PEAT AND ITS PRODUCTS

W. A. KERR V.C.

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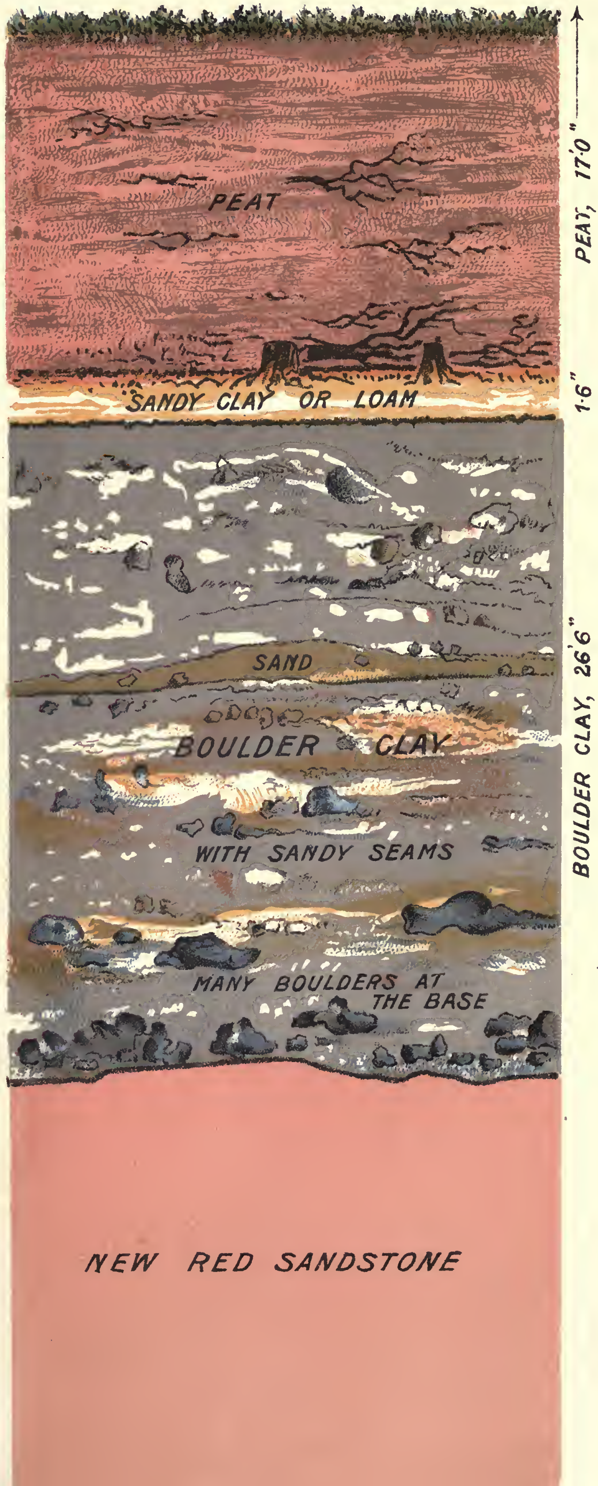
PEAT AND ITS PRODUCTS

SECTION OF CHAT MOSS, NEAR ASTLEY STATION.



The Peat was 17-0 thick, but it shrunk to 9 feet.

At the base of the Peat there was much timber—Oak Trees, Alder, Hazel, and Birch—and many Hazel Nuts. The roots were in the 1-6 Loam, above the Boulder Clay.

An area of about 25 yards square had been excavated by H M. Ormerod, Esq., the agent for Col. Ross. Marl and Clay was removed from the base and placed on the surface of the Moss, thus forming good land. About 200 cubic feet of timber was found in this excavation, showing that a forest grew there before the moss.

The floor is of soft red Rock.

This section is copied from my Note Book of 1866, and was the subject of a note published in the Proceedings of the Manchester Literary and Philosophical Society of that year.

W. BROCKBANK.

PEAT

AND ITS PRODUCTS

AN ILLUSTRATED TREATISE ON
PEAT AND ITS PRODUCTS AS A NATIONAL
SOURCE OF WEALTH

BY

W. A. KERR, V.C.

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PREFACE.

"THE SOMBRE GENIUS OF THE MOOR."

The aim of this work is to direct general attention to the economy of Peat as a substitute of coal and for the development of its numerous bye-products. The subject, now that the Irish land difficulties have been relieved by legislation, and that we have lately had bitter experience of a coal famine, is ripe for serious discussion and practical consideration.

In directing the attention of the community at large to the various uses and products of this source of wealth lying at our doors, together with the methods of preparation and manufacture, care has been taken to quote every reliable authority to whom we have had access. Hitherto, save in the cot of the crofter or in the cabin of the "rug-headed kern," Peat has been little known as a fuel in these Islands, though its value on the Continent has long been appreciated and its production fostered by various States. Abroad, throughout the German Empire, in many parts of France, in Austria, Russia, Holland, and throughout the length and breadth of Scandinavia, it is regarded as one of the most precious national assets, adding materially to the general national resources in its application to manufactures generally and to domestic uses.

In July, 1892, the Premier, the late Lord Salisbury, addressed a circular to Her Majesty's Representatives at the Hague, St. Petersburg, Stockholm, Copenhagen, Berlin, and Paris requesting them to obtain information with regard to the manufacture of fuel, moss-litter, and other products of Peat. This information, in due course, was published in a Blue Book, Commercial No. 2, of 1893. Since then, so far as official action in the important subject is concerned, the matter lay fallow till interest in its possibilities was revived by exhibits at the Cork International Exhibition, in 1902; and by a paper read by a gentleman from Schleswig-Holstein — Mr. Tissington Tatlow — before the Industrial Conference held in connection with that admirable and instructive Exhibition. Here Peat, it may be said, has hitherto been unaccountably neglected, though from time to time spasmodic misdirected efforts have been made to give it a commercial value. And yet, Peat covers about 2,831,000 acres, one seventh of Ireland's surface, calculated to contain 33,972,000,000 tons of fuel valued at £850,000,000, an enormous national treasure only requiring working, with an extended means of transit, to prove a gold mine of fabulous capacity. Scotland too, from the far North down to the Borders, possesses vast treasures of Peat, the deposits of Western Isles, being especially valuable for their bye-products; and in England and Wales it is found in large quantities, making a grand total approaching to 6,000,000 acres. The levels known as Marshland (Yorkshire), the Isle of Axholme, and the rich land stretching away from the Thorne and Hatfield moors down through Lincolnshire and Cambridgeshire, were originally peat bogs, and are unsurpassed for fertility. At one time the Marshland properties changed hands at £200 an acre, and commanded a rental of four guineas. In Dumfriesshire, on the extensive Lochar bog at Racks, the Scottish Peat Industries, Limited, under the able superintendence of Mr. A. B. Lennox, have established an extensive and rapidly extending factory, which, with the vast amount and excellence of raw material, and the facilities of getting the manufactured fuel and other various bye-products, etc., on to the rail and to a port, promises to prove a source of profit to its shareholders, and a reliable and interesting object lesson of strenuous labour and intelligent enterprise.

Dr. Johnson, Professor of Botany at the Royal College of

Science, Dublin, who has devoted much attention to Peat, observes in a paper, published in 1899, "while the average thickness of turf in Europe varies from 9 to 20 feet, Ireland has bogs as much as 40 feet." Another authority, Lieutenant-General Sir R. H. Sankey, K.C.B., Royal Engineers, late Chairman of Public Works, Ireland, in an article in the *Nineteenth Century*, entitled "A future for Irish Bogs," says—"We could thus count on having a heating power in the bogs for steam raising, to give us a constant output of 300,000 horse power for 412 consecutive years." This writer advocates the utilization of this vast amount of carbon which nature has stored up in the Irish turbaries for the generation, *in situ*, of electric energy, which, through the application of modern scientific principles, can be transmitted and made available at an extremely low price in all parts of the country, and anticipates the feasibility of generating a horse power per hour for one farthing, which would allow of a unit being sold to customers at the surprising low price of a penny or a little over. "Generating Stations," he adds, "permanent or semi-permanent, may be set up at any place where the conditions prove to be most convenient." It is true that, to some extent, we have wrested the Moss-litter industry from the Dutch and Germans, but this, to a very limited extent, touches only the surface of the deposits, viz., the light fibrous Peat, and does not utilize the dense black material which it covers. On the Continent, where all the Northern countries, and some of the Southern—Austria-Hungary and Italy—are interested in the development of their peat-moors and bogs, there are journals devoted exclusively to this interest. Mr. Tatlow, who has personally visited most of the moors and centres of manufacture, and who is thoroughly versed in the present position of the industry on the Continent, states that a band of scientific and practical men works incessantly on the question of the utilization of the bogs; that there are several experimental stations, the results of the operations of which are duly published for general information; and that country societies are in existence whose duty it is to keep themselves *en rap-*

port with kindred institutions, at home and abroad, so that, through these widely circulating mediums, the proprietor of a small turf factory in Bohemia is kept posted up in what is going on in far-distant Sweden. Courses are held for instruction, the Governments afford State aid, there are public subscriptions devoted to the advancement of the utilization of Peat, and the experiments and observations of specialists become public property. A grant in aid of £3500 a year is made by the Swedish Government, and there are three thousand members of a Society, established for the development of the various peat industries, who contribute a small sum each per annum. What in this direction do we? Nil![1] Beyond an occasional article in a magazine, a short paragraph in some journal, or an advertisement concerning Peat-moss litter, of Peat we hear and see nothing, and most of our people are utterly ignorant of its value. Well may it be said, that "one is amazed and dejected to think what they (the Dutch) have done, and what Ireland has left undone in the utilization of her bogs." And in considering the question of this, one of the many melancholy instances of Ireland's neglected opportunities, the neglect becomes accentuated, for the climatic conditions are alike and both countries lack a supply of soft coal. It is the duty of the lately constituted Department of Agriculture for Ireland, charged with the resuscitation and promotion of industry and technical instruction, to second the efforts of capitalists and others who, on business or philanthropic lines, may venture to follow the Continental examples, and thus help the people along this industrial road—a road which we confidently believe leads to great wealth. At present, so far as the peat industry as a National source of wealth is concerned, it apparently is discouraging the

[1] NOTE.—The Department of Agriculture and Technical Instruction for Ireland has lately commenced some limited experiments in the Co. Cavan to test the adaptability of machinery to "turf" manufacture. The plant is confined to cutting and lifting the peat from the bog, and to masticating and shaping machines. This is merely playing with the industry, and is unworthy of a Government Department whose bounden duty is to foster this industry by every means in its power.

introduction of capital. Ireland's economic life will do more towards peace, contentment, and plenty, than all the parliamentary sops the long-suffering "predominant partner" may be coaxed or browbeaten into offering her. Political considerations and the dignity of productive labour apart, the capitalist, from a financial point of view, will in this industry find a certain and handsome return on his vested capital. It gives promise of success rarely offered or realised in so early a stage of any legitimate enterprise. The Shares of Richardson's Moss-Litter Company Limited are quoted at 300 per cent. premium. Another Anglo-Dutch Moss Litter Company, weighed down by a huge capital, earns 10 per cent. dividends, and its off-shoot, a mere distributory concern, gives equally good returns.

Life in Northern latitudes implies the free use of fuel. We, as a nation, are in abject dependence on coal-owners, the miners, and the coal factors, for the right to live. As we write we read of closed factories, dislocation of railway traffic, and locomotives stand idle, owing to the great Westphalian coal-strike. The old adage of the advantage of having several strings to one's bow is surely applicable to this all-important question of fuel. If still another material, comparable in efficiency and in price to coal, can be brought into commercial competition with it, the situation must be decidedly improved. If, too, the winning and preparation of such a practically illimitable natural product would create an entirely new field of home industry of the first magnitude, employing capital and labour on a very extensive scale, utilizing resources now almost, in these British Isles, entirely dormant, there would be every reason, from the public and private point of view, for welcoming the introduction of a new fuel such as we find in peat, whether in the form of gas or as machined or briquetted blocks of varied shape, size and weight.

Second only to its varied applications as a heat producer is the use of Peat as a fertilizer. Apart from the well-established value of its ashes and "mull," its antiseptic, deodorant qualities and powers of absorption and retention, suggest its employment in the manufacture of various artificial manures, useful alike in agriculture and horticulture. It overcomes the hitherto insurmountable difficulty of disposing of night-soil, and of the malodorous wastes of breweries, distilleries, tan-yards, dye and chemical works, and slaughter-houses, giving their residuals a commercial value, relieving the owners of these often poisonous effluents of much anxiety, obviating the pollution of rivers and streams, and placing at the disposal of the farmer, the market gardener, and the horticulturist, a wide range of powerful, cleanly, plant food, which can be manufactured and placed on the market at a low yet remunerative rate.

That there have been failures in the past cannot be denied. But these are easily explained away. The promoters of the various schemes possessed no technical knowledge of the peculiar nature of the material they proposed to handle, and were consequently groping in the dark. Peat is a curious substance, possessing peculiarities of structure and ingredients differing widely from any other natural product. Though allied to coal, lignite, petroleum, and wood, it differs from all its relatives, having the characteristics of india-rubber or gutta-percha, being, till disintegrated, remarkably retentive of air and water, and refusing, till treated in a peculiar manner, to be converted into a homogeneous solid. The common aim of the numerous processes, machines, and devices was compression, without any consideration for the peculiarities and chemistry of the raw material. In some cases, notably that of the Irish Peat Company established at Athy, Co. Kildare, in 1854, over-capitalization coupled with an enormous outlay for buildings and plant, and a bad selection of locality and material, brought the fabric to the ground. The inefficient machinery and buildings cost £60,000, whereas to-day a well-equipped distillation factory, capable of treating an equal amount of Peat and of obtaining the best results, need not cost more than £6000.

If one or more of the multi-millionaires who so generously lavish their vast piles of dollars on libraries, often donating large sums where these institutions are neither wanted nor acceptable, could be prevailed upon to divert the golden stream towards the establishment of technical instruction, they would for ever settle the Irish Land question, relegate the venomous agitator to the limbo of the past and forgotten, and a happy and prosperous Ireland would for all time applaud their philanthropic wisdom and statesmanship. Irish Land will then become a marketable commodity, agrarian outrage will no longer sully the good name of the peasantry, and the sister isle will be rescued from financial chaos. What she wants are industrial schools, workshops for the training of handicrafts, scientific laboratories, technological collections, co-operation and capital. To this end the State might, nay should, contribute a handsome yearly dole. What, during the last two or three decades, has been effected in Austria and Hungary, in relation to small rural and urban industries and trades, can surely be put into practice in Ireland. The country is "waking up" is the assurance of every Celt, and will cheerfully respond to any efforts to aid her in seizing the present opportunity. Lord Iveagh, Mr. W. J. Pirrie, and other patriots, are bent on developing her commerce by means of much needed facilities for transport; and Mr. George Wyndham is determined to fill her fields with lusty labourers. The nation is starting on a path of material progress. An industrial revival is on foot. One seventh of the whole Island is under Peat, and Peat properly handled is gold.

The reader's particular attention is drawn to the valuable paper on *The Utilization of the Peat Bogs of Ireland for the Generation and distribution of Electrical Energy*, by Lieutenant-General Sir R. H. Sankey, K.C.B., R.E. (retired), read before the Industrial Conference at the Cork International Exhibition, 1902. Further, we desire to draw attention as an object-lesson to the economic conditions now rapidly growing up in Austria-Hungary, set forth in an equally valuable paper read on the same occasion by Dr. William Exner, K.K., Sections-chef, Technologisches Gewarbe Museum, Vienna, on *State Aid to Industries (including "Gewerbe" Museums and Cottage Industries)*. Dr. Paul

Dvorkovitz's paper is a learned technical contribution to the geology, botany, and chemistry of Peat, and also to the possibilities of turning it to profitable account by a new, continuous, and economical system of low distillation. Coming from the President of the Petroleum Institute, one who has had long and varied experience of fuel in whatever shape, and who brings to the investigation a profound practical chemical knowledge, these researches are of special value. No apology is needed for the reproduction of this trio of admirable contributions. A careful perusal of all the papers read before the Industrial Conference at Cork, and published by the *Department of Agriculture and Technical Instruction for Ireland*, is recommended.

We are much indebted to Mr. T. H. Leavitt, of Boston, U.S.A., for his interesting compilation *Facts about Peat*, from which we have quoted freely. Our aim is to briefly give such facts in regard to Peat as have come under our observation, or which we have been able to collect from a variety of sources, with a view to interesting the community in the development and various resources of an invaluable though homely substance, which stupid prejudice alone prevents from coming into general use. Ordinary skill and enterprise, backed by moderate capital, will suffice to demonstrate the little dreamt of value of our Peat bogs.

Apart from Peat *per se* and its numerous applications, the value of reclaimed Peat bog, and the successful results attending judiciously conducted operations in that direction by Urban Councils, has been fully demonstrated by the enterprising Corporation of Manchester on Chat Moss, which from an unproductive waste has been converted into a fruitful agricultural, horticultural, and market garden area, yielding a considerable revenue to the municipal coffers. "*One of the most important facts obtained is that by using peat instead of coal there is a great saving, and this may very likely assist in pushing a new Danish industry, i.e. the working of peat moors for obtaining cheap fuel, and consequently converting moorlands into good, sound, productive land*" *(Consular Report,* 1902*)*.

If with no other object than to combat the evils of smoke pollution, the adoption of peat fuel, or peat in combination with anthracite coal, should be general in our cities and towns.

It is declared by the Coal Smoke Abatement Society that the Bell Harry Tower of Canterbury Cathedral is suffering badly from surface decay owing to the action in the atmosphere of the products of imperfect combustion of coal. If this is the case at Canterbury, what is the condition of Westminster Abbey, St. Paul's Cathedral, and other historic buildings in the Metropolis? Very much worse, according to experts. Tons of Epsom salts, Professor Church says, might be taken off Westminster Abbey. Describing the effects of the coal smoke, another authority said: "Each atom of soot is a sponge absorbing and holding the acid gases, and transferring them liquefied to the surface of stone or brick. But sulphuric acid is the active agent. This acting on the magnesian limestone much used in the Houses of Parliament, for instance, forms sulphate of lime and sulphate of magnesia, or in other words Epsom salts. If there was no soot the acid gases freed on the combustion of coal would be carried away by the wind." The Hon. Rollo Russell estimates the loss to the Metropolis by the coal smoke nuisance at £5,000,000 a year. In this estimate he takes into consideration the decay which is produced in buildings, the extra cleaning involved by the soot deposits, the depreciation of fabrics and treasures of arts, and the depreciation of shopkeepers' stocks.

By those who are trying to get a cleaner London the contention is made that the constant repairing which is always going on at St. Paul's Cathedral, Westminster Abbey, and other large buildings is due for the most part to the action of the smoke.

The secretary of the Coal Smoke Abatement Society states that while a great deal has been effected in the matter of preventing the emission of smoke from factories, little can be done effectually to purge the Metropolis from smoke evils until the ordinary household grates and kitchen chimneys are constructed with a view to fuel economy and smoke abatement. The results of exhaustive tests made by the society have proved that smoke pollution from domestic fires can be reduced to a minimum if proper grates and other appliances be adopted.

When the King, standing in St. Patrick's Hall, crowded with the representatives of all the learned, scientific, philanthropic, and other bodies of Ireland, in reply to numerous loyal deputations uttered these words: "*I rejoice to hear of a newly-awakened spirit of hope and enterprise among my Irish people which is full of promise for the future. It will be a source of profound happiness to me if my reign should be co-incident with a new era of social peace and of industrial and commercial progress in every part of Ireland,*" His Majesty voiced the fervent hope of every one of his subjects. To her bounteous but now seriously exhausted coal measures Great Britain owes much of her wealth and position, and though Ireland can boast of no such mineral wealth she, in her vast acres of excellent Peat, possesses a fuel supply which it has been calculated will, if worked on a sound business basis, meet all her wants as to power, illumination, and heating for centuries.

The peat question has been fully and satisfactorily solved in the Netherlands, and also to a large extent in Russia, Germany, Scandinavia, and in Canada. Holland, always the pioneer of this industry, has turned her bogs to good account, deriving from them a cheap fuel for her own consumption, and providing Great Britain and France, as well as the United States, with a never-ceasing and always increasing supply of moss-litter. "When these sources of profit are exhausted she turns her cut-away bogs, owing to the careful systems of cutting and draining observed, into smiling corn-fields and vegetable gardens, or plants them with trees" *(Journal of the Department of Agriculture and Technical Instruction, Ireland).*

W. A. K.

THE LOCHAR MOSS.

