, and at the same time to encourage the prospector and miner in order that the mineral resources may be made valuable by development.

COPIES OF THE REGULATIONS MAY BE OBTAINED UPON APPLICATION TO THE DEPARTMENT OF THE INTERIOR.

A. M. BURGESS,

Deputy Minister of the Interior.