CHAPTER I.

WHAT IS PEAT?

PEAT is a spongy vegetable substance, composed generally of mosses and aquatic plants in different stages of decomposition. More than one genus is present, the varieties differing with the zone in which it is found, that called Sphagnum being most common in European bogs. The vegetation in these bogs consists mainly, together with various grasses and heather, of Eriophorum, Calluna vulgaris, Erica tetralix, Andomeda, Ledum, Empetrum, Vaccinium, and the moss Sphagnum cymbifolium. All these plants help in forming peat, but in European bogs Sphagnum palustre largely prevails. Fallen and decayed timber, ferns, bracken, rushes, reeds, and other plants, of a bygone age, are also found together, proving the antiquity, in some instances, of these morasses. The decomposed remains of these plants, acted upon by the atmosphere, form a dark, friable soil overlying a layer of different depths, of a light vandyke warm-tinted bright yellow, dirty white, but never black fibrous material known as "red" peat, this again being succeeded by a strata, also of varying thickness, of dark-coloured, decomposed material overlying the bottom or hardly-compressed "stone peat," which, when cut, shows few traces of fibrous matter, is dense and fine in the grain, of a cheesy substance, and of a dark sepia hue. In the "older peat" no living animal exists. It is in the progressive stage from a vegetable substance to a mineral coal. Whole forests of oak, fir, ash, birch, yew, willow, etc., have been overwhelmed by the steady, resistless growth of these aquatic plants, and are found in all positions at the bottom, or in the middle of the bogs. Much of the value of peat, as a fuel, depends upon the amount of turpentine it contains, and wherever remains of resinous trees, such as pine, abound the fuel is "fatter," because the resin is converted into wood tar. We find this in some parts of Scotland, where the fir-wood from the bogs was used by the country folk for candles; also in the case of the so-called "tallow-peat" in the neighbourhood of Lough Neagh in the north of Ireland, where the Pinis Sylvestris largely predominates. The peat on the famous and broad moor of Rannoch, the great flat morass, "open, silent, and solitary," occupying the table-land of Scotland, twenty square miles in extent, resting on granite, is especially bituminous. This great level, intersected by the brawling perennial Gauer Water, holds sufficient "creashy" peat, charged with resin and oils, to generate electric producer, and illuminating and heating gas to meet the wants of many industries for a long term of years. In this dreary waste we find, submerged, the roots and stumps of giant firs in a perfect state of preservation. It is not so very many years since these roots were the favourite means of illumination in the sheilings of this part of the Highlands. In a record of the district we find it stated that these roots were at one time the sole source of artificial light obtainable. We know of an old shepherd and his wife who used to live in a hut towards Kingshouse, on the western verge of Rannoch Moor, who unwillingly abandoned the use of this primitive lamp, in *favour of paraffin, only about five years ago.* When he had gathered his flock into the fold, the shepherd would return to his low thatch-covered sheiling with an armful of the roots, to be dried before the great peat fire for a night. In the morning he would break them into small pieces, about the size of a finger, and in the dark winter evenings it was the duty of the old man to keep one of the little torches flaring while his aged wife sat spinning at her wheel in the "ingle-neuk." The method of burning the roots was curious. From the crook in the chimney hung an iron instrument, like the "girdle" on which oat-cakes are baked, but instead of presenting to the fire a flat surface, the "girdle" was ribbed with bars like a gridiron. One of the small pieces of resinous fir-root was placed on these bars and blazed up in the heat of the fire, illuminating the whole hut, and as soon as the flare began to die out the old shepherd would put on another, the whirr of the spinning-wheel never ceasing. Such a spectacle as this was to be seen until quite recently in hundreds of sheilings around the moor. The West Highland Railway virtually floats over this moor, which is 1000 feet above sea level. It is built upon fascines of brushwood, laid in thick layers across trenches, and this elastic formation, preserved by the bituminous peat, never decays. On the moor of Caithness similar conditions obtained. In these peats the acidity is peculiarly strong, and much of the bottom peat is akin to the solid, tenacious, and heavy "*baken peat*," which is known in Ireland as "*mud turf*," is the "*mire-black*" of Loch Neagh, the "*Ince peat*" of Lancashire, the "*greasy clods*" of Aberdeenshire, "*la houile de Kilkenny*" of Brochant, the "*Bears' Grease*" of the Lincolnshire fens, and which is also found in great quantities in the Western Isles, and is closely allied to surturbrandt or Bovey coal, or what Waller terms "*vegetabile fossile bituminosum.*" Bearing upon the proposed rehabilitation of Ireland with woods of commercial value, it is worthy of note that in the bogs resinous or coniferous trees are generally found with six or seven feet of compact peat under their roots, whereas the stumps of oak are usually resting on the clay sub-soil. Commonly these remains are found standing as they grew in an erect position (see sketches in Dvorkovitz's paper) furnished with all their roots. From this it appears that the conifers grew in successive layers or tiers upon ancient surface peat, which, as it died down and decomposed, became submerged in the surrounding swamp and that the hard woods grew on the original bottom of the bogs. It should be noted also that fir trees preponderate where sand sub-soil prevails, the oak taking the place of the resinous timber where clay forms the pan. Professor Lyall in his *Principles of Geology* says: "It is a curious and well ascertained fact that many of the mosses (bogs) of the North of Europe occupy the places of immense forests of pine and oak, which have, many of them, disappeared within the historical era. Such changes are brought about by the fall of the trees, and the stagnation of the water caused by their trunks and branches obstructing the free drainage of the atmospheric waters, thus giving rise to a marsh. In a warm climate such decayed timber could immediately be removed by insects or by putrefaction, but in the cold temperature now prevailing in our latitudes many examples are recorded of marshes originating in this source. Thus, in Mar Forest in Aberdeenshire, large trunks of Scotch fir, which had fallen from age and decay, were soon immured in peat partly formed out of the perishing leaves and branches and in part from the growth of other plants." We learn also that the overthrow of a forest by a storm about the middle of the seventeenth century gave rise to a peat moss near Loch Broom, in Ross-shire, N.B., whence, in less than half-a-century from the fall of the trees, the inhabitants dug peat. Dr Walker mentions a similar change when in the year 1756 the whole wood of Drumlanrig was overset by the wind. Such events explain the occurrence, both in Britain and on the Continent, of mosses, where trees are all broken within two or three feet of the original surface, and where their trunks all lie in the same direction. Nothing is more common than the occurrence of buried trees at the bottom of Irish peat-mosses, as also in most of those in England, France, and Holland and Scandinavia; and they have been so often observed with part of their trunks standing erect, and with their roots fixed to the sub-soil, that no doubt can be entertained of their having grown on the spot. They consist for the most part of the fir, the oak, and the birch. Where the subsoil is clay their remains are most abundant; where sand is the substratum fir prevails. In the marsh of Curragh, Isle of Man, vast trees are discovered standing firm on their roots at the depth of eighteen or twenty feet below the surface. The leaves and fruit of each species are frequently found immersed along with the parent trees, as, for example, the leaves and acorns of the oak, the cones and leaves of the fir, and the nuts of the hazel. The durability of pine wood, which in the Scotch peat-mosses exceeds that of the birch and oak, is due to the great quantity of turpentine it contains, and which is so abundant that the fir wood from the bogs was used by the country people, in parts of Scotland, in place of candles. Such resinous plants, observes Dr. MacCulloch, as fir would produce a fatter coal than oak, because the resin itself is converted into bitumen. In Hatfield moss, near Doncaster, stems of pine have been found ninety feet long, and sold for masts and keels of ships; oaks also have been discovered there above a hundred feet in length. The dimensions of an oak from this moss are given in the *Philosophical Transactions*, No. 275, which must have been larger than any tree now existing in the British dominions. In this same moss at Hatfield, as well as in that of Kincardine and several others, Roman roads have been found covered to a depth of eight feet by peat. All the coins, axes, arms, and utensils found in the British and French mosses are also Roman, so that a considerable portion of the European peat-bogs are evidently more ancient than the age of Julius Cæsar; nor can any vestiges of the ancient forests described by that General, belonging to the time of the great Roman way in Britain, be discovered except in the ruined trunks of trees in peat. De Luc ascertained that the sites of the aboriginal forests of Hiricinia, Semona, Ardennes, and several others, are now occupied by mosses and fens; and that a great part of these changes have, with much probability, been attributed to the strict orders given by Severus and other Emperors to destroy all the woods in the conquered provinces. Several of the British forests, which are now mosses, were felled at different periods by order of the English Parliament because they harboured wolves or outlaws. Thus the Welsh woods were cut and burned in the reign of Edward I., as were those of Ireland by Henry II., to prevent the natives from harbouring in them and harassing the English troops. It is curious to reflect that considerable tracts have, by these accidents, been permanently sterilised, and that during a period when civilisation was making great progress, large areas of Europe had, by human agency, been rendered less capable of administering to the wants of man. Dr. Rennie observes with truth that in those regions alone which the Roman eagle never reached, in the remote circles of the German Empire, in Poland and Prussia, and still more in Norway, Sweden, and the vast empire of Russia, can we see what Europe was before it yielded to the power of Rome. Desolation now reigns where stately forests of pine and oak once flourished, such as might now have supplied the demand of the world with timber. At the bottom of the peat mosses is sometimes found a cake or "pan," as it is termed, of oxide of iron; and the value of bog ore is familiar to the mineralogist and the gas manufacturer. The oak, which is so often found dyed black in peat, owes its colour to this metal. From what source the iron is derived is by no means obvious, since we cannot in all cases suppose that it has been precipitated from the waters of mineral springs. According to Fourcroy there is iron in all compact wood, and it is the cause of one-twelfth part of the weight of oak. The heaths (Ericæ) which flourish on sandy ferruginous soil are said to contain more iron than any other vegetable. It has been suggested that iron, being soluble in acids, may be diffused through the whole mass of vegetables when they decay in a bog, and may by its superior gravity sink to the bottom, and be there precipitated so as to form bog-iron-ore; or, where there is a sub-soil of sand or gravel, it may cement these into ironstone or ferruginous conglomerate."

Sir A. Geikie, in his well-known work, *Text-Book of Geology,* mentions that in 1657 an ancient pine forest, its trees being all dead and tottering to their fall, occupied a level tract of land among the Ross-shire hills. About fifteen years later every vestige of a tree had disappeared, the site being occupied by a spongy green bog into which a man could sink up to his arm-pits. By the end of the century it had become firm enough to yield peat fuel.

Peat is not peculiar to any age or, indeed, though constantly stated to be confined to the arctic and sub-arctic temperate zones, is it restricted to any climate. Savants may term the vegetable deposits of Brazil, California, and Australia; the "sudd" or "sood" swamps of the Bahr-al-Ghazal where the papyrus, the um-soof-reed, and the ambatch take the place of our water plants, ferns, and sphagnum mosses; the black mud found in the jheels or swamps of Pertabghur in Oude, which the natives trace to enormous sacrifices by godly generations of the gentle Hindoo in bygone times of ghee and grain burnt to the gods *in situ*; or the dense black vegetable fat-land bordering the rivers of the Malay Peninsula "bastard peat"; but to all intents and purposes these beds are Peat in every sense of the word. Call them Cespites, Turba, Turbae, plain Turf, Tula, or what you will, the compound still is Peat. No mosses, it is true, are found bordering on or within the tropics, where vegetable matter is more rapidly decomposed, but nature provides substitutes. Tropical ferns and plants are found in the coal measures. An ostrich egg was found buried in thirty feet of Peat in Orange County, United States of America; also the bones and teeth of the hippopotamus, mastodon, rhinoceros, elephant, tiger, hyæna, and of other quadrupeds peculiar to the tropics, have been discovered in various peat bogs, proving that part of these "older peats" were formed when the temperate zone possessed a tropical climate. That tropical peats do not contain the same thermal properties as those of colder climes may be admitted, but judging from the products of distillation from peat obtained at Maranu, in Brazil, the components of peat wherever grown or formed appear to be the same. The "black swamp mud" of Pertabghur was tested by the locomotive superintendent of the railway at Cawnpore, who reported that "it would do very well for locomotives and could be supplied at six annas the maund." In the extensive peat bogs of America the sedges, grasses, and mosses are identical with those found in European peat bogs, viz., seventy species of mosses, five or six species of lycopodiaceæ, and as many ferns, eighteen or twenty species of palm trees, reeds, and phanerogamous monocotyledonous plants. Only one species is peculiar to America. The trees, however, differ. In the "Dismal Swamp" of Virginia, a tract of about fifteen thousand acres, are found juniper, cyprus, gum, poplar, lofty white cedars, and other valuable woods. The magnolia grows with a luxuriance unknown in these climes, some of the buried trunks measuring more than one hundred feet without any marked diminution of diameter. A French writer, quoted by Leavitt in support of the theory that lignite is only peat in an intermediary stage before becoming coal, instances the case of a deposit of lignite near Leipzic formed of large trunks heaped one on the other, about fourteen feet thick. This matter is entirely soft, and all the trunks are flattened, measuring in one direction scarcely half the diameter they have cross-wise. It is also entirely black, and yields an excellent fuel. It is extracted with shovels like peat, after its surface has been bared of twenty feet of sand and gravel overlying it. In Denmark, about twenty miles below Copenhagen, near the sea-shore, there is an extensive plain covered with the finest grass, and affording excellent pasture to large herds of cattle. By digging there they find, under one foot of humus, a bed of peat entirely composed of the bark of birch trees. This bark is six feet deep, and closely packed and flattened. It is cut out and dried in long rolls entirely devoid of earthy matter. This woody substance, nearly fluid, transformed into a very soft yellow mass formed at the bottom of these beds, is taken out of the excavations with buckets, spread on layers of straw through which the water percolates, and when drained it is beaten hard, dried, and burnt like coal.

Peat-moss is formed by a process of comparatively slow growth, the time occupied in its formation depending greatly on the climate and humidity. The living moss and plants dying down on the surface are being constantly renewed thus forming an ever-increasing bed of decaying and decayed vegetable matter. Water, as stated above, collects, and the sub-soil of the depression being retentive it stagnates, and in colder climes, where there is little surface evaporation, a lake or tarn is formed. In tropical and sub-tropical countries, where the sun is more powerful, the aquatic plants —as seen in the Nile, on the Ganges, on the St. John's in Florida, and other rivers—being of a stronger, more rank, and quicker and closer growth—prevent excessive evaporation. Around the margins of these lakes or jheels various kinds of sedges and reeds establish themselves; others, true water plants, spring up in the beds of the stagnant reservoirs. Soon a heavy growth of these plants is established all over the surface, and year after year, according to the law of nature, these plants, dying down and reproducing themselves, form a spongy material which, floating at first, by degrees attains a specific gravity greater than water, sinks to the bottom, and, as the superincumbent weight increases, is pressed down and consolidated. The degree of decomposition which the matter has undergone usually determines the specific weight of the peat. It always contains some earthy matter according to the position of the bog relative to the soil in the surrounding region. As decomposition proceeds a degree of solidity is acquired by the mass, enabling it to support a dense growth of shrubs. Generally this formation is found in moist climates and in low-lying countries where no natural drainage exists. But, though the most extensive morasses are found in level countries favourable to the organic growth, it is by no means confined to such districts. We find mountain-peat in various localities in Great Britain and Ireland as well as in Europe. Along the western coasts of Scotland, Ireland, and Scandinavia, bogs are found at high elevations upon undulating uplands, and even on the surface of granite rock, as is the case on Dartmoor and Rannoch. They exist high up in the Alps, the Jura, and the Vosges. The constant formation of clouds upon these elevated regions, together with the imperviousness of the rock, favours the growth of the mosses.

The process which converts the dead vegetable matter into peat is a chemical one, and the chemistry of peat is a subject over which many experts differ. We make no pretence to chemical science. The best explanation, it appears to us, is that given many years ago by Dr. W. V. V. Rosa, of Watertown, New York. In answering the question of "What is peat?" he says:—"Let us review for a moment all we know about wood. It will assist in following the changes which take place in one form of it—the vegetable fibre of mosses and ferns, for instance—while it is passing into peat; most peat being the product of partially decomposed and partially preserved beds of mosses and ferns in swampy places. Wood, then, is a compound substance, namely, carbon—that is, coal—united variously with mineral substances, such as potash, lime, silex, together with gases, oxygen and hydrogen, and with water, etc., in the form of gums, resins, starch, sugar, and the like, in great variety. These substances, in burning, form new compounds, such as carbonic acid, creosote, naphtha, wood-vinegar, alcohol, and the like, which pass away in smoke and vapour; and the other parts remain as ashes.

"If, however, we wish to convert the wood into charcoal the process is controlled and modified somewhat. The wood gathered in bulk is covered over thickly with earth to *prevent free access of air*: a very little being admitted below, sufficient and a little more, however, to consume that, portion near the air holes. A tolerably high heat is thus diffused through the pit, and the slight access of air thereby quickened in its action, soon causes new combinations to take place, and decomposes and carries off the more destructible parts, and then the draft being closed, the fire goes out, the pit cools down, and the earth being removed, the coal is ready for use. By this means, excepting just about the air holes, only parts, the more volatile and destructible constituents of the wood, are burned, are decomposed, or passed away, while the main part—the carbon and mineral part—is left unconsumed.

"Now, what is understood by burning? When we say a substance burns, it signifies usually that the substance—coal or gas wood, weeds, grass, or moss, for instance—unites very rapidly with oxygen, which is abundant in the air; the substance burned being thus changed in its form, but not destroyed nor annihilated, as that, of course, would be impossible. All that existed in the wood before still continue to exist, though in other shapes; mainly in gases, partly in mineral as in ashes. During this process, or rather by it, peat is created. If the process goes on very fast it is very hot; or slow less hot; and though so very slow that no heat can be perceived, the burning is in reality still going on, though to a degree too slight to cause sensation of the slightest warmth.

"Metals—iron, for instance—may burn, that is, unite the same as wood or coal with oxygen. In this case but little gas is formed; nearly the whole remaining as oxide of iron. If the oxidation is rapid, as when it is burned, that is as rust. Rust is ashes of iron. If the oxidation is rapid as when it is burned in a jar of pure oxygen, great heat and light are caused: if slow, as when iron rusts in damp air, or under water, none is observed; but yet the rusting of iron under water is as really a burning of the iron as when the same occurs in oxygen or at the forge with intensest heat and light.

"Water, indeed, being composed in part of oxygen, and holding a little extra in solution, is a good substance (strange as it may sound) to burn things with; in some instances, better by far than air. And this is an essential part to observe in studying the formation of peat, that water is a good substance to burn things with; that is, if you are in no hurry, if you have years to spend in burning a very little—so very slowly that an insurance policy might run out and be renewed, and out again a score of times before the job is finished.

"Although water, by preventing the free contact between actively burning bodies and the air, will 'put out' fire, that is, will stop the rapid combustion which air favours and supports, still the water does not put out that fire absolutely as chemists would define the term, but rather, in many cases, makes its continuance certain, though centuries might be the measure of the slowness of the work. Though water will burn many things better than air (even iron, for instance, which, unless very highly heated from without, will not rust at all, that is, not burn, in *dry* air) still it is slower, or will not burn other substances which are easily consumed in air. And coal is just one of these. Coal will not oxidise, that is, not burn or rust or decay in even hot water. It will keep there for ever.

"And now it being clear that water prevents rapid oxidation by excluding free access of air, and yet ensures its slow continuance to a certain stage by furnishing a little, and that it burns and converts most substances easily or surely, and stops at others, among which is coal, it may be understood but with little further thought how peat is formed and where it is most likely to be found.

"We can see that where large quantities of woody substances, such as mosses, ferns, etc., are for a long time accumulated, and remain always thoroughly soaked with water, as in many swampy localities, such places may be considered much like very slow-burning coal-pits; that they are places where mainly, by exceedingly lingering oxidation, new compounds and recompositions take place, and the more easily consumable portion of the vegetable matters there gathered, being volatilised or burned, pass off and leave the coaly portion especially unconsumed much in the same way, in principle, that it is made and left in ordinary pits, the water acting here in part as the earth covering does there, to govern and moderate the change and oxidation by preventing free access of air, yet allowing or furnishing a little; and finally, when the coal stage is reached, the bed being already coal, the oxidation, absorption, and recompositions cease, and the carbon, ready for use, is preserved for centuries.

"When wood or vegetable fibre dies, and remains in places freely exposed to air and sun, it is soon almost wholly decomposed, passing away in gases mainly, as has been mentioned, and but very little of it remains. If, however, in a cold climate, and other circumstances being favourable, it falls in large amount into places always thoroughly wet, then the decomposition is only partial, and the most of the carbon remains."

Outside the United Kingdom in Greater Britain vast and valuable deposits of peat are found. In Canada large areas, often resting on shell-marl, nearly pure carbonate of lime, present themselves in various districts. At forty feet, in one instance, bottom has not been found. In the Island of Anticosti there is one bed covering a surface of over one hundred and sixty square miles. The supply of material capable of being converted into a superior fuel is nowhere more abundant than in the Dominion. "There is no social question," says the *Montreal News*, "that causes more anxiety to these friends of Canada who peer into the future than the difficulties of securing a cheap fuel supply. Great suffering and privations are now endured in old settlements in consequence of the destruction of the forests. In the houses of many a habitant who owns a good farm, roots are dug up, and branches gathered for fuel, which in bygone years have been rejected. Yet year by year the forest is falling back, and the price of an indispensable article of consumption rising in price." Experiments made on the Grand Trunk Railway demonstrated the fact that in heating power a ton of air-dried peat equalled five-sevenths of a ton of coal, or a cord and a quarter of wood. In addition to the tests as to its qualifications for steam-raising, it was applied to smelting purposes, and the castings were reported to excel in toughness and quality of chill any specimens previously produced. In Canada, where winter reigns for six months in the year, a cheap method of generating warmth is absolutely necessary to existence. Peat graved from a bog drained by the Lacolle River, south of the St. Lawrence, dark coloured, fine grained and compact, with a specific gravity considerably over that of water, yields only 3·53 per cent. of ash from the bottom of the bog, and 4·6 per cent. from that on the surface. It is remarkable for its freedom from earthly matter. In Newfoundland and Nova Scotia it abounds. The fogs of the banks of Newfoundland encourage the growth of the mosses.

At the bottom of these bogs the substance closely resembles ordinary bituminous coal. On the North-West arm of the River of Inhabitants (Nova Scotia) appears, under twenty feet of boulder clay, a hard bed of peat resting on a bed of grey clay. Pressure has rendered this peat nearly as hard as coal, though it is somewhat tougher and more earthy than good coal. It has a glossy appearance when rubbed or scratched with a knife, burns with a considerable flame, and approaches in its characteristics to the brown coal or more imperfect varieties of bituminous coal. It contains many small roots and branches, apparently of coniferous trees allied to the spruce. The Falkland Isles, destitute of wood and coal, abound in peat. We are strongly impressed with the conviction that the important question of the Egyptian fuel supply will be solved by the conversion of the millions of acres of "sudd" into coal. Lord Cromer, that able and impressive British Pro-Consul, may yet find a friend in that obdurate obstruction of which he writes:—"As to the 'sudd,' I am dying to grapple with it. I wish to have it in pieces and draw it out in bits from its mosquito-ridden, pestilential lair. I also want dredgers to dredge away the mud which I believe underlies the 'sudd.'" How can rapid progress be made when coal is at £4 a ton, and at Khartoum "black diamonds" fetch £6 a ton? The Suakim Berber Railway lately sanctioned, the projected lines to Kassala and along the Abyssinian frontier, that to Obied, the Great Cairo and Cape Town Line, and others still in the womb of time, may yet burn "sudd" coal. With it the Soudan would immediately become self-supporting. Such a discovery—and it is within the pale of possibility—would be of far greater value than finding gold. We commend this to the serious attention of Sir Reginald Wingate, whose efforts are beyond all praise. Wherever the main source of artificial motion may be hidden away, awaiting the ultimate development, whether in the air or in the water, or in the heat of the earth itself, matters less to the practical man than to the philosopher. The main sources from which the present generation may expect to derive practical benefit, and to which we look forward in the economising of our fast diminishing coal measures, are gas and electricity produced from peat and petroleum. It cannot be supposed that nature has created and is creating these enormous masses of vegetable matter for no purpose. It becomes us to consider how to produce a fuel which shall satisfactorily occupy the position of coal in manufactures, steam-raising generally, in the generation of electricity, as a producer-gas, and in the household. The comparative absence of smoke in peat and the total absence in certain varieties of all sulphurous vapours ought to be a sufficient inducement, independently of the economy effected.

"The Statesman who shall effect this work of utility (the development of the peat industries of Ireland) will live with honour in her social history when names and dates of many monuments will be forgotten."—J. M'Carthy Meadows, author of *The Turf Industries of Ireland.*

CHAPTER II.

PEAT AS AN ARTICLE OF FUEL.

EXCEPT in the form of air-dried *turves*, peat as an article of fuel is comparatively little known in the United Kingdom. Though many bodies not contained in coal are found in peat the elements of the two are the same. In physical appearance coal, wood, and peat are closely allied, all three being mainly composed of ligneous fibre, a compound of the four elements—carbon, hydrogen, oxygen, and nitrogen. Coal and peat, though differing in some particulars, are both produced by the decomposition of species of organic growth. Professor Emmons, writing on the important subject, remarks—"There is one consideration which commends itself to the philanthropic of all our large cities, viz., the introduction of peat as a fuel to supply the necessities of the poor. It is believed that much suffering may be prevented and much comfort promoted by the use of peat in all places where fuel is expensive. We have in this homely substance of peat an invaluable article of which prejudice alone can prevent a general use."

We have not experienced the bitterness of a coal famine such as lately existed in the Eastern and middle States of America, when numbers died from lack of fuel, works were closed, coal trains held up and looted, and every substitute for coal improvised, leaves and stalks of plants, saw-dust, wool, oil, and even corn being requisitioned. So desperate was the situation, and so sore the famine, that at one time it was seriously suggested that the residual products of the entire grain crop, including corn, wheat, oats, barley, and rye, should be chemically treated and compressed, by which means it was calculated that about 200,000,000 tons of artificial fuel could be yearly grown and manufactured. When properly treated, scientists asserted that the calorific proportion would be 20 tons of the artificial fuel to 14 tons of bituminous coal. With us the price of coal at the pit mouth doubled between the years 1888 and 1900. Between the time the coal leaves the pit and it reaches the consumer the cost increases by leaps and bounds. Taking the best Wallsend as an example. This household fuel at the pit mouth was lately 13s. 6d. a ton, on the Tyne (shipper's price) it sold at 15s. 6d., rising to 19s 6d (factor's price in the Thames), finally being sold to the consumer at 30s. The freight by sea from the Tyne to London is 3s. 3d. a ton, to which must be added local railway haulage, 2s., making 5s. 3d. in all.

Experts differ as to the date when the coal measures of these islands must be exhausted. In 1900 we produced 225,181,000 tons, valued at £121,653,000. At this rate of working the evil day cannot be far off. The days of cheap coal have gone till some potent substitute forces the middleman, the Miners' Federation of Great Britain, and kindred labour combinations, to their knees. An ex-President of the Society of Engineers has given as his opinion that there are no fewer than 6,000,000 acres of peat in the country having an average of 12 feet, and capable of yielding 3500 tons per acre of dried peat, or 21 billions in all. Though this estimate may be correct as to area, it certainly very much under-estimates as to depths and contents. The average depth of the bog of Allen in Ireland is 25 feet, and in America peat has been found at a depth of 80 feet. As the density, and consequently the weight, of peat varies with the positions in which it is found, the organic substances from which in different localities it had its origin, the character in different localities of the atmosphere and climate, the proportions of earthy and mineral matters which it contains, and the degree of decomposition to which it has been subjected, all exercising an influence on the specific gravity, this estimate of the tonnage per acre is mere guess work. One deposit differs from another in appearance, in quality, and in the uses to which it may be best economically applied. This difference may be detected by the naked eye, whether in the moss or in the morass or on the mountain, in the form of wet or air-dried turf, or when reduced to ashes. "Some," remarks Dr. Rennie, "are of a bright yellow colour, others brown or jet black; some are composed of congeries of vegetable in an organized state, in others few or no traces of organization can be seen. Clay, sand, and shells may be detected in some, in others no mixture can be discovered. Some are soft and greasy like butter, and form a hard, brittle, tenaceous peat almost like coal; others are loose and friable like mould. The water squeezed out of one moss is of the colour amber, of another of claret or port wine, and of a third as black as ink. In some cases the water effervesces with chalk, in others not. Sometimes it leaves a copious sediment by evaporation, which is highly inflammable; in other cases the sediment is small and scarcely inflammable. Some are covered with a rich luxuriance of aquatic plants, others are utterly barren and destitute of vegetables on their surface." As peats vary so much in their thermal value it is of importance that, before any attempt be made to convert a bog into fuel, several samples, taken from varying depths and wide apart, should be carefully analyzed by a competent chemist. Pure moss (Sphagnum) peats are invariably good, those strongly impregnated with bituminous matter being especially valuable for generating steam, for the reproduction of gas, and for low destructive distillation. The dense compact peat represents the first step in the progressive stages from vegetable substance to mineral coal.[1] "Peat is sometimes entirely converted into coal" (Dama). "I have always looked upon the peat of the old world as one of the principal sources of our coal" (Sir James Hall). The colour varies with the age and the

[1] This is known as Surturbrandt.

progress of decomposition. In the older thoroughly decayed strata no living organism exists. This "older peat" shows few traces of fibrous matters, such as roots, stems, or leaves, but it presents, when cut, a pitchy shining hue, is dense and firm in the grain, and will not float on water Some of these "Stone Peats" are improved as fuel, where there is little draught, by an admixture of the light golden-tan fibrous surface, which serves to bind it firmly together, at the same time producing a more cheery fire. So highly inflammable are some of the denser kinds of bottom peat, due no doubt to the large percentage of naphtha, paraffin, and wood tar, that the term "tallow peat" is applied to them. Such deposits have been found on the shores of Lough Neagh, Antrim; near Ince, in Lancashire; on the western isles of Scotland; and in other localities. This fat peat is thought by some, with whom the wish is father to the thought, to be saturated with petroleum from bituminous springs. These too sanguine and somewhat too previous elucidators argue that these surface indications point to the presence of oil fields, and claim that at last the Emerald Isle has "struck ile." This is a consummation devoutly to be desired, and would have a marked effect on the important fuel supply for the navy, the merchant marine, and manufactures generally; but Dr. P. Dvorkovitz, Principal of the Petroleum Institute, ascribes the presence of petroleum in peat bogs to a chemical action which is going on in the bogs themselves, and is not by any means hopeful of finding oil in Ireland.

Of peat as an article of fuel comparatively little is understood in England. In Ireland and Scotland, where, as *turf*, it has been burnt for centuries in a crude unprepared state, it, by the cottars and others, is highly esteemed for domestic uses; but for manufacturing purposes, in the form of compressed briquettes or in that of coke, charcoal, or gas, it is practically unknown. Its value also may be said to be unknown, and even those who have used it in its crude state, simply cut and air-dried, do not realize the increased value it possesses when properly prepared, condensed, and solidified so as to bear carriage. Some of the turves, as graven from the bogs, have been sold in the Metropolis, and have been much appreciated by the Upper Ten Thousand, but no serious or successful attempt has been made to place this prepared fuel before the masses or the large employers of power. The community stands in need of information as to the value and economy of this compact, cleanly, smokeless, and healthy heat giver.[1]

Peat can be advantageously employed in the manufacture of various grades of fuel, viz. :—

(a) In its natural form, dried and pressed into briquettes, and improved by the removal of elements of low calorific value.

(b) Semi-carbonized peat, *i.e.* peat that has been subjected to a higher temperature than that required for drying, but which is briquetted while still retaining the tar and combustible elements.

(c) Fully coked or carbonized peat known as charcoal, coal, or coke.

(d) As "mull" or powder, in a fine state of division, mixed with air injected into the combustion chamber by natural or forced draught.

(e) In the form of gas for power, heat, or as an illuminant.

By regulating the degree of carbonization the fuel for domestic purposes can be made to contain more or less combustible elements giving more or less flame and heat. Owing to its antiseptic properties it is specially suited for hospitals and kindred establishments. Let us quote from an important paper read by Dr. Dvorkovitz before the Society of Chemical Industry. "The question," he said, "presents itself, is peat advantageously convertible for industrial purposes? If we turn our attention to the development and use of peat in Europe we discover that it is used in very great quantities in different industries. Already in 1856, in Germany, the Aldenburg Iron Company

[1] At the Falcon Inn, a few miles from Scarborough, Yorkshire, there is a peat fire which has never been "out" in the memory of man.

was established, and has consumed no less than 20,000 tons of peat per year, and notwithstanding coal existed in the immediate neighbourhood, and very profitable results followed. Not far from the works of the company, in 1873, another company was established for steel manufacture by means of charcoal. Further, we find that, in 1890, 27 glass works in Germany used peat fuel, one ton of glass consuming eight tons of peat. A Mr. Peach, at Berlin, said that one ton of ready-made bottles (1600 ordinary wine bottles) required only 2 tons of peat dried in the air; or if we take 1000 sods of peat as equal to 3½ tons, we find that one ton of bottles required 700 sods. A glass melting stove, with eight pots having a charge of 400 kilos each, consumed 4½ tons of peat a day. In Bavaria about 60,000 tons of peat are used annually as fuel for railway locomotives.

"In the report prepared by the Russian Government for the Exhibition of 1893 at Chicago certain figures are given about the utilization of peat for different manufacturing purposes; and we found from it that in 1890 the following industries have used peat as fuel, viz.:—The cotton manufacturers have consumed 537,000 tons; sugar manufacturers, alcohol manufacturers, confectioners, flour mills, and macaroni manufacturers, 70,000 tons; chemical manufacturers, 5000 tons; candle, tallow, and leather manufacturers, 4000 tons; wood workers, 1000 tons; metal manufacturers, 60,000 tons; glass manufacturers, 80,000 tons; paper manufacturers, 12,000 tons; miscellaneous manufacturers, 2000 tons—aggregating approximately 772,000 tons. In addition the Oural Mines used 60,000 tons, and the railway companies 15,000 tons, with prospectively an increased demand, proving conclusively the value of peat as fuel."

From another paper entitled *Peat as an Article of Fuel*, published in Boston, U.S.A., we are furnished with particulars "regarding six thousand million tons of peat purified and dried in the crude state, or being reduced to charcoal to two thousand six hundred and ten millions of tons, the heating power of which equals that of wood charcoal."

"From the figures of the most skilful mining engineers in the French Empire we find that:—

			Degrees of Heat.
1	Kilogram of	wood charcoal yields -	7·000
1	„	purified peat charcoal yields	7·000
1	„	coal coke yields - -	7·000
1	„	raw coal yields - -	5·000
1	„	raw wood yields - -	2·600
1	„	raw purified peat yields -	4·300

while condensed peat (charcoal?) deprived of the excess of oxygen possesses nearly double the heating power of coal.

"Again, it is proved that the general annual consumption in France of all kinds of mineral and vegetable fuels was as follows:—

Wood charcoal for iron works - -	667,902 tons
„ other purposes -	472,630 „
Raw wood for iron works - - -	8,405 „
„ other purposes - -	1,989,710 „
Coal coke for iron works - - -	767,622 „
„ other purposes - -	2,402,400 „
Raw coal for iron works - - -	1,108,252 „
„ navigation, railroads, etc.	3,725,200 „
Raw and carbonized peat actual consumption - - - -	359,319 „
Total - -	11,561,440 tons

If peat had been used in place of these different kinds of fuel it would have required 15,656,687 tons, raw and purified, to produce the same effect, and at that rate the supply of peat in France would have sufficed the Empire for nine hundred years without importing a pound of coal, and leaving her free to export annually the seven million five hundred thousand tons of coal she raised in 1863, and free likewise from the necessity of importing eight million tons of coal as she did from England and Belgium in the same year.

"But can peat be used at less or even at the same expense as other kinds of fuel for manufacturing purposes? Take the article of pig-iron. By the French engineers it is found that in the process of working pig-iron the cost was as follows :—

1 ton of wood charcoal was - -	£4	11	0
1 „ raw coke was - - -	2	16	0
1 „ „ coal was - - -	2	15	4
1 „ purified charcoal was - -	2	4	11
1 „ crude peat (condensed) was -	1	10	0

This is enough to prove the economy of peat for all purposes. The general results if thus stated: 'For domestic consumption the economy—all conditions of heat being equal—would not be less than thirty per cent. of the cost of fires with wood charcoal or wood, coke, and raw coal; and for large manufactories, which on account of the quantity they will consume annually, that calculation of economy would in certain cases be raised to sixty per cent.'

"It has been proved and acknowledged that for equal bulk raw purified peat contains more heat than coke and less by one-fifth only for an equal bulk of coal of good quality." Mr M. Bute, Superintendent of the Railway Engineers for the Kingdom of Hanover, reported :—"We can, by the help of a hopper placed on a tender, carry the quantity of peat which would be necessary for a trip of one hundred and twelve English miles. No difficulty will be presented to the employment of compressed peat for ordinary fixed engines and eventually for steamboats." When this testimony was given the manufacture of peat briquettes was in its infancy, but even at that remote date a process employed by the *General Association for Working the Peat and Metalliferous Deposits of France* produced from six to fifteen hundredweight of condensed fuel to the cubic yard.

Amongst the various branches of German industry which, by reason of their economy and utilization of a raw material this nation fosters and we neglect, may be mentioned the manufacture of fuel briquettes composed of brown coal, brown coal in combination with peat, peat *per se* with or without a matrix or bind, and the dust or waste of coal mines known as "slack." Briquettes are employed principally as the domestic fuel of Berlin and other cities and districts throughout Germany; they are used also for locomotive and steam firing generally, and in various other processes of manufacture. A writer in *Cassiers Magazine*, evidently well informed on the subject, says:—"For all these uses they have three tangible advantages—they are clean and convenient to handle; they light easily and quickly, and burn with a clear intense flame; when made of lignite or peat they burn practically without smoke, and are withal the cheapest fuel for most purposes. It need hardly be said that the general use of briquettes for domestic fuel in a large densely built city, as well as for generating steam in a number of electric generating plants and factories, must have a decided and beneficial influence in reducing the smoke, which in many places has become a persistent and oppressive nuisance. Berlin, although a busy manufacturing city, ranks as one of the cleanest and best kept in Europe." In 1900 there were eighty-nine factories of fuel briquettes in Germany, each producing over 100,000 tons annually. Briquettes of pure condensed peat are much appreciated on account of their safety, cleanliness, and easy transport. They, in burning, if manufactured from selected bogs, give out no phosphorous or sulphur.

The principal advantages of briquettes may be summed up as follows:—

Diminished freight rates, especially for water carriage.
Exemption from shifting on a rolling vessel.
Exemption from spontaneous combustion.
Exemption from pump-clogging on board ship.
Diminished insurance rates on the fuel.
Diminished insurance rates on vessels carrying the briquettes.
Less deterioration from age and weather.

Convenience in checking the quantity delivered, by count or by measurement.

Convenience in firing by varying the amount of each size delivered.

Freedom from smoke; of special advantage for the navy in war-time.

Ability to "blend" material from different bogs.

Ability to keep a reserve against strikes.

Opportunity for advertising thereon.

Guarantee of quality by trade mark impressed thereon.

Increased regularity of firing.

Ability to regulate the size of the output.

Utilization of waste product, as culm or breeze.

Preservation of size and shape in handling and shipping.

Cleaner decks, etc., on board ship.

Coaling less disagreeable to the crew.

Grade of fuel, especially with anthracite, may be raised without a mixture of other fuel.

Less ground space for storage; they may be stacked up in vertical walls.

No bunkers required, thus increasing cargo space.

"While the gases exhaled from burning coal are in a closed room injurious to health, giving rise to feverishness, parched throat, headache and lassitude, peat is admittedly healthy (*Diet and Hygiene*)." "It is more heat giving than coal; it reduces the coal bill of the householder 50 per cent." "A fire well packed before turning in needs no attention during the night, and one can sleep in peace and safety." (Professor Huxley). The *Lancet* affirms it to be a valuable palliative in cases of consumption, asthma, bronchitis, and other chest complaints, and adds that its intense red mellow fire is never the cause of that lassitude and drowsiness experienced by sitters over a coal fire. To burn in an open grate in a sitting-room it is both economical and agreeable, the picture frames and other ornaments are not tarnished, there being no injurious gas. For an open fire in the sick chamber (where none but an open fire ought ever to be allowed) it is invaluable as a purifier of the air, can be replenished noiselessly, and produces a genial and pleasant temperature. We are convinced that when the peat briquette finds its way into the establishments of Mayfair and Belgravia, "black diamonds" will no longer be admitted into the households of the West End. Of clinkers there are none, and the percentage of ash differs widely. All of it, however, is valuable as manure. The better qualities of peat yield from 7·8 to 8 per cent., whereas that of the inferior sods reach as high as 33 per cent. At a depth of four feet the deposit is generally very free from ash, and is, therefore, well adapted for gas-making, metallurgical purposes, etc. "In general," says Sir Humphrey Davy, "one hundred parts of dry peat contain from eighty to ninety-nine parts of matter destructible by fire, and the residuum consists of earth together with oxides of iron." The following analyses of twenty-four peats from various parts of Ireland, France, Germany, and Holland indicate the percentage of ash remaining after peat has been burnt:

	From	Ash.	Observer.
Black firm peat	Neumunster	2·2	Suersen
,, ,,	Sindelfingen	7·2	Schubler
Brown peat	Schavenningen	2·3	,,
Old peat	Vulcare	5·58	Regnault
,,	Long	4·61	,,
Peat	Champ de Feu	5·35	,,
,,	Berlin	9·30	Achard
,,	Berlin	10·20	,,
,,	Berlin	11·20	,,
Old black peat	Maglin	14·40	Eirchof
Young brown peat	Maglin	14·30	,,
Peat	Eichfield	21·50	Buchholz
,,	Eichfield	23·0	,,
,,	Eichfield	30·50	,,
,,	Eichfield	33·0	,,
Grass peat		1·5	Karmarsh
Pitch peat		8·0	,,
Young dark brown		7·0	,,

	From.	Ash.	Observer.
Old peat	Erzgeberge	from 1·0 to 2·40	Winkler
41 kinds	Holland and Friesland	from 4·61 to 5·580	Mulder
3 „			
27 „	Bog of Allen	from 1·120 to 7·898	Kane and Sullivan
3 „	Tuam,	from 3·695 to 4·819	Ronalds
9 „	Saxony	from 5·300 to 3·710	Wellner

From the above it will be seen that in several of the German varieties no less than one-third of the entire weight consists of incombustible matter. Such varieties are, however, valuable as manure, as they contain a large quantity of phosphates and other salts which serve to enrich the soil.

Professors Sir Robert Kane and Sullivan have made a careful analysis of several of the Irish peats, and have furnished the following table illustrating the variety of their composition. As a knowledge of the composition of these ashes is of importance in determining their value for agricultural purposes, this table is especially valuable and interesting:—

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Specific gravity	0·297	0·405	0·669	0·434	0·984	1·058	0·481	0·280	0·335	0·924
Potassa	0·362	1·323	0·461	0·641	0·347	0·774	1·667	8·146	0·491	0·280
Soda	1·427	1·902	1·399	1·875	0·679	0·704	2·823	0·466	1·670	2·180
Lime	26·113	36·496	40·920	22·702	45·581	40·623	20·907	8·492	33·037	30·744
Magnesia	3·392	7·634	1·611	6·809	1·256	4·352	15·252	4·702	7·523	9.237
Alumina	4·180	5·411	3·793	1·109	0·129	1·671	2·034	10·705	1·686	2·027
Sesquioxide of Iron	11·591	15·608	15·969	29·845	15·974	10·368	17·040	15·052	13·281	19·797
Phosphoric acid	1·461	2·571	1·406	2·019	0·188	1·114	1·447	1·557	1·438	1·290
Sulphuric acid	12·403	14·092	14·507	16·381	44·371	24·208	23·375	13·974	20·076	20·857
Hydrochloric acid	1·568	1·482	0·983	1·591	0·337	1·052	1·424	0·196	1·747	3·128
Silica in compounds decomposable by acids	0·980	3·595	1·111	0·737	1·043	6·317	6·634	12·476	2·148	3·096
Sand and silicates undecomposable by acids	22·519	2·168	2·107	14·505	2·653	3·710	10·682	31·198	7·683	3·163
Carbonic acid	13·695	7·761	15·040	1·470	16·120	4·981	6·721	—	8·310	3·570
	99·691	100·043	99·307	99·693	99·678	99·844	100·006	98·928	99·120	99·369

The *Dublin Journal of Industrial Progress* also publishes the results of analysis conducted by those well-known experts, giving the contents of carbon, hydrogen, oxygen, and nitrogen in seven varieties of Irish peat:—

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.
Surface, Philipstown - -	58·694	6·971	32·883	1·4514
Dense peat - - - -	60·476	6·097	32·546	·8806
Surface peat, Bog of Allen -	59·920	6·614	32·207	1·2588
Dense peat - - - -	61·022	5·771	32·400	·8070
Surface peat, Twicknevin -	60·102	6·723	31·288	1·8866
Surface peat, Shannon - -	60·018	5·875	33·152	·9545
Dense peat Shannon - - -	61·247	5·616	31·446	1·6904

Professor Muspratt also furnishes the following:—

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.
Peat from Westmeath - -	61·040	6·670	30·470	
" " Clare - - -	56·630	6·330	34·480	
" " Kildare - - -	51·050	6·850	39·550	
" " Tuam - - -	57·207	5·655	28·949	3·067
" " " - - - -	58·306	5·821	29·669	2·509
" " " - - - -	59·552	5·502	28·414	1·715
" " Eastern Russia -	39·084	3·788	51·088	

Peat always contains some earthy matter, though, in some localities, in such quantities that its presence can only be accounted for as being brought in the form of dust by the moving air. The quality depends on the locality. On this account bogs in the vicinity of sand hills contain large quantities of undecomposed sand and silicates. The ash differs in colour from white to grey and ochre red.

The economy of peat in the matter of burning out furnaces and grates is well worth the attention of all producers of power. Peat will destroy no more furnaces than wood; the fuel having little or no smoke and much gas keeps up a constant flame. Herr F. Schükle, of Hamburg, converts peat into artificial coal, having a thermal value of 6250 calorics, at a cost of 10s. a ton. The salient feature of his process is, having cleaned the turf of roots and stones, to liquefy it with water and pump it through a pipe-line several miles to the works, where it is leached and converted by heat into briquettes. This appears to be a needlessly expensive operation.

For some time peat-fuel, for domestic purposes, mainly in the form of air-dried turves, has been meeting with a ready and appreciative sale in the Metropolis. One thousand of these blocks, weighing about 2 lbs. each, are delivered at 38s., leaving at this price a very handsome profit to the retailer. In this form the fuel is too open in texture to burn economically, or to give its full thermal value, it carries badly being too "crumbly," and as the weight is disproportionate to the bulk, is costly to carry and transport. Much better results are obtained from the compressed briquettes, which burn more slowly, give forth a more intense heat, are free from all dust or mull, and occupy less storage space. But even at the price mentioned, air-dried turves have been found very inexpensive, as one block, costing no more than a halfpenny, keeps a fire going with a comforting, mellow, heat for three or four hours without any risk of the crackling and shooting of red embers. Nurses, now so much in evidence, as might be expected, favour the peat fire, not only on account of its pleasant fragrance and antiseptic qualities (" valuable palliatives in cases of consumption, asthma, bronchitis, and other chest complaints "—(*Lancet*), but because it saves trouble. Its value in the sick room is unquestionable. Once ignited it burns steadily without any resort to the poker until the whole be consumed. It is absolutely noiseless, a matter of no small importance to the patient, where the frequent replenishing of coals, and the still more frequent dropping of cinders or fragments of unconsumed coal, constitute a grievous disturbing nuisance. We know that peat being free from noxious gases leaves a pure atmosphere, and that by using it a room can be kept comfortably warm without poisoning the air and producing that lassitude and drowsiness experienced by sitters over a coal fire ; we know also that it does not injuriously affect picture frames or the most delicate draperies; but, till our attention was directed to "Beauty's Queens," we had not observed its superiority over coal, as regards the complexion, the complexions of the women of Ireland, where it may be said to be the national coal, being of proverbial cleanness and delicacy. "One of the great causes," says the writer, "of the ugly skins we see in London is the all-pervading presence of smoke, and until something can be done to remove this disagreeable factor from our midst, we must continue to have very inferior complexions. Having said so much, we feel that the occupation of the numerous brood of Madame Rachel is gone, that the days of emotional creams for the skin, lotions, and the hundred and one complexion nostrums—mostly injurious—are over, and that in the boudoir and throughout the mansions of the 'Upper Ten' democratic peat will reign supreme."

In France, Germany, and Austria, as has already been stated, a vast amount of briquette fuel, compounded of peat with "breeze," either from soft or brown coal, is manufactured. The coal dust is mixed and manufactured with peat in such proportions and in such a manner that these briquettes, though possessing strength and solidity, burn more freely than coal, yield intense heat, and coke perfectly. This fuel is particularly well adapted for steam service, where great pressure is aimed at, for the smelting of ores, and the manufacture of gas both for power and lighting. In this direction we shall find a use for the vast heaps of coal dust lying on the banks of our collieries. By this means also will be found a market for the accumulations of anthracite dust. It is estimated that there are 182,000,000 tons of anthracite waiting to be worked in Ireland, but which, owing mainly to the lack of means of communication and the greed of railway companies, are now lying idle. Perhaps, as advocated by Sir Richard Sankey, this mixture of mineral coal and vegetable peat may be advantageously used by the process of the Central Cyclone Company's stoker, the fuel being previously partially carbonised and made to yield its valuable bye-products. This "slack" accumulates in vast quantities at all our pit-mouths, and in no inconsiderable quantities on the wharves and in coal yards of dealers and large consumers. The amount on the banks of the pits, varying of course with the nature of the seam, is said to average full thirty per cent. of the marketable mineral. The only objection to this "slack," from a thermal point of view, is that it is difficult to handle, and costly and wasteful to transport, that the "dumping" ground occupies a large space, and that removal of the encumbrance entails expense. All these drawbacks can be overcome.

So far back as 1866 this compound fuel, in briquette form, was tested on the Western Railway, at Chester, Massachusetts, U.S.A., and as the subject is of great importance we reproduce the engineer's report *in extenso*:

"The fuel arrived in good order, and, by consent of the managers of the road, we were allowed to use the freight locomotive "Rhoda Island," built at Lowell in 1838, twenty-eight years ago—weight, twenty-six tons; four feet six inch driving-wheel, sixteen inch cylinder, twenty inch stroke, two inch exhaust pipes; a wood burner, one of the poorest on the road, and by no means adapted for burning our fuel to advantage. The first trial was made in July last, on a regular trip from Chester to Washington—the latter point being the "summit" of the road; and the section between here and there is well known to be the most difficult portion of the whole line to traverse, having several short and some double curves, with a grade of eighty-three feet to the mile for a part of the distance, and requiring the most severe steam service for locomotives. The distance is twelve miles, and the total rise or elevation between the two stations is 950 feet.

"We weighed and took on a thousand pounds of fuel, and started from the station at 3.15 P.M. with sixty pounds steam; engineer, Theo. Dandarend, who has been on the road for ten years. Our train consisted of eleven freight cars, three of them loaded, which is equal to fourteen empty cars, a heavy train for this grade. Rail bad; the grade on leaving the station rises for half a mile, and then descends for perhaps the same distance; and then commences the heavy grade.

"Nine minutes after starting the steam had risen up to 140, and we had to open the furnace door. Twice we pumped cold water into the boiler—once with both pumps—when the steam fell ten degrees, from 130 to 120, but in five minutes was up again to 130. Had we been burning wood and used both pumps in the same manner as in this case, the steam would have run down sixty degrees to 70—so said the engineer (driver). The furnace door was open nearly four-fifths of the time. We made seven miles in thirty minutes, have passed the worst curves and the heaviest grade. Here our fuel gave out—steam standing at 130—and we were obliged to commence using wood for the remaining five miles of the trip. Steam soon fell to 120, and we were unable to raise it above that point. We ran the first seven miles, by far the hardest portion of the route, in thirty minutes with our fuel; while the remaining five miles took forty-five minutes.

"The facts brought out are these. It will burn in any wood burning engine, though if it is to come into common use we shall doubtless have fire-boxes especially adapted for it, which can easily be done, and a little experience will teach economy in its use. The exhaust pipes should be larger than for hard wood, perhaps three to three and a half inches. Combustion appears to be almost perfect; there was no caking of the fuel in the fire-box, and it made but very little smoke. The heat is clear, steady, and extremely intense.

"The engineer was astonished and delighted; said it was the greatest fuel for making steam he had ever used. He thinks the half-ton, if burned in one of the large locomotives, with six-foot driving wheel, would have carried a passenger train from Chester to Pittsfield, twenty-four miles. He thinks a ton of the fuel would take a passenger train over a common grade road one hundred miles, and says a tender will carry four tons of it. If his estimates and opinions are correct you will see at once that, at a cost of even ten dollars per ton for the fuel, it would cost but ten cents per mile to draw a passenger; but if the railroad people were to make it themselves, at your figures of first cost to produce (the cost of manufacturing the fuel, after the materials are at the mill, was less than one dollar per ton), the expense would be but little over three cents per mile to run a train.

"In order to a better understanding of the relative amount and cost of this fuel as compared with wood, I should state that I went over the same route with the same engine burning wood. We took on 2½ cords by measurement; were sixty-nine minutes running time between the stations; stood at Becket fifty minutes waiting for trains to pass; and on arriving at Washington found, by measurement, that we had consumed two cords lacking ten feet. Cost of wood for the trip, at 7·00 dol. per cord, was 13·27 dol."

The machinery by which this compound fuel was produced was of a crude type, but nevertheless it turned out fifty tons a day at a cost for labour of less than one dollar per ton. Though these tests were applied on an old-time worn-out locomotive, they must be accepted as eminently satisfactory. As we have shown elsewhere, the French and German modern briquette plants work on a most extensive and economical scale, many of the systems being well adapted to this peculiar class of fuel. No matrix or binding material is necessary. By the application of heat the materials give forth their own bind, and improved machinery does the rest. The ordinary coal briquette is open to the objection that it is an exceedingly sticky mass, disagreeable to handle, and liable to leave dirty black marks not easily removed; moreover, it bubbles up in burning, resolving itself into a sluggish, pasty compound. The combustible character of the materials used is dissimilar, causing unequal burning. The more inflammable and costly ingredients—pitch, tar, rosin, etc.—are the first to ignite and burn themselves out before the coal-dust is half consumed, the consequence being that a mass of this fine coal gradually falls through the grate bars, and becoming embedded in the bottom of the fire-box, shuts off the draft necessary to sustain combustion. Many of our mineral lines pass through extensive deposits of peat, so that the cost of freight on the raw material, always the heaviest item in manufacture, can be reduced to a minimum. The peat mull can go to the "breeze" dumping ground, or the "slack" can be carried to the peat bog. Gas companies and users of gas engines will do well to give the artificial fuel a trial. In gasworks two or more qualities are generally in use—the poorer for volume, the richer for body and strength. "Numerous experiments," says Mr. Leavitt, "some on a large scale, have clearly developed the fact that peat has a very considerable value for the same purpose (the development of gas), the volume being greater, while the strength or illuminating power is believed to be above the average of coal." The quick intense heat generated by this fuel gives it a decided advantage over coal in the treatment of ores. It has been suggested that the ores and flux being crushed, should be mixed with ascertained proportions of coal and peat, and the whole manufactured together in the form of fuel wherewith to charge the furnace for smelting and desulphurising.

We here give some particulars of the manufacture of peat-fuel in Schleswig-Holstein, for which we are indebted to the *Journal of the Department of Agriculture*, Dublin. As the bogs of this damp bleak portion of North Germany bear a striking resemblance to those of Ireland, the description of the methods employed, though somewhat crude, are of interest. It appears that one thousand briquettes of peat can be bought in the town of Schleswig for 3s. 2d., and that peat is underselling coal in many towns of the province. Much depends upon the cost of transit. When coal is dear, Hamburg imports peat largely from Schleswig. Labour is scarce, the working months few, and the climate damp.

"The manner of producing peat for use as an article of commerce in Schleswig-Holstein includes two methods—1st, the *Back Torf*; and 2nd, the *Press Torf*.

THE BACK TORF.

The first mode is chiefly adopted by the peasants for the manufacture of peat for their own use, and may be described as the hand-made system. It was introduced from Holland some time prior to the year 1803 by Herr Goopmans, a gentleman sent for the purpose. The peat is ploughed up or dug with a species of harrow. It is then, with the mud, dust, etc.—not a scrap being allowed to go to waste—thrown into a large shallow wooden trough called a pritsche. This pritsche is usually a little over one foot in depth, and must be of sufficient size to allow a man with one or two horses to run round in it. Water is thrown over the stuff in the pritsche. A man then, standing in the centre, drives the horse or horses round and round in a circle in the pritsche. By means of this the peat is gradually kneaded into a kind of paste or dough. The action of the atmosphere, of course, assists. When the kneading has produced a sufficiently stiff dough, which is filled into a wooden case, divided into narrow compartments, worked up with the hands, and smoothed off with a large knife, the peats are left to dry in the open air, generally from ten to fourteen days, according to the state of the weather. During the drying stage they are turned over once or twice, and in the last stage are put into little stacks. When finished they are removed to the storehouses on the bogs. The briquettes are about half the size of those made in Ireland. It is surprising how many briquettes two men can turn out in a short time.

In the case of the high dry banks of peat, the peasants in some parts of the country, before resorting to the Back-Torf system, cut sods of turf out of the upper parts of the banks by means of spades and cutters, two men generally working together. The spade, or *stecher* as it is called, which is about a foot long, has a sharp edge, and is raised or flanged on both sides. One man uses the stecher, with which he shapes the sod, and the second man detaches the sod from the bank with the cutter. These sods are identical in size and appearance with those made in Ireland. They are stacked in little groups of three each on the banks, and when sufficiently dried are stored. This is not considered an economical mode of making turf.

THE PRESS TORF.

The second method may be divided as follows:—Process A, manufacture of Peat for Fuel; Process B, manufacture of

Torf-streu, or Peat-moss litter for use in stables, and *Torf mull,* or fine turf dust, made up in large packets for disinfecting purposes, for the preserving of meat, fish, and fruit, and for the filling up of walls and ceilings, stalls, and ice-houses; also packing material.

The establishment from which the following description is taken is that at Westermoor, near Owschlag, some distance south of the town of Schleswig. It is the property of Herr C. E. Maurice, from whom the writer received every courtesy and attention. Westermoor factory, which is one of the finest of its kind in the province, is a model manufactory, and fully equipped with the most modern machinery. In addition to its local and export trade, it supplies the fuel for a large brick, tile, and drainage pipe factory alongside the bog, which is also the property of Herr Maurice. The bog is traversed by the Haupt Bahn, or main railway from Hamburg into Denmark. It is also intersected by several light tramways, the property of Herr Maurice. These tramways can be rapidly taken up and laid down through any part of the bog as necessity arises. The machinery for the manufacture of process A (peat for fuel) is moved about upon the tramway lines. That required for Process B is immovable, being in the factory. The two processes are quite distinct and separate, the machinery for each being driven by separate steam-engines. The peat-fuel machinery is driven by an ordinary engine, which, when not at work in the bog, is hired out to drive threshing-machines. The Process B machinery is worked by a stationary engine, which also drives a saw-mill.

PEAT FOR FUEL.

The machine used stands on a wooden platform, which runs on wheels. The tramway lines having been laid down in the direction required, the machine is moved along the lines until it arrives at a position parallel to the portion of bog about to be operated upon. The lower end of an elevator, by means of which the stuff is passed up into the mouth of the machine, is depressed until it rests upon a beam of wood placed upon the floor of the bog. The stuff having been dug down with spades and thrown into heaps on either side of where the elevator stands, and well mixed, a number of men with large shovels then throw it in a damp state into the elevator, which passes it rapidly up and drops it into the mouth of the machine. The machine, when working at full speed, requires seven men to feed the elevator. The stuff passes from the mouth of the machine into the mincer, which is exactly on the same principle as a machine used by a cook in the kitchen for turning out mincemeat. The minced stuff is forced out of the machine lower down through a rectangular funnel on to a board, where it is cut off into requisite lengths by a cutter, which is driven by the engine. If there is no cutter, a man must be employed for the purpose. The board when covered with briquettes is rapidly removed, and another put in its place. The boards are put on a cart standing alongside, which, when full, is driven off to the drying ground and unloaded. The cart then comes back with the empties and awaits its turn; and, of course, to prevent congestion, there must always be a cart at the machine to take off the boards. The briquettes are generally turned over twice upon the drying ground, then put up into little stacks of about eighteen or twenty each, and finally, when perfectly dry, are stacked in gigantic ricks. The briquettes are of the same size as those made by the Back-Torf process.

The machine described as above is driven by an eight-horse-power engine, and, with a staff of twenty-four hands (inclusive of those at the drying ground), is capable of turning out up to 80,000 briquettes per day of eleven hours. This amount, however, is not always turned out, and the average might be taken at 65,000 per day.

THE ESTIMATED COST OF A MACHINE CAPABLE OF TURNING OUT FROM 60,000 TO 80,000 BRIQUETTES PER DAY OF 11 HOURS.

Elevator, 33 feet long - - - - - -	£52 10 0
Torf press machine - - - - - -	52 10 0
Briquette cutter, which saves the labour of one man - - - - - - -	12 10 0
Moving apparatus, etc., about - - -	40 0 0
Total - - - - - -	£157 10 0

To this, of course, must be added the cost of the steam engine and tram lines.

Machines similar in principle to that just described, but driven by one or two horses, are also in use, and are very simple in construction. They are manufactured by Messrs. R. Dolberg, hereafter referred to. One of these machines driven by one horse can turn out from 8,000 to 14,000 briquettes per day. It is simply a large mincing machine, and is fed by two men, who throw the peat into the mouth of the machine. A long pole or shaft is attached to the machine by means of a pivot. A horse is harnessed to the pole, and driven round and round the machine. The pole thus revolving works the machine. The stuff passing down through the mincer is forced out of the rectangular funnel on to the boards. One man cuts off the briquettes as they come out of the funnel. The briquettes are then brought to the drying ground as already described. The price of one of these one-horse machines is £18.

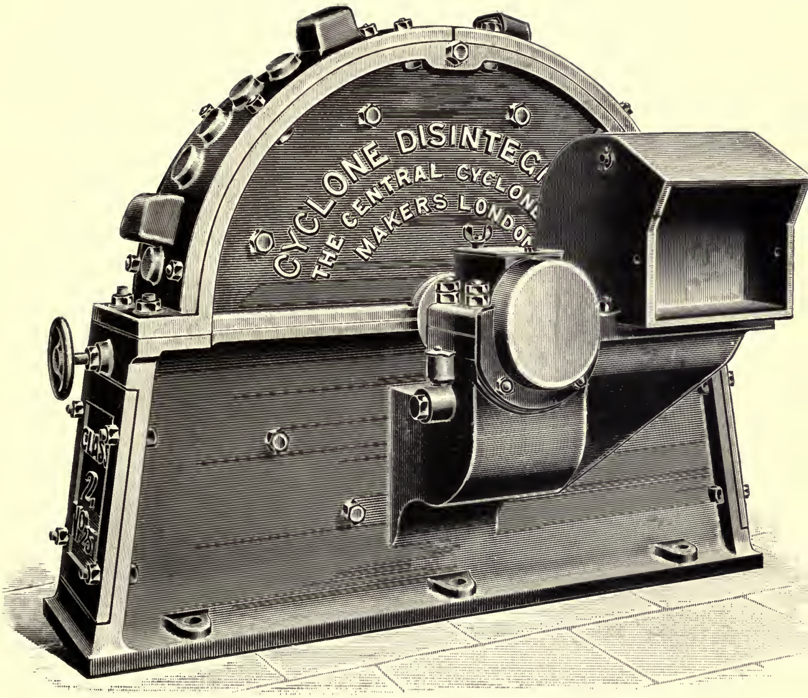
PRESS TORF KOHL.

This is yet another process; but which has gone out of vogue in Schleswig-Holstein. The portion of the bog to be worked is first cleared of heath, etc., and the turf is then ploughed with a light plough. The turf thus turned up is further turned over into long ridges by two men, who follow the plough. It is then brought to the mill, where, by means of the elevator, it is raised to the upper floor and drops into the tearing machine, from which it falls on to the sieve. The fine stuff passes through the sieve and falls down into a kiln, where it is dried and passed into a stamping press. The stamper turns it into briquettes, weighing half-a-pound each, at the rate of sixty or seventy briquettes per minute. The advantage claimed for this process is that, owing to the briquettes being artificially dried, they contain a smaller percentage of water than those dried in the open air under the Press Torf system, and that consequently the heating power is much greater. This manufacture also can be carried on regardless of weather.

PEAT DUST (MULL) FUEL.

American experts have lately been making a series of comparative "consumption" tests between coal in bulk and pulverized coal, the results showing that "slack" or "smudge" fuel, in the matter of economy, has a 20 per cent. advantage over hand-fed furnaces. As in the case of oil fuel, the dust has to be blown into the furnace, and, no doubt, any such automatic method of firing must result not only in economy of fuel but also in the greater regularity of steam generation—a matter of greater importance to the attainment of economy than is generally recognised. Here again read peat for coal, for an unlimited supply of "mull" can be obtained at a comparatively infinitesimal cost. Manufacturers of moss-litter will, in this process of firing, find another use for their impalpable powder. There is said to be nothing new under the sun, and this mode of firing is certainly no novelty. Years ago Dr. Whelpley, of Boston, U.S.A., by means of a mechanical pulverizer—not comparable with our modern disintegrators and grinders, making 5000 revolutions a minute—coupled with a peculiar mode of combustion, claimed that with refuse coal ground to dust he made this powder do *six* times the duty of the best coal. Probably there was considerable stretch of imagination in this claim, but, undoubtedly, a great saving was effected. Our makers of machine-stokers might advantageously turn their attention to the production of a suitable process. Powdered peat has been used with marked success for a number of years at Jonkoping, in Sweden. At a demonstration of this fuel cold fire-bars were put down in the heated furnace, and melted in five minutes. A crucible full of glass material was liquefied in four hours, twelve being the usual time with other fuel. While intense heat can be thus produced, it can be kept absolutely under control, and the temperature of the furnace regulated as desired. The calorific value of the flame temperature of peat, when burnt with air, has been determined by Mr. P. Mahler in his bomb calorimeter. A comparison of the figures given below shows that the flame of peat has a higher calorific power than all the other fuels tested except the smithy coal from Roche la Molière and the anthracite from Commentry.

—	Calorific Power.		Flame Temperature.
	Water Condensed.	Water as Vapour.	
	Calorics.	Calorics.	°C.
Oak wood, Lorraine	4690	4370	1865
Peat, Bohemia	5900	5590	2020
Lignite Trifail, Styria	6650	6370	1960
Flaming coal, Blanzy	8350	8060	1990
,, Decazeville	7840	7530	1960
Oxidised (weathered) coal, Commentry	6380	6200	1960
Gas coal, Commentry	8410	8110	1950
,, Bethune	8670	8380	1990
,, Lens	8740	8450	2010
Cooking coal, S. Etienne	8860	8580	2010
Smithy coal, Roche la Molière	8860	8600	2030
Semi-bituminous, Auzin	8660	8430	1980
Anthracitic, Commentry	8460	8290	2030
,, Kebao, Tonkin	8530	8370	2020
,, Creusot	8690	8480	2010
Pennsylvanian anthracite	8266	8141	2000
Ethylic and methylic alcohol	—	—	1700
Amylic alcohol	—	—	1850
Crude American petroleum	—	10400	2000
Petroleum spirit, American	—	10270	1920
Refined petroleum, American	—	10280	1660



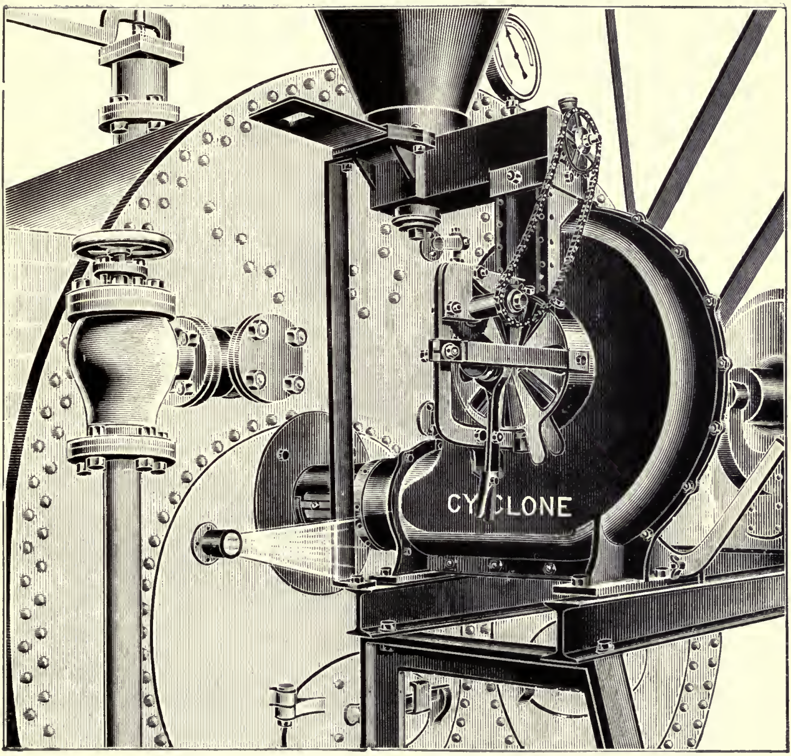
CYCLONE DISINTEGRATOR.

The advantages and possibilities of burning coal or other fuel in a very fine state of division, mixed with the right proportion of air for complete combustion, have been known and appreciated for a very long time, and boilers with this system have been worked in various places from time to time, invariably with economy and success. Many have in former years, however, been abandoned in consequence of the difficulty of obtaining a constant and uniform admixture of coal and air, regularity of feeding, and a uniform finely ground coal at a reasonable cost. These difficulties have now been overcome. By the use of the Cyclone System and by continual experiments with different forms of combustion chambers, and methods of feeding, successful practical results have been obtained, and the system can be seen at work daily in London, giving results that no other system can claim, and being in itself a most simple and practical process.

The system, briefly described, is to reduce any gaseous coal (those containing about 25 per cent. or more of volatile matter are most suitable) to a powder of about 100 mesh (or 10,000 holes in the square inch); to mix this with air, in the correct theoretical proportion, and pass this mixture, either by natural, induced, or forced draught, into the combustion chambers of the boiler or heating apparatus. All fire boxes, dead plates, etc., are removed from the boilers, and a combustion chamber of fire bricks is built to receive the coal and air in a similar manner to burning gas. The brick work attains white heat and keeps up combustion. The flame is all that is necessary—a little oily waste or wood fire and the coal catches immediately—the charge being gradually increased to the full or necessary consumption, all being regulated by dampers in the stokehole.

In Paris one manufactory has employed this system on five Belville boilers for five years, using cheap small coals and obtaining full efficiency from them, while one man looks to the five boilers. A convincing illustration of the value of the efficiency and economy of this system of firing is furnished by the Tramway Electric Co. of Brussels, where at their depot at Ixelles they have three Babcock & Wilcox's boilers, each of about 400 square metres heating surface, driving three pairs of horizontal engines. Each engine works a dynamo of 500 ampères and 500 volts. One of these boilers has been fitted with the powdered coal system, and the latest results are so satisfactory that the company contemplate erecting a central station on this system. One boiler using 13,860 B.T. units, hand fired, gives 9·22 lbs. water evaporated per pound coal from and at 212° Fahr. (equal to 64·3 per cent. efficiency), the boiler fitted with the coal of 12,554 B.T. units gave 10·3 lbs. per pound coal from and at 212° Fahr., or 79·3 per cent. efficiency, and, moreover, was able to drive two engines against one from the hand-fired boiler. This, however, was its maximum duty, and it could hardly maintain this all day. The increased efficiency was thus 15 per cent., and there is a still further saving in the price of coal. The saving in coal by weight alone amounts to 11½ per cent., although the cheaper quality contained 18 per cent. of ash.

In a 30 feet by 8 feet Lancashire boiler now working at the Central Cyclone Coy.'s works, 345 Cable Street London, E., equally satisfactory results have been obtained. These results are given in the annexed tables. This boiler works with an economizer and a chimney only 33 feet high, the draught being obtained by a gas engine and fan at foot of the chimney in order to obtain full draught with a cold boiler. The fire bars, etc., are completely removed, and the flues lined with fire brick for about 10 feet. A bridge and baffle of special form are placed inside each flue. A feeding or stoking apparatus is fixed in front of each furnace, and occupies a space of three feet from the front plate. The mixing and feed of coal powder is worked entirely by the draught, and the hoppers containing the coal over each feeder are fed by a worm conveying the powder from the pulveriser plant. The steam pressure falls very little during the night when



CYCLONE AUTOMATIC STOKER (AS APPLIED TO FURNACE).

the works are shut, there often being more pressure in the morning than when left at night, this being due to the brickwork giving off its heat. The fire is started in about three minutes in the morning and steam very quickly raised, and so long as the coal is delivered regularly there is little for the stoker to do. Sight holes are provided, and from the colour of these it is easily seen if the furnace is working regularly.

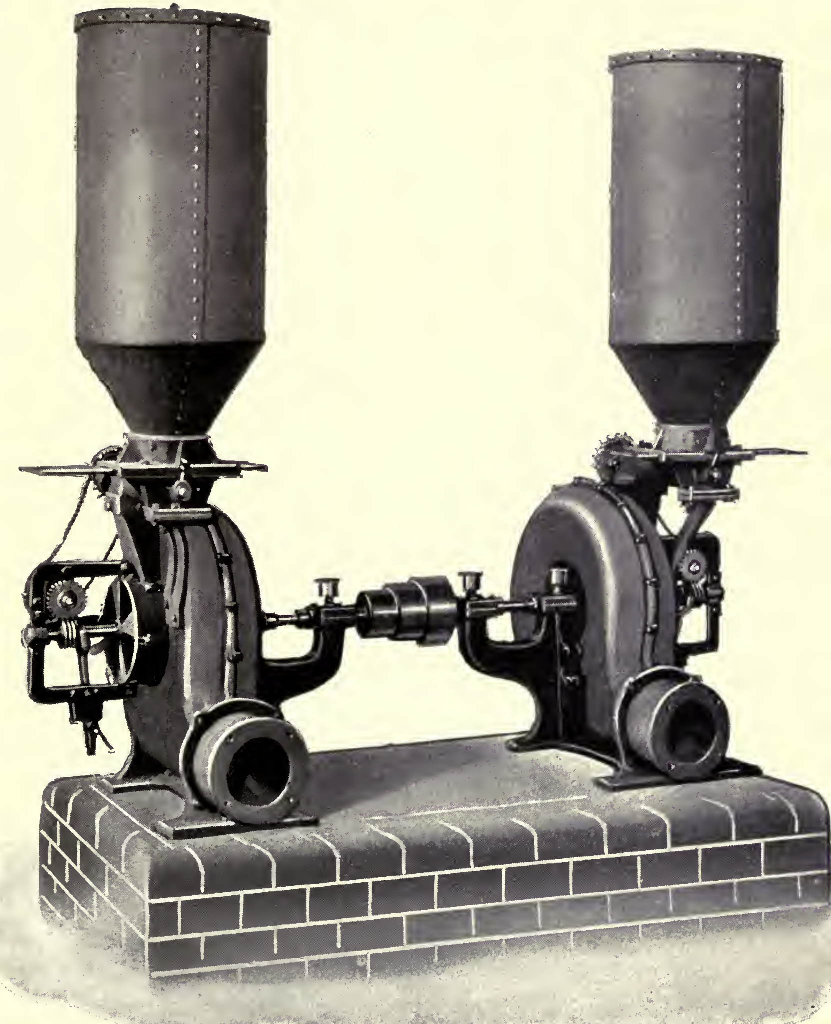
RESULTS OF BOILER TRIALS.

Date	2.12.02	17.4.02	21.4.02	5.4.02	8.4.02	Dec. '96	
Boiler	London. Lancs. 30×8 & Economiser.			Brussels. Babcock&Wilcox		Berne. Cornish.	
				HAND	POWDER	HAND	POWDER
Duration of trial hours	6½	2	2	6	6	9·5	95
Steam pressure, lbs.	75	80	87	135	135	98	99·8
Feed temperature, Fahr.	42	53	53	77	77	62·4	58·8
Coal burnt, lbs.	3011	1097	1030	6600	7050	1528	1328
Coal per hour	463	548	515	1100	1175	161	140
Water evaporated, lbs.	20500	8800	9100	51348	61428	12544	12923
,, per hour	3155	4400	4550	8558	10238	1325	1360
,, evaporated per lb. coal	6·88	8·02	8·83	7·78	8·69	6·87	8·1
Water evaporated from and at 212° F.	8·23	9·62	10·6	9·23	10·3	8·21	9·73
Maximum theoretical evaporation	10·2	14·1	13·4	14·35	13·0	13·8	13·5
Percentage of efficiency	81·37	68·3	79·0	64·3	79·3	59·7	72·21
Thermal units in coal	9853	13624	12962	13860	12569	13316	13028
Moisture ,, ,,	12·74	2·8	3·0		} 30·8		
Volatile matter ,,	30·06	30·2	21·6				
Coke ,, ,,	45·24	62·0	59·0		51·10		
Ash ,, ,,	11·96	5·0	16·4		18·10		
Heating surface of boiler	930	square	feet	4300	4300	368 sq.	feet
Heating surface of economiser	900	,,	,,				
Evaporation per square foot H.S. boiler	3·39	4·73	4·9	2·0	2·38	3·59	3·7

The actual saving in the London trial is shown by the fact that on the old locomotive boiler Welsh coal at 27s. per ton had to be burnt, whereas on the Lancashire boiler coal at 12s. 6d. per ton was used. Slightly more of the latter had to be burned owing to its inferior heating qualities.

The cost of grinding varies to the size of the installation and the quantity dealt with. The larger the installation the less the cost, but 1s. per ton to include depreciation, interest, power, wear and tear, labour, etc., may be considered an outside figure. On the other hand, there is a considerable saving in labour from fewer stokers being employed. Taking a battery of say five boilers working day and night, burning six cwts. of coal per hour each, or thirty cwt. per hour, the requirements would be two stokers to clean out flues, start fires and watch boilers; two men to mind the pulveriser if working day and night, or one man if sufficient coal be ground and stowed in the hoppers for night running. The Cyclone Pulveriser Class 1 will give 18 to 20 cwt. per hour of the required powdered coal, taking 19 horse-power. The class 2 machine will give 35 to 40 cwt. per hour with 24 horse-power, and the class 3 over 60 cwt. per hour with 40 horse-power. The wearing parts of the pulveriser are the steel beater arms, and these are easily renewable. Practically the raw coal is shot into the hopper from carts, or ordinary mode of delivery, and it is never touched by hand or seen again. Having removed the ordinary furnace and fire-grate, a special front is fitted to each furnace, and, as already stated, a fire-brick arched chamber is built in the furnace. The apparatus for feeding the coal consists of a hopper for each furnace, fed by an elevator and a worm; the hopper delivers through a special feeding apparatus to the suction of a fan, where the powdered coal is well mixed with the air, and delivered into the furnace, where it burns practically like gas flame. The coal feed is regulated by a small worm conveyer driven by a pitch chain off the fan shaft, and can be very easily regulated. The quantity of air used is regulated by "hit and miss" slides into the suction fan.

Messrs. Burstall & Monkhouse, 14 Old Queen Street, Westminster, made careful tests of this method of firing, and summarising generally the results of their test, reported: "We consider that, taking into consideration the good efficiency, absence of smoke, little attention



CYCLONE AUTOMATIC STOKER.

required, ease of regulation, and convenience of the apparatus, the system is one which is most suitable for use." In this peculiar case coal was used costing only 12s. per ton delivered, the cost of pulverising being 1s. to 1s. 2d. per ton. The cost of best Welsh coal, which would have been used in an ordinary boiler, to ensure smokelessness, would be from 24s. to 25s. per ton. *A perfect combustion of coal was obtained,* as was shown by the large percentage of carbonic acid in the samples of combustion collected for analyses:—

Carbonic acid, - - - - - -	15·1
Carbonic oxide, - - - - - -	0·0
Oxygen, - - - - - - -	3·5
Nitrogen, - - - - - - -	81·4
	100·0

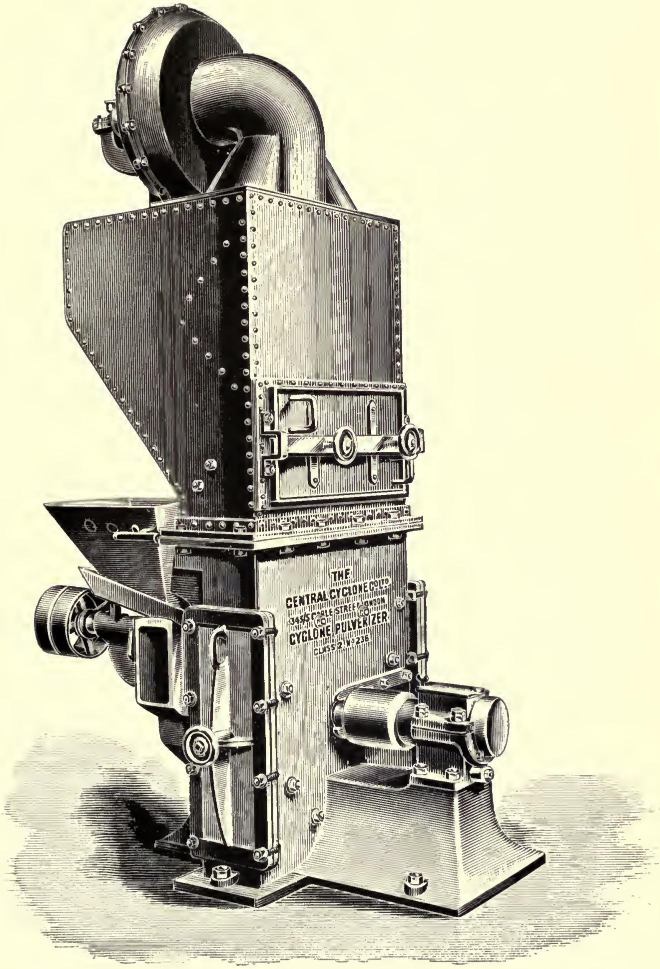
Under more favourable circumstances, there being a leakage of air in the brickwork of the boiler, a still better efficiency would have been obtained. Despite this consequent reduction of the temperature of the furnace gases, the efficiency of the boiler alone (an ordinary Lancashire boiler was used) was 65·4, and the boiler and economiser 76·5.

As all uncarbonised dust fuels carry possibilities of explosion, it may, in theory, be rightly argued that there is danger in the coal dust. In practice, however, there have been no explosions in the grinding, nor has it fired after being pulverised. By this system the danger is reduced almost to an impossibility, for the ground material is deposited in a setting chamber of wood and canvas, and a lighted candle may be put in this chamber, which is full of floating powder, without causing any explosion. A Berlin firm that has been engaged in grinding coal for the last twenty years have never had any explosions, although these works are lighted by gas. The risk, therefore, is not worthy of consideration.

Peat giving out little or no smoke and abundance of gas, a constant hot flame is kept up, combustion is almost perfect, there being no soot and, as has already been said, no cinders or clinkers (peat mull can be manufactured into briquettes, with or without an imflammable plastic binder). Its own acid tar readily and cheaply procured by low distillation, can, if needful, be so utilised; or by heating it to 180° the material gives out its own tar.

In Germany there is a briquette trust controlling thirty-one firms or companies, or more than nine-tenths of all the producers of the Empire, regulating the output and prices for each year. Of the 1,566,385 tons sold during 1901 by this combine, 749,208 tons were taken by the German railways, 124,380 tons were sold to retailers, 497,136 tons were disposed of to various factories and works, and 149,089 tons, or 9·8, were used by the German navy and merchant marine, or exported. The Thuringian Aktiengesellschaft, at Deuben, near Halle, makes briquettes of brown coal in which no matrix or binder is used. The manufacture of briquettes from brown coal (lignite, a vegetable coal of recent formation, and therefore, a less perfectly carbonised structure, and of lower caloric value than anthracite or bituminous coal), has long passed the experimental stage, and become a standard commercial industry. The utilisation of various coals and peat dusts in combination is a subject of importance. Repeated experiments have demonstrated the fact that coal dust mingled and manufactured with peat, in such proportions and in such a manner as to produce a compound of great strength and solidity, burns more freely than coal, and, converted into briquettes, yields an intense heat. It cokes perfectly, and is peculiarly well adapted for raising steam; also is well adapted for the smelting of ores and the manufacture of gas for power and for illuminating purposes. In Germany peat mixed with wood or charcoal is very extensively used in the production of iron, the greater proportion of peat employed the better being the quality of the product.

Peat fuel, like wood, is improved by age if properly housed and sheltered from rain, snow and frost, and sun.



CYCLONE PULVERIZER.

(Hard coal exposed to the weather loses in bulk 8 per cent. per annum; soft coal fully 12 per cent.) It is in its best condition for use at the end of six months, when it may be said to be perfectly cured. The compressed artificial briquettes may be used immediately after delivery from the machine, but should not be exposed to the weather. A good article of fuel deserves being taken care of. Bituminous peat, air-dried, becomes covered with a skin or envelope, which to a great extent protects it from the wet, and this is common to most peats.

A new fuel has been introduced by the Randall Synthetic Coal Company, of Boston, Mass., U.S.A. It is a mixture of peat and petroleum. The peat is raised from the bog by a clam—shell digger or dredger, and conveyed to a disintegrator, which separates the fine from the coarse material. It is then treated to expel the water, and again disintegrated. Lime is then added, and the whole is dried. Petroleum, with bituminous pitch as a bind, is intermixed with the peat in a pug-mill, and the mass is then pressed into briquettes. Following on this, a suggestion to manufacture peat-petroleum has been brought forward. Some extensive experiments have already been made with coal briquettes in the French navy, and with such favourable results that our neighbours are prepared to place large orders for this fuel as soon as American petroleum owners have perfected the manufacture of their briquettes. The experiments made with oil fuel on H.M.S. "Hannibal" and "Mars" have, so far, been satisfactory as regards the generation of steam, but observers of the trials complained of the latter belching forth a plume of greasy, dark-grey smoke, which would have given her away to an enemy ten miles off. The "Hannibal" returned to port with leaky oil tanks. This betrayal by smoke given off can surely be obviated. The historic trials with liquid fuel instituted by Admiral Selwyn years ago have proved that the smoke difficulty can be overcome. Messrs. Armstrong, Mitchell & Co., the well-known engineers and shipbuilders, claim to have vanquished this foul fiend. If the Admiralty is at sea in regard to the way in which oil should be burnt let it consult with Dr. P. Dvorkovitz, Principal of the Petroleum Institute. Perhaps the Wilson smokeless process may solve the difficulty. This simple remedy consists of injecting a mixture of air and nitrate of soda solution over the fire. The smoke, it is claimed, is not only prevented, but there is an increase of more than 20 per cent. in the output of the boiler and its evaporative efficiency. The theory advanced by the inventor is that the solution of nitrate of soda creates nuclei of intense heat, which fire the gases and enable the injected air to combine with them. As for the leakage of tanks, that suggests carelessness, and is a subordinate point easily overcome. There is no more difficulty in carrying a mineral oil-tank on a war vessel than on a trader or on a railroad. The advantage of such a fuel as peat-petroleum briquettes would be very great if it can be put on the market at such a price as will render its use as economical as that of coal. In Scotland there is a vast amount of peat in close proximity to the shale-oil distilleries, and the briquettes could be laid down at the new arsenal by the Forth Bridge in any quantity and at a cheap rate. One of the earliest experiments with oil fuel for naval service was made about 1867 on a small gunboat, the "Palos," belonging to the United States navy. In forty-eight minutes she ran eleven and a-half knots, whereas her best record with coal was eight knots. The engine-room staff was cut down from twenty firemen and passers to three hands. The petroleum was supplied from two large iron tanks on deck, each with a gauge at its side to indicate contents, and a vent-pipe on top to permit escape of vapour. From these the oil was conducted through half-inch pipes to the furnaces. Thence it dropped into heated iron retorts and was instantly vaporised. To this mixture of vaporised petroleum and decomposed steam there was added a percentage of oxygen, supplied by atmosperic air forced in by an ordinary air pump. *The heat was intense, and the combustion so perfect that there was no smoke.*

CHAPTER III.

PEAT CHARCOAL OR PEAT COAL.

In a paper read by Professor Brande in 1851, before the Royal Institution, he said, "Peat may be rendered valuable either from the charcoal which may be obtained from it or by various products derivable from what is called destructive distillation." Of this destructive distillation and the distillates resulting therefrom, we shall have something to say later on. When it was desired to convert peat into charcoal, the plan adopted by the Irish Amelioration Society was to carbonise blocks of peat, partially dried on wicker-work trays, in movable pyramidal furnaces. The charcoal so obtained varied in character with the peat from which it was produced, and when the peat was compressed, previous to its carbonisation, the resulting charcoal exceeded common wood charcoal in density. Professor Johnson, who is frequently quoted as an authority, states that "when peat is charred it yields a coal or coke which, being richer in carbon, is capable of giving an intenser heat than peat itself, in the same way that charcoal emits an intenser heat in its combustion than the wood from which it is made." It is stated that one firm working at Laincourt, seven leagues from Paris, in 1855 converted some ten thousand tons or more into charcoal, obtaining from forty to forty-two per cent., and sold wholesale for one hundred francs the one thousand kilograms (two thousand two hundred and four pounds), which was then about the same price as wood charcoal, and about three times the price of wood and mineral coal of the same weight. Again quoting Professor Johnson, we find him recording his opinion that "a peat which is dense as the result of proper mechanical treatment and slow drying, yields a very homogeneous and compact coal, superior to any wood coal, the best qualities yielding nearly twice as much per bushel." Mr. V. Lamy made a series of experiments to determine the quantity of heat evolved by the burning of peat compared with other combustibles. One kilogram, or 2½ lbs., of the varieties mentioned below evolved caloric as follows:

Wood charcoal	75 Parts.
Coal coke	66 "
Charred peat	63 "
Bituminous coal	60 "
Charred wood	39 "
Dry wood	36 "
Raw peat	25 to 30 "
Wood with ¼ moisture	27 "

It must be observed that the "charred peat" here referred to was charcoal from air-dried carbonised turf, not from compressed briquettes. As in the case of wood, peat charcoal produced by burning the turves differs somewhat in various localities. The raw material should be of the most suitable quality, and the carbonisation perfect, though not overdone. Dense peat should be selected, that of a fibrous nature being unsuitable, as in coking or charring it yields a friable coal. Charcoal made by a low red heat, not exceeding cherry red, and which has a dull surface, is the most valuable. If the heat be carried beyond this point it acquires a brilliant metallic surface, and deteriorates in quality. That best suited for forging purposes is one that burns slowly and deadens so soon as the blast ceases. If imperfectly carbonised it may contain a sensible amount of hydrogen. Charcoal burning is effected in the open air in piles or stacks provided with a yielding cover; in pits, in kilns or chambers of brick or stone; or in iron retorts heated externally like common gas retorts. The method of pile burning is that most extensively practised, and to this process the rectangular blocks or turves are well adapted, since the material in this form admits of closer packing in the heap. Heaps six to eight feet in diameter, and four feet high, are a good size. The object to be kept in view is the greatest amount of compact fuel from a given weight of raw material. The system of charcoal burning in the pile may be adopted in treating peat, and is as follows:—Pieces of lumber of equal length are piled concentrically round a chimney or vent formed by driving three stakes perpendicularly into the ground (in the case of peat this vent can be built up of turves). The pieces of peat to be charred are then built up against this chimney on end, and with a slight but gradually increasing inclination or lean-to. A second row, or, in the case of very large piles, even a third is built round in a similar manner, one outside and over the other. The pile or pyramid is then covered with turf or soil to exclude the air and retain the heat, and is kindled by filling the space between the three upright stakes with easily inflammable wood, which is lighted. The character of the smoke or reek issuing from small vents made in the pile indicates exactly the degrees of carbonisation in the different parts. When the charcoal is drawn from the pile, it is extinguished by cold water, dust, or dry soil. The Chinese, large users of charcoal, practise the method of charring in pits.

In the United States the Pierce process is largely used for the preparation of charcoal and the recovery of the by-products. Some of the kilns are of large size, capable of heating as much as 60 tons of wood at one time. The wood is heated in brick kilns, 32 feet in diameter and 16 feet high in the centre, and hold 55 cords of wood. The oven being charged with wood-gas, from a previous operation, together with the requisite amount of air for its combustion, is sent in by means of steam jets. As the wood dries steam is given off, and is allowed to escape into the air. After about eighteen hours the wood is quite dry, and distillation begins. The top of the kiln is then closed, and the exit tubes are connected with the condensers. These condensers are a series of copper pipes set in wooden boxes about 4 feet square and 14 feet long, through which the water circulates. The products of distillation are drawn away by means of fans and passed to the condensing apparatus, and the uncondensed gases, mixed with the proper proportion of air, are returned to the kiln. The carbonising occupies six or eight days, after which the kiln is allowed to cool and the charcoal is drawn. The whole operation—charring, carbonising, cooling, and discharging—occupies eight days. There is more gas than is required for charring, and the excess is used for raising steam. The kilns are set in batteries of sixteen, each set having its own fan and condensers. The charcoal so produced weighs about 20 lb. to the bushel, and is of excellent quality (*Fuel*, *Sexton*).

The uses to which charcoal can be applied are numerous and varied. The high heating power of peat charcoal, and its freedom from properties deleterious to metal, invest it with peculiar interest to the smelter. It must find a great future in the new process (Neuhausen) of manufacturing aluminium. As a loose granulated substance in conjunction with the porous earthenware slabs (see chapter on Peat Earthenware) for filtering operations at waterworks and in the household, the demand must be great. These slabs can be freed from all organic matter by being replaced in the kiln and reburnt. As iron manufactured by the aid of vegetable charcoal does not splinter, our makers of armour plates would find it to their advantage to experiment with charcoal iron. For horse shoes it has no rival. The Swedish iron, on this account, stands first in the market. The Bowling Company's iron, which, excellent though it be, is not comparable with bar iron produced by peat charcoal, sells (these prices are those of ten years back) at £17 to £19 a ton; whereas the brands known as "K.B.W. Crown Best Best" was quoted at £7 7s. 6d. a ton, and "B.N.F. Treble Best" at £9 5s. In France there is a large demand at the Catalon Forges, French Pyrenees, where the price not long ago of wood charcoal was 54 francs or 45s. a ton. Monsieur M. Challeton de Burghet, a French gentleman of great experience manufactures this fuel, it is said, at a profit of three hundred per cent. Owing to the value of the other bye-products evolved in the process, this charcoal costs practically nothing to manufacture. The Paris *chef* pays from £6 to £6 8s. per ton for his culinary peat-charcoal, and greatly prefers it to that of wood. Of late it has been largely used in the various cold dry air storage systems. Fresh burnt peat charcoal bleaches all the vegetable dyes. It can be moulded into hard and solid briquettes and flat slabs, and can, in fact, be shaped to any form required.

Probably the best and most economical method of converting or condensing peat into charcoal is the low distillation process advocated by Paul Dvorkovitz, by which all the valuable bye-products are obtained by a continuous automatic system, at a low cost. The distillation of peat for its bye-products is no new idea. Mineral oil and paraffin was produced on a large scale at works established at Marahu, in Brazil, in 1899. In the *Journal of the Society of Chemical Industry*, there is an account of this establishment, which was producing no less than 80 tons per month of solid paraffin for candle-making. Discarding all previous methods, including carbonisation by superheated steam and by burnt and consumed gases, this chemical expert uses a comparatively low temperature, and gasifying in the presence of an inert gas which has no chemical or destructive influence on the substances received, but possessing the mechanical effect of extracting all the bye-products, including the charcoal.

The results obtained by Dr Dvorkovitz, who has had a large experience in dealing with peat in Russia, and whose investigations extend over the chief bogs of Ireland, were embodied in a lecture delivered by him before the Society of Chemical Industry in London. This lecture will be found in the appendix. The cost and profits of the process worked on a large scale are estimated as follows:—

Low Distillation of 100 Tons of Peat:—

Products—

35 tons of charcoal at 25s per ton - -				£43	15	0
1 ton of 80 per cent. acetic acid - -				17	10	0
70 gallons of naphtha solvent at 1s per gallon				5	10	0
6 tons of paraffin oil at £2 10s per ton -				15	10	0
$1\frac{3}{4}$ tons of sulphate of ammonia at £12 per ton				21	0	0
				£100	15	0

Cost of Manufacture—

100 tons of peat at 5s - - -	£25	0	0			
10 tons of peat fuel at 3s 6d -	1	15	0			
Labour and depreciation -	12	0	0			
Sulphuric acid - - - -	6	10	0			
				45	15	0
Net profit				£55	0	0

The cost of erecting a continuous plant to distil 100 tons of peat per day should not exceed £1500 to £2000.

There is always a ready sale for these bye-products:—*Acetic Acid* is largely used in dyeing and calico printing, in pickling and preserving animal substances. *Proxylic Spirit*, *Wood Spirit* or *Hydrated Oxide of Methyle*, commonly known as *Methylated Spirit*, is used chiefly in vapour lamps, in dissolving resins and volatile oils, and especially shellac for varnishes. Of late years the demand for methylated spirit has increased considerably, and in the near future promises to attain still greater proportions The French in particular are turning much attention to this distillate. At the late International Exhibition of Automobiles at Paris there was a special section for "alcohol" or methylated spirits and its application for driving motor cars, lighting, and heating generally Among the various exhibits were some excellent lamps for household use, notably those of Landi, Denayrouse, and Dalamotte, fitted with mantles like the Welsbach gas lamp. There was a clever radiating household stove for heating purposes, the invention of Mr. Barbier. This stove consists of a reservoir from which the alcohol is drawn by wicks into a boiler, where it is vapourised and the vapour, mixed with air, passes into the upper chamber or furnace, where it blazes, heating a metal cupola from which warmth radiates into the room. Some of the heat is also applied to vaporise the alcohol. Open fires resembling asbestos gas fires, were also on view. There were a number of hand or portable heaters for cooking, as well as other evidences, that this alcoholic production industry is destined, at no distant date, to become largely developed. *Naphtha* is used for making varnishes and for dissolving caoutchouc. According to the *Annual Scientific Discovery,* peat, "in addition to gas and ammonia, yields a peculiar acid, and a bituminous adipose compound, which is called 'paranapthadipose.'" One of the products of this is a good solvent of guttapercha, caoutchouc, etc.

The crude *Sulphate of Ammonia* is principally used for manure, and in the preparation of Sal-ammoniac and sesqui-carbonate of ammonia. A mixture of 10 per cent. of this sulphate with 20 per cent. of bone dust, some gypsum (native sulphate of lime), and farm manure gives a manure greatly superior to what is now commonly vended as guano.

Paraffin is largely used for making candles, for which purpose it is specially adapted, surpassing all other candle materials, even spermacite, in illuminating power. It is also added to starch to give a gloss and brilliancy to the ironed surface of linen.

Carbon pencils for electric light are manufactured from peat charcoal. At present this industry is conducted chiefly at one factory, controlled by an American trust, and by German firms. The field is a wide one, for these American works cover eighteen acres of floor space, employ five hundred men, and turn out four millions of carbon a week.

It is not generally known that the British army and navy is, at present, almost entirely dependent upon Germany for carbon used in the searchlights of coast defence stations and on war vessels, and that British municipalities have mainly to depend upon the same source for their electric lighting. Our relations with Germany are none too friendly, and at any moment we may find ourselves at war and helpless, and the Metropolis and our great towns and works in utter darkness. Here, then, is a grave national danger.

There is only one factory in Britain where carbon is manufactured, and there it is made at a loss owing to the cutting of prices by German firms. Mr. Hirst, of the General Electric Company, recently stated "that several attempts have been made to run carbon factories in this country during the last twenty years, but all have failed. Factories have been started in London, and at Barnsley, Brymbo, and other places, but in every case the owners were unable at the outset to sell at the prices charged by German firms. It is impossible to start the industry here under present conditions, but if a tax could be imposed on imported carbon while British labour is being taught to produce it as cheaply as Germany can, it would greatly help. The General Electric Company have laid out £70,000 on land, buildings, furnaces, machinery, ovens, and presses for their carbon factory near Birmingham. The first year was spent in training labour. The result was that we dropped £15,000, and about one carbon in ten was fit for use. When we succeeded we began to sell carbon at the then current price of the German article—viz. 37s. to 40s. per 1000 feet of a certain quality and diameter. The Germans at once dropped the prices charged to English customers, and to-day they charge 25s. here and from 37s. to 40s. in Germany. The Free Traders say that we get our carbon cheaper because of this competition, but if we were to close our factory to-day, carbon would go up to its original price to-morrow. We are compelled to charge the same price as the Germans. Certain municipalities, however, from patriotic motives, give us better prices, and we get small contracts at more than the market price from the Admiralty and War Office. But our Birmingham carbon factory is really run at a loss. In the event of war with Germany at any time, it is contended, this country would be absolutely without carbon for the searchlights and the coast defences, while the majority of our streets and cities would be plunged into darkness."

By adopting a newly discovered and patented process for the manufacture of peat charcoal, we are confident that the German system of dumping can be met and overcome.

Peat charcoal promises to take a leading part in overcoming the smoke nuisance, promoting at the same time thermal economy. It has been found that when smoke has been passed through a filtering medium of peat charcoal, saturated with petroleum, this medium retains all the particles of soot and carbon in the smoke, and the gases, combustible and non-combustible, being enriched and charged with petroleum, thus make a superior gaseous fuel. Part of the heat goes to vapourize the petroleum, and part for lighting, heating, and motive purposes. The carbonized coke also makes a rich fuel, so that all the smoke is utilized. The gas can be used without purification, scrubbing, or brushing, in internal combustion engines. It is cleanly and convenient, and is important as a producer of power in gas engines.

The future demand on an extensive commercial scale for peat charcoal is assured by the new discovery of its application, in the form of briquettes, in conjunction with peat tar, in the process of smelting iron ores. To this we desire to direct special attention. Irrespective of our own low grade ores, there are millions of tons of iron sand to be found on the shores of the St. Lawrence, in Canada, and the Tesanki, in New Zealand, all of which, by the processes known as the Robert Strong and the Elmore oil, can be smelted in the open hearth, and rendered of marketable value.

The recent discovery in connection with the application of pyro tar, one of the bye-products of peat already referred to as being obtained in the process of low distillation, and as a bind in the manufacture of non-porous briquettes of the low grade pulverized iron ores of Ireland, Cornwall, and North Devon, is of the greatest importance in the direction of developing these lodes. Further, it, in conjunction with the Elmore oil separation process, appears to solve the difficulty of utilizing the large magnetic sand deposits on the Gulf of St. Lawrence and in New Zealand. Vast quantities of iron ore, in the form of dust, are found also in the United States, many of the American ores having the appearance of soft earth or stones which had been disintegrated. These broken up ores and the materials for making briquettes suitable for the blast furnace exist also in Sweden, Norway, and in Spain. The system is the invention of Mr. Robert F. Strong, and, with a view of ascertaining the adaptability of these briquettes compounded of ore, peat-tar, lime and peat-charcoal, they have been tested at the Leeds Steel Works, at the Normanby Iron Works, Middlesborough, and at the Clyde Iron Works. These briquettes were tested in various kinds of furnaces for temperature, and they were also mechanically for carrying the burthen, and, both as regards their behaviour at the highest temperatures and their resistance to crushing, they were found in all cases to stand equal to raw ore. No alteration of the blast furnace was required.

Many interesting particulars of this Strong process will be found in an instructive paper, read by Mr. Thomas B. Grierson, M.Inst.C.E., at the Royal United Service Institution, on "The Treatment of Low Grade Iron Ores for the Smelting Furnace." After dismissing Mr. Edison's secret system of binding iron ore briquettes as not having realized the results claimed for it in inflated, sensational, paragraphs of the daily papers, the author, who is an admitted authority on peat, and who occupies a high position in the engineering world, gave the following particulars of the Strong process, which possesses the merit of being of British origin, and which has been adopted at the Broken Hill Mines in Australia, also at the Rio Tinto Works in South Wales, where it is worked upon copper concentrates. "Mr. Strong," he remarks, "has not devised machinery for the mechanical reduction or for the concentration of the ore, knowing that there is ample and efficient machinery for the reduction or concentration of the ore, and that there is ample and efficient machinery at hand by various makers for this purpose. He confines himself to putting the ore into a suitable condition for use in the blast furnace. To this end he makes his briquettes of 85 per cent. concentrate, which he incorporates with 5 per cent. of powdered quicklime and 10 per cent. of pyroligneous tar—100 parts. The mass is formed into briquettes under pressure, the briquettes being ready for use directly they leave the press, do not require to be baked as Edison's do. The tar in the briquettes is of assistance in economizing fuel in the blast furnace, while the quicklime forms the best possible binding material, and also assists as a flux. Assuming the concentrate to contain 75 per cent. of iron ore, which it does on an average, the briquettes would contain 63·75 per cent.—equal to 47·81 per cent. of metallic iron. The briquettes would be manufactured *in situ* at the mines at which the ore is produced, and delivered to iron works in England at the market price of the ore. They would, however, have an advantage over the raw ore, owing to the fact that they would be more easily reduced, and with a saving of fuel."

Such is the briquette which Mr. Strong has devised for employment in the blast furnaces using ordinary coke fuel. He has, however, devised another ore-briquette for use in the charcoal furnace, in which the ingredients are varied. In the ordinary furnace—except the very small ones—the charcoal will not carry the burden. With small furnaces, the production is necessarily restricted and costly. To meet this, and to enable the briquettes to be used in blast furnaces of full size in those countries where charcoal is employed as fuel, Mr. Strong combines powdered charcoal with the other ingredients, adding also granulated limestone as a flux. By this means charcoal pig-iron could be produced in the ordinary blast furnace at a less cost than common foundry pig, and this charcoal pig would be available for ordinary steel making, with the result of greatly improved products. The pig-iron would thus be produced *in situ* at the mines, and no carriage or freight would have to be paid upon the ore. The cost of transport to the steel works would be that of the metallic product alone., the matrix being left behind in the form of slag.

Mr. Strong proposes to systemize the method of production of briquettes at the mines so as to render the operation continuous from first to last. By a purely mechanical arrangement the rock ore will be mined crushed, concentrated, made into briquettes, and delivered direct to the blast furnaces, while the molten metal would be run into pig-moulds, and delivered thence into railway trucks (or into canal boats) for shipment. The manufacture of pig-iron would thus be a continuous process, with a great saving of cost, as against the present mode of producing pig.

As regards the cost of mining and concentrating the ore ready for the briquette factory, the author gave the following figures, which are those of actual working in a mine in Sweden. At the present time (May, 1901) the cost works out at 4s 3d per metric ton of 75 per cent. concentrates. This includes miners' wages, tools, explosives, crushing and concentration, loading and transport to the briquette factory, and management, which comes to 1s. 8¼d. per ton of raw ore. But it requires 2½ tons of 30 per cent. ore to give one ton of 75 per cent. concentrates in Sweden—equivalent to 63·75 per cent. per ton of briquettes.

Briquettes, to be of any use in the blast furnace, should be hard, non-porous, impervious to moisture, and capable of standing rough treatment in the same way as large ore. These qualities will enable them to resist the great superincumbent weight in the blast furnace, and the slow grinding action which tends to disintegrate them. Above all, they must be able to withstand the gradual increase of temperature in advancing to the melting point, almost up to which point they should retain their form. This, in the author's opinion, is precisely what the British briquettes will do, and what the American briquettes will not do.

Before pointing out the working advantages of Strong's ore-briquettes, the author may perhaps be permitted to explain, for the benefit of those not conversant with the blast furnace practice, that the present method of charging is to put in the proper proportions of ore, coke, and limestone by hand labour, the materials being in their rough state. The briquettes are put into the blast furnace and smelted in the usual way, but instead of the quality of the metal produced being largely dependent on the attendant whose duty it is to feed the furnaces, the briquettes when smelted, produce, almost automatically, the proper material required, the proper proportions of the ingredients being fixed and invariable in the briquette.

With the present arrangement, especially during the night-shifts, any neglect on the part of the man in charge of the furnace in not putting on the proper relative proportions of the materials, would, and no doubt sometimes does, result in the metal not being uniform in character, or perhaps quite useless for the purpose intended. With briquettes this could not happen, as they would be composed of the exact quantities of the ingredients required to produce the specific result. The weighing of the ore, fuel, etc., in the method now in vogue, and the constant attendance on the blast furnace while the smelting is going on, involves considerable expense for labour, a large amount of which would be saved by the adoption of the briquette system. Mr. Grierson believes that the general adoption of the method of making steel from briquettes would result not only in large saving in cost of production, but also in a much more uniform and better quality of the steel produced.

During the discussion following, it was elicited that the whole question of the Strong process hinges on pyroligneous tar, *coal tar being useless for the purpose.* In this country it is impossible to extract the necessary supply of this acid from wood or from saw-dust, but in most of the peats we find it in large quantities, and, from experiments made with Scotch and Irish peat, the tarry acid yielded by low distillation was better than that produced from wood. Thus, districts having peat and ore can, in the future, be entirely independent of coal in the production of iron and steel, and can produce these metals at even a much lower cost than is possible under existing conditions. Practically each grain of ore is covered by pyro-tar and lime which greatly facilitates its reduction.

In conjunction with the Elmore oil process of concentration, it is now possible to smelt magnetic and titaniferous ores, also deposits of magnetite which are found associated with sulphides, such as copper pyrites, iron pyrites, pyrrhotine, and kindred ores. Advocating this system, which is of vast importance to the mineral oil trade, Mr. H. L. Sulman said—"As regards the Elmore oil method he had lately been investigating its application to a large number of mines. Two or three cases had been mines in which the magnetite was associated with various metallic sulphides, and largely with copper. Magnetic concentration had been tried, and had failed either to withdraw sufficient copper to make it successful as a copper concentration process, or to leave the magnetite sufficiently clean from sulphur and copper to render it suitable for the production of steel. As the result of many trials, he found the Elmore process effect such a separation very perfectly, and to yield pure magnetite suitable for briquetting. He had therefore advised the adoption of the oil method in place of magnetic separation. The Elmore process simply consisted in bringing the crushed ore pulps (in water) into intimate and continuous contact with heavy mineral oil. The oil had the property of sticking to the sulphide minerals, whilst it let the oxidised minerals and the gangue pass away. That very remarkable property has not, so far, been satisfactorily explained, but *the results were complete and very perfect.*

Ireland is not wanting in iron ores, and in many instances the mines, worked and unworked, lie in close proximity to vast areas of the best peat. A visit to the Irish Mineral

Note.—Of Antrim it is said that the whole county rests on a bed of iron ore.

UNIVERSITY OF CALIFORNIA

Section of the Imperial Institute will dispel all doubts on this head. There will be found examples of the oxides of Antrim, Longford, and Leitrim, with articles manufactured from the ore. Lord Trevor contributes samples of ore mined at Deehommed, Co. Down; Admiral Lord Charles Beresford's agent sends clay-iron-stone from Cavan; and from Leitrim come samples of the same mineral as mined, and in the form of pig. Samples of the hæmatite shales won in Co. Cavan are to be found in this exhibition of Ireland's mineral wealth, not the least interesting being those from the Earl of Darnley's estate, Athboy, and from other contributors. At present the Antrim iron ore deposits are being worked, and the material exported to Barrow-on-Furness. Fireclay, suitable for the manufacture of bricks for furnace lining, though the prospecting is far from complete, has been found in Co. Limerick, Co. Dublin, Co. Tyrone, Co. Kildare, and in all probability will, on examination, be discovered in the form of ball clays from the granite deposits, of which the Island possesses enormous quantities of superlative quality.

As the treatment of low grade pulverized iron ores for the smelting furnace just referred to must create an enormous demand for wood charcoal, in the form of coke peat, and as coke making and the recovery of bye-products must go hand-in-hand, we desire to call attention to the Otto coke-oven and recovery plant, which, however, so far, has only been constructed to treat coal. Of its adaptability to work equally well with peat we entertain no doubt. An objection may be raised to these new ovens on the score of the great expense of an installation, but the Otto-Hilgenstock Coke Oven Company, Limited, comes to an arrangement on the deferred payment system, by which complete plant, coke-ovens, and the necessary apparatus for the recovery of the bye-products, are erected at the Company's own cost, it advancing all the required capital, and taking the bye-products for a certain number of years in payment. The number of years over which the period of payment is extended depends on amount of bye-products obtainable. The Company has a ten ovens test plant and a staff of reliable chemists, and is prepared to analyze and report on, free of cost, any coal submitted giving the value regarding coke and available bye-products. A careful analysis of various peats has been undertaken by the Company, at the suggestion of the writer.

The general advantage claimed for this system are appreciated by such firms as Sir B. Samuelson & Company; Messrs. Bolckow Vaughan & Co., the owners of the Priestman Collieries; the Yorkshire Iron and Coal Company, Limited; and many others here and in Germany. Over 16,769 retort coke ovens and bye-product coke ovens, according to the various Otto patents, have now been built. These advantages are briefly as follows:

1. Uniform heating of the whole oven; and this great desideratum is attained to a marvellous extent. Complete control.
2. Diminished length of the combustion flues.
3. Full utilization of the heating power of the gases.
4. Possibility of a most complete supervision of the heating, and of inspecting every portion of the walls.
5. Equality of pressure in flues and coking chambers, rendering the walls practically gas-proof.

From which advantages result:—

First and foremost a very satisfactory yield and quality of coke or charcoal both in the case of peat and coal. In many plants, consisting of 60 ovens, 50 or more are drawn per day, and it is by no means unusual to have a yearly production per oven of 1700 to 1800 tons. The dimensions of the ovens are: 33 feet long, 20¼ inches wide in the middle, 5 feet 11 inches high, but by increasing these internal dimensions this production can be considerably increased. The coking or caking properties are in some instances greatly improved by compression, by which the separating air-spaces between the particles are done away with, and the volatile constituents brought into so close contact that the products of low distillation exert a binding influence. By stamping or tamping the charge can be increased from 15 to 18 per cent. Consequently, the coke is firmer and of greater density. Experience has shown that 8 to 12 per cent. of moisture in the coking material gives the best results. The Kühn coal stamping machine is rapidly displacing hand labour, and by this appliance, at a considerable saving in cost of labour, blocks 33 feet long, 6 feet wide, and 15 inches high have been successfully stamped. This machine can, if required, be constructed to perform the service of a coke pusher, by means of which the coke is pressed out of the oven to admit of rapid re-charging. The power necessary for driving this apparatus is 1 to 1½ h.-p., and the stamp attains a speed of 70 strokes a minute. The advantages are:—

1. Greater durability of the oven.
2. Increased output of bye-products and a richer tar.
3. Large productions of steam.
4. Superior quality of coke-oven gas, with a surplus for other purposes, *i.e.* for driving gas engines, illuminating, etc. The city of Boston, U.S.A., is illuminated by means of gas produced by Otto ovens. The candle-power is 18½ without any other enrichment.

"*The Peat-fuel Problem solved at last, Peat-coal by Electricity. A National Industry*" was the pretentious heading of a circular issued a few months ago by a Canadian gentleman, Mr. Joseph Byron Bessey. Unfortunately, however, for those interested in peat, a demonstration of this electric process lately given at the works of Messrs. Johnson & Phillips, Electric Engineers, Charlton, Kent, fell far short, in its results, of the advertised anticipations. Mr. Bennett Hayes, C.E., in the British Government Report on Peat, is quoted as saying: "It is obvious that to make the working of peat a commercial success the production must be continuous and uninterrupted throughout the year; with air-drying alone neither of these conditions can be complied with. The great desideratum remains to ascertain some method of getting rapidly and economically off the large amount of water which all peat in its crude state contains." This is precisely what legions of inventors have for years been striving after, and in pursuit of which much treasure has been expended. By this "improved process for the manufacture of peat fuel and fibrous peat" all difficulties, we are told, are removed, and in the short space of 2½ hours, from beginning to end, peat-fuel of high calorific power—about 9000 British thermal units of heat and upwards—perfectly smokeless, and free from clinkers, is to be supplied at a cost far below that of coal at the pit mouth. On looking over the provisional and complete specifications of the patent we confess to entertain very considerable doubts as to the future of this somewhat elaborate and certainly costly method, and when the awkward word "chemicals" presented itself our scepticism increased. When we read that, in order to assist the conductivity of the electric current in certain peats, it is proposed to add or use salts, carbonates, carbon, hydrocarboniferous, and suitable rock and other mineral ingredients, we concluded that the cost of these enrichments, not to mention the cost of production of electric current, must consume the bulk of the profits. Then when we found mention of tilting troughs for the reception of the green peat, electrodes, rollers, kneading apparatus, disintegrators, heated drums and surfaces, mechanical presses, moulds, etc., we reluctantly concluded that this inventive genius is not destined to solve the difficult problem. Shortly put, the process, as described by the patentee, is as follows: The peat is cut in the bog by the most improved method, and is then conveyed by dumping trucks to the operating plant in the vicinity. The first stage is to pass the peat through a revolving cylinder or centrifugal provided with beating fans which it is claimed press out most of the water. It is then packed firmly into tilting troughs, or rather receptacles made from wood, and electrodes are inserted at each end —or sides—to which are attached the electric wires, directly or otherwise connected with the dynamo. The mass of peat becomes the medium of completion of the circuit between the electrodes. The fibres and cells of the peat not having been ruptured and broken the centrifugal was ineffective, moreover, it travelled at far too slow a speed and was of too small a diameter for effective work. It is hopeless to expect any real result from a 2 ft. 6 in. cylinder making only some 300 revolutions. Though admitting the capacity of the electric current to separate the particles, it does not exert that tearing force which is essential. Certainly the current of 220 ampères at 200 volts used at this demonstration failed to produce "a perfectly disintegrated and pulverised material." Electric energy for this purpose had previously been applied in Germany, the United States, and Canada, and had been abandoned. But further than this, the visitors were informed by a printed paper handed round that the electric heat dried out the peat, but when we consider that one unit of electricity cannot generate more than 3·410 heat units when passed through wet or damp peat, this part of the claim may be dismissed as purely imaginative. Remarking on this item of the process *The Electrical Engineer* says: "From the scanty figures we were able to elicit as the result of our enquiries, we understand that 24 units of electricity are consumed in treating one ton of virgin peat, and that the resultant yield of fuel is about 15 cwt. 10 lb. This means a loss in operation of just under 25 per cent., and this in spite of the fact that virgin peat contains from 76 to 80 per cent. of water, which, we are told, is extracted in the process. We are unable to get a satisfactory explanation of this curious contradiction." The sample briquettes handed round were testimony to the failure both of the centrifugal and of the electrical treatment. As peat holding 60 per cent. of water looks and feels merely damp, and at 30 per cent. is to all appearance bone dry, these samples can have parted with only an inconsiderable amount of this moisture. In a paragraph on the Drying of Incombustibles *The Electric Review* aptly remarks: "Electricity is out of the question as a heating agent in affairs commercial except when the article warmed has a value out of proportion to its mass. Substances which are valued in shillings and pence per ton, and have a high capacity for moisture, are not to be dried economically even by direct furnace heat." Three of the briquettes hung in tape before a fire for eight hours showed only a loss of 20 to 25 per cent.

Reverting to the further treatment of the mass as it leaves the electric baths, it is then passed through rollers on to a kneading and teasing apparatus. We have had some experience of passing wet peat through rollers. Some varieties, no matter how fed to the rollers or how the rollers are placed, stubbornly refuse to pass between them. Smooth faced rollers are useless, and the grooves of such as are fluted rapidly become filled up. There is no patent in the mixing and kneading apparatus, and we very much doubt that the existing type can be improved upon. From this machine the putty-like plastic mass, "which may be expedited by the use of hot or cold pressure," reaches the moulder. The contraction, we are informed, "is materially hastened by the use of heated drums or surfaces and mechanical presses acting in combination or alone," and, we may add, the cost materially added to. Finally, we are told that by no other heat than that from electricity can these results aimed at be obtained, and that the effect of heat derived from electricity is quite different and distinct from that which is afforded by any other heat, that of fire for instance. To this we demur, and we deny that the current ruptures the cellular fibre. Disintegration and tearing up of the fibres and air cells can best be effected by mechanical means, and at a lower cost. It is stated that the first installation of this plant is to be erected in Ireland, where a 1000 acre bog has been secured.

The issue of this attractive circular was followed by the formation of a concern, the Electric Peat Coal Company, with a capital of £130,000, of which no less than £65,000 went to the promoting syndicate. The scheme was "sauced" with a large four-page sheet of press opinions, but only one of any technical authority was quoted, and that journal was very careful not to commit itself. The adverse notices of the *Electrical Review* and another technical journal were conspicuous by reason of their absence. Save as regards the generation of heat in the mass of peat, we deny the possibility of the electric action of which so much is made in the prospectus and in the patentee's claims. As a generality, the carbon compounds are not subject to electrolysis. Peat, seeing that it is an element, could not under any circumstances be electrolysed. That this expensive electrical treatment dries out any appreciable percentage of the large amount of water found in peat freshly graven from the bog was disproved by the sodden condition of the small briquettes handed round at the works of Messrs. Johnson and Phillips at Charlton, which after being weighed and put aside for some weeks in a drawer lost from 36 to 40 per cent. of their moisture. The accuracy of the reports of the chemist and engineer have been freely and very properly questioned. A more unsatisfactory scheme has never been brought before the public, and with the writer of the article in the *Electric Review* we say: "We would not touch this electrical process even if the peat were dumped down free at the works on the Thames, and we join in his regret that the issue of this prospectus will probably do an incalculable amount of harm to the peat industry. As one of the largest shareholders has, on account of the prospectus being misleading on material points, declined to pay any further calls, we shall probably hear more of this scheme in the law courts. Those interested in the Electro-Peat Coal Syndicate and the Directors of the Company have been warned, and if this gentleman wins his case restitution will have to be made.

The coking of peat by electricity is not new. A plant for that purpose was installed some two or three years ago at Stangfjord, in the neighbourhood of Bergen, Norway.

The heating was effected by an electric current taken from a waterfall in the vicinity. Each kiln was loaded with 400 to 500 kilograms (881·8 to 1·102 pounds) of dried machine peat. The current was of 500 ampères, with a tension of 40 to 50, the temperature of the kiln being about 570° F. The coking was complete in from three to four hours. The resulting charcoal was fairly compact, it was well adapted to domestic and commercial purposes and commanded a fair price, and was in great demand. Herr P. Jebsen, of Dale, Norway, has also invented an electrical process for carbonising peat. By this method the partially dried peat briquettes are carbonised in hermetically closed retorts. Several retorts are treated at the same time by one dynamo. The dynamos are driven by water turbines. The process ensures the carbonisation of the blocks in short time, producing a dense uniform mass showing the structure of the peat. In broken condition the specific gravity of this coked fuel is about 0·3, with a theoretical calorific value of 7000 to 7500 thermal units. It burns well, yielding a very small amount of soot, gives a rapid and strong heat, and the ash does not retard combustion as do the ashes of coals and lignite. The following is the analysis of this fuel from the Royal Norwegian High School at Christiania.

	Per Cent.
Carbon	76·91
Hydrogen	4·64
Oxygen	8·15
Nitrogen	1·78
Sulphur	·70
Ash	3·
Moisture	4·82
Total	100·

The retorts consist of upright iron cylindrical vessels, about 6 feet 6 inches high and 3 feet 3 inches in diameter. Each retort is provided with a removable cover, a discharge hole below, gas exit pipes, and a pressure gauge.

The retorts have special resistance coils so constructed that the briquettes can be built up in contact with them until a pigeon-holed mass of peat entirely fills the retort, in the centre of which the heating agent lies. The top cover is then clamped down and the electric currents switched on. During this process the peat yields three products. Openings in the retort cover allow the exit of the gaseous products, which are conducted to drying chambers for heating the air.

CHAPTER IV.

GAS FROM PEAT.

THAT gas of an excellent quality for lighting and for power can be economically produced from peat, either in its carbonised or partially carbonised solid form, as air-dried, or in the form of tar or its pure residual oil, has been abundantly proved in Europe and in the United States. The attention now being directed to peat and its products must bring inventive genius and combined skill to bear upon the great enterprise, and may be trusted to devise some efficient process such as shall, under certain conditions of locality, bring its gas-producing capabilities into general use. For possibilities in this direction we have only to look back some thirty years to first crude gas engines of Brayton and the Hock, the latter patented in Vienna in 1873, in which mixtures of petroleum spirit and air were substituted for coal-gas and air. These were the forerunners of such oil motors as the Priestman, Hornsby, Akroyd, and the Trusty, and the prototypes of the petroleum spirit explosion engine now seen in such perfection in the up-to-date automotor.

In connection with peat as fuel, in the form of powder or "mull" with automatic stoking, it may be mentioned that in the Brayton engine, patented in the United States in 1872, ordinary burning oil was sprayed, under high pressure, into a carburettor placed at the top of the combustion cylinder together with a fresh supply of air, and was then led into the explosion chamber and ignited.

In anticipation of what the near future may bring forth in the economy of peat, we take the following from the *American Gas Light Journal,* written in the middle of last century:—

"Take as a period the last fifty years, and see what improvements have been made in the economy of the use of fuel. While our forefathers were content to warm the humble cottage by the aid of the 'fire-place' which occupied one side of the dwelling, whose capacious jambs required the immense 'back log' and 'fore stick' and the various components to form the huge pile for a respectable fire, their children employed the 'box and Franklin' stoves, which used both coal and wood, and were, scientifically, an improvement in the degree of radiation attained, because they do not carry the most of the caloric up the chimney in the tempest.

"From this we come to the more modern and scientific appliances for heating, cooking, etc., embracing heaters and registers, radiators, base burners, smoke and gas consumers, patent cooking stoves, ranges, galleys, and numerous other inventions. So also, in equal or greater degree, has there been improvements in the various processes of smelting and in steam engines, both land and marine, by the aid of improved draft or blast, by return, horizontal, and inclined flues, patent jackets, grates, condensers, etc., to more completely consume the smoke and gases, to increase the radiating surfaces, and various improvements, until, when we look back to the old methods, we smile at their primitiveness and inefficiency.

"Science is progressive; and the enquiring mind will ever be on the alert to improve the various appliances now in use, whether coal or other fuel is to be employed, to more completely utilize and economize the caloric evolved during combustion, to devise more economy and to discover and apply substitutes for coal fuel. It is safe to say that by modern improvements we have got from to two hundred per cent. more caloric and *work*—which is but another name for it—from a given amount of fuel consumed, than we did fifty or even twenty-five years ago, and there is no reason to believe the inventive genius of the age will not improve upon the present methods of consuming fuel economically, during the next hundred years in a similar ratio at least."

Chemical analysis, as we have already pointed out, shows that, weight for weight, peat contains only three-fifths of the heating properties of coal, and from this theorists come to the conclusion that for raising steam it is little more than one-half as valuable. Practice and theory are, however, often widely divergent, and the tests of the laboratory are not always to be depended upon. Despite the efforts of the inventor, coal, so far, has not been forced to yield anything approaching its true theoretical caloric. Under the title "A Study of Power Gas," in the *Review of the Engineering Press*, there is a valuable contribution by M. Lencaushez to the Societé des Injenieurs Civils de France on "The Generation of Motive Power in Internal Combustion Engines, and the Utilization of Waste Furnace Gases," in which is this striking paragraph: "So far as thermal economy goes, it has been found that, with properly constructed engines, the efficiency with very lean gas is as high, if not higher than with the richer gas, but, naturally, a larger engine is required to produce a given amount of power." In this connection we may point out that a certain engine gave 80 horse-power with coal-gas and 67 horse-power with blast-furnace gas, or a difference of only 16 per cent., while the thermal values of the two gases were about 600 for the former gas and 120 for the latter. It may be noted that, when only air is employed for the partial combustion of the fuel in the producer, the combustible portion of the gas consists of carbonic oxide gas with only a small portion of hydrogen, and the gas has a thermal value of about 100 B.T.U. per cubic foot. When water-vapour or steam is added to the air-supply the gas contains a higher proportion of hydrogen, and has a thermal value of from 130 to 150 B.T.U. per cubic foot.

It has been well said that while the nineteenth century has been the era of the steam-engine, the twentieth will be that of the gas-engine. The conclusion is unavoidable that the latter is doomed to be displaced by its more economical rival. Its highest development has resulted in its capacity to produce a horse-power per hour from about one and a-half pounds of good steam-coal, which corresponds to an efficiency of not more than twelve per cent. of the actual heat-energy contained in fuel. One of the principal factors in favour of the gas-engine is found in the more direct conversion of the heat-energy contained in the fuel, the heat being directly carried into the cylinder of the engine in the form of gas, whereas with steam the heat has first to be transferred from the coal to the water, and not until the heat appears in the form of steam under pressure, is it in a position to deliver its energy to the piston of the engine. Further, gas can, as has already been stated, be carried long distances without material loss or deterioration, while with steam loss by condensation in mains is unavoidable and costly. Again, gas-producers respond immediately to a sudden increase in demand, while a steam-engine must be allowed time to increase its output; and moreover, what is of greater importance, the working, as between the gas-producers and gas-engines is automatically controlled, so that the quantity of gas produced is regulated in accordance with the demand. As regards regularity and reliability in actual practice, it may be mentioned, as an illustration, that an engine working with Mond gas has run continuously day and night, at full load, for six months without any stoppage whatever.

Among the advantages claimed for the use of gaseous fuel are material economy, cleanliness, freedom from smoke, and general convenience. Fuels altogether unsuited for steam-making may be utilized in the gas producer. Although the modern gas-producer shows no fundamental difference in principle from that of the earlier types, many important improvements have been carried out effecting both the more convenient operation of the apparatus and the utilization of the valuable bye-products.

Engines of varying sizes (up to 650 indicated horse-power) are now working, and indicating a horse-power-hour on a consumption of 60 cubic feet of Mond gas involving the gasification of less than nine-tenths of a pound of common "slack." A safe basis for the calculation of fuel consumption is one pound of fuel per indicated horse-power-hour, and this makes provision for intermittent working with various loads.

The following are some of the advantages claimed for power-gas applied by the Power Gas Corporation of 39 Victoria Street, London, S.W.

This gas is produced from the cheapest quality of coal, namely "slack" or "dross," thus obviating all necessity for expensive steam coal for the generation of power in the works.

The amount of labour required for its production is extremely small.

The heating value is equal from 81 per cent. to 86 per cent. of the total heat energy contained in the fuel used for its production.

Its cost when produced on a large scale is less than ½d. per thousand cubic feet.

One ton of rough slack produces about 150,000 cubic feet of power gas of a calorific value of 140 B.T.U. per cubic foot.

The quantity of gas required to produce an indicated horse-power-hour in a large gas engine is about 60 cubic feet.

When gasified and used in a large gas-engine, one ton of slack gasified is sufficient to produce about 2500 indicated horse-power-hours, or 2500 horse-power for one hour.

By using this gas in gas-engines a given quantity of fuel will produce about four times the power obtainable with ordinary steam-engines.

The fuel cost of an indicated horse-power-hour, obtained from a gas-engine running with Mond gas generated from "slack" at 6s. per ton, is $\frac{1}{40}$th of a penny.

It is best for gas-engines because they require a clean gas of a regular quality.

In every steam plant, working with a variable or intermittent load, a considerable proportion of the fuel consumed is wasted. Some loss under this head is unavoidable, but the employment of gas remedies this.

Among the other advantages due to gas fuel are cleanliness, freedom from smoke, absolute control, general convenience, and material economy. At the present moment *Power Gas*, as applied to internal combustion engines, is attracting much and deserved attention in engineering circles. "The suggestion of the more extended use of peat by the establishment of a power placed close to the source of supply, with power distribution thence by means of fuel-gas or electricity, is practically interesting and in direct line with the best modern practice in the economical utilization of natural resources" (Editors, *London Engineering Magazine*, November, 1902).

A cheap power is essential to the manufacturer, and this desideratum is found in *Producer Gas*. Until very lately power users have had to rely mainly upon steam and the steam-engine as a motive power. It is only within the last year or two that the gas-engine assumed its present position as a cheap and efficient power on a grand scale. The rivalry of the electric light, by no means a decaying competitor, has put gas engineers on their metal, and with truly professional spirit strenuous efforts have been made to maintain the development of the industry. The mechanism of combustion is now an anxious study, exercising the active brains of technical *savants* both at home and abroad. Though there may be no fundamental difference between the more recent producers and the earlier ones, the improvements which have been made are very important, affecting both the more convenient operation of the apparatus and the utilization of the valuable by-products. Prior to the introduction by Dowson of his producer gas plant, town gas alone was available, and was, on small engines, though not economical, used chiefly on account of its convenience. This practice has now, to a large extent, been set aside by this system by which "poor" or gas of low calorific value is manufactured from inferior fuel. By this method fuels altogether unsuited for steam-making may be utilized. Improvements on the Dowson process, adapted chiefly to large powers of over 100 brake horse power, were wrought by Wilson, Duff and Mond in England, and by Körting in Germany, but these plants did not affect the problem of the economical generation of power by small installations. These pressure producer or "poor" gas plants have been used for driving gas-engines where economy of fuel has been of the first importance, but the initial cost, the floor space occupied, and the amount of attention required, together with the necessity of having a steam boiler and a gas holder, have prevented their general adoption, particularly for medium and small powers. We are indebted to Mr. Hal Williams, the well-known gas expert, for much information anent the *Suction Gas Producer*[1] which originated on the Continent, and is now largely used for purposes where moderate power is required. It is well known that when a gas-engine is working it produces a suction effect on the gas, and the air it draws into the cylinder *vide* the gas bag. In the suction plant this has been made use of, and the principle of the process is that the gas-engine, by drawing air or water-vapour through an anthracite, coke, or peat coke fire, makes its own gas as it wants it. There is practically no waste, for the volume of air and water-vapour passing through the generator is regulated entirely by the number of times the engine takes gas, and, as this in its turn depends on the work the engine has to do, the gas is produced directly in proportion to the load. Owing to the whole of the gas being below the pressure of the atmosphere there is no smell, and indeed, Mr. Williams has seen a plant of this kind working in the middle of a tobacco factory with bales of leaf tobacco stacked all round it. As is generally known, this leaf is very sensitive, readily absorbing odours.

A comparison of the relative advantages of steam and gas for motive power is instructive, in that it establishes many important points in favour of the latter, the chief of these being the wonderful economy in fuel. "Setting aside for a

[1] Peat coke is perfectly adapted to the production of gas by the Suction Producer.

moment the high speed electric-lighting engines working with super-heat, and taking the average run of non-condensing engines providing motive power for the bulk of the factories and works throughout the country, it will be no exaggeration to say that the steam consumption is nearer 40 lbs. per indicated horse-power-hour than 20 lbs. Indeed, one of the principal drawbacks of the steam-engine, from an economical point of view, is the virtue so often claimed for it—that 'it is so reliable,' or, in other words, that unless it has absolutely broken down, it will continue to work so long as there is steam behind it. On the other hand, a gas-engine, like an electric motor, must be either all right or all wrong, and therefore the efficiency cannot fall very low without the engine pulling up and the defects revealing themselves.

"About one ton of slack, which can be bought in the colliery districts for 6s. a ton, will produce about 150,000 cubic feet of power gas, having a calorific value of from 130 to 150 British thermal units. A gas-engine of, say, 40 brake horse-power will require from 70 to 80 cubic feet of this gas per brake horse-power-hour. Large engines only require from 60 to 70 cubic feet per brake horse-power hour. What does this mean? It means that, neglecting the steam required for boiler feed, pumps, etc., a factory steam-engine requires not less than 4 to 5 lb. of coal per brake horse-power-hour, while a gas-engine only requires 1 lb. of coal per brake horse-power-hour. Further than this, to give anything like a good evaporative efficiency, the coal burned in boilers must be of a much better quality than that which can be used in a producer, and is consequently more costly. Boilers also have to be stoked, and in other ways require to have a larger quantity of labour expended upon them; while gas-producers require little or no attention, and will work very well with only casual supervision on the part of the man in charge. Another great feature of economy where the load is intermittent is the facility with which a gas-producer will respond to increased or diminished demands upon it. It takes, or should take, twelve hours to get up steam from cold in a large Lancashire boiler of, say, 250 indicated horse-power.

It takes from ten to twenty minutes to generate gas for, say, 500 indicated horse-power from cold in a producer; while if the plant has been standing by with the fire alight during the week-end, this can be reduced to about five minutes" (*Producer Gas Power for Factories, Cold Stores, etc.*, by Hal Williams).

At some tests which the author made with one of these suction plants during his investigations on the Continent, burnable gas was being produced seven minutes after the fire in the generator was lighted, and the engine was working on its load three minutes later. Another advantage this producer possesses is that the plant occupies little room, a matter of moment in our great cities, can be placed in any corner of the works, and that the engines can be put close up to their work. In fact, a 50 brake horse-power would stand with ease on an ordinary dining-room table.

Suction Gas Plants—the gas produced suitable for heating as well as power—of from 5 to 250 H.P., simple in construction, easily handled, and only requiring attendance at intervals of three to four hours, are now obtainable. One of these subjected to a continuous test of six days and nights ran a gas-engine of 18 indicated H.P., developing a mean of 16·9 brake horse-power, and even with this moderate load the cost of working was at the rate of 10 brake horse-power for one penny per hour. The fuel was Welsh anthracite peas costing 20s. per ton. With larger engines (40 B.H.P. and upwards) the economy would have been greater. This works out one-fifth the cost of town gas at 2s. per thousand cubic feet. With Bituminous Gas Plants the cheapest grade of coal may be used, provided it is of a non-coking nature. Common bituminous slack, which can be obtained in the coal districts and from many of the coal depots at one-fifth the cost of anthracite, and for one-half to one-third the cost of coke, shows equally good results. Till now this low class of fuel for gas producing has been impeded by the great difficulties experienced in using the gas made from it, owing to the presence of tarry vapours in the gas, which condense but for gas engines which require a very clean gas this is very serious owing to the gumming up and choking of the valves on the engines.

The advantages of the "*Suction*" type of *Gas Producer*, as compared with the older form, are many. We enumerate a few:

No steam boiler or gas holder is required, so there is no liability to explosion, with consequent extra cost of insurance.

It does not need constant supervision as it can run for several hours without being refilled with fuel.

It occupies only a small amount of floor space, requires no chimney and no foundation.

The apparatus may be fixed indoors, so there is no more danger from fire than from an ordinary stove.

There is no risk of gas escaping, as it is generated by suction, and below atmospheric pressure.

Great economy of fuel.

The apparatus may be "banked" at night or meal time with small loss. It can be restarted, after being shut down, in a few minutes, and even in a cold condition, in from 15 to 20 minutes.

Gas is generated only as required.

No gas is blown or burnt to waste on light loads.

It is smokeless and free from smell.

A process in which the writer takes a deep interest, and which is now long beyond the experimental stage, has arrived at a point by which peat gas of low quality can be manufactured suitable for blast purposes, with very high efficiency, and by another process peat gas of very high quality, suitable for heating and lighting, is produced. The producer-gas possesses, for equal volumes, more than twice the potential or calorific energy of the product of Dowson, Dawson, Mond, or other similar systems, and, being entirely automatic in its action, and efficient in small units, is applicable to small as well as to large instalments. The flame temperature of the gas by this system is about 25 per cent. higher than that of town gas. By the use of the high potential producer-gas engines can develop their *continuous* maximum power. This gas is free from tar.

As the result of extensive investigations and experiments, the well-known firm of Messrs Crossley Brothers have, by means of a centrifugal tar extractor, succeeded in pefecting an apparatus which thoroughly cleans this gas, rendering it practically as clean as ordinary town gas so far as gas engine requirements go. Using bituminous peat, that bottom variety known as Ince peat, that from the borders of Loch Neagh, Antrim, and the "creashy clods of Scotland, a gas of high potential and a gas of high calorific power, and of uniform quality, is obtained. From the absence of sulphur in certain peats the purification of this gas is much more easily accomplished than that from coal. Some of the bituminous black peat produces gas of good illuminating power which requires no purifying for ordinary purposes. The chief difficulty is the amount of carbonic acid found in the crude gas, but, as in the case of wood gas, this can be eliminated if, in burning, mantles are employed. Purification by means of lime is found to remove a large proportion of this acid. This difficulty is also to a great extent overcome by the partial charring or baking of the raw peat before it is used. There are, however, advantages in peat which more than counterbalance the excess of carbonic acid. As this fuel does not clinker, the process of gas-making can be performed without interruption. The resulting coke being pure vegetable charcoal is of much greater value than coal-coke, and, as stated, can be employed in the manufacture of gas by the suction process.

"Gas may be made from peat at a comparatively low temperature, but its illuminating power is then trifling. At a red heat alone can we produce a gas of good quality. The chief impurity of peat gas is carbonic acid. This amounts to 25 and 30 per cent. of the gas before purification, and if the peat be insufficiently dried, it is considerably more. The quantity of slaked lime is, therefore, much greater than is needed for coal gas, and is an expensive item in the making of peat-gas." (*Professor Johnson.*)

As to the yield of gas we have the following data:—

	Cubic Feet.
100 lbs. of peat of medium quality from Munich gave - - - - - - -	303
,, ,, of air-dried peat from Biermoss, Salgburg gave - - - - - - -	305
,, ,, very light fibrous peat gave - -	379 to 430
,, ,, Exters machine-peat from Haspelmoor gave - - - - - - -	367

Thenius states that to produce 1,000 English cubic feet of purified gas in the works at Kempton, Bavaria, there were required 292 lbs. of peat in the retorts; but, according to Stammor, 4 cwt., of dry peat are necessary, showing that some peats are better adapted than others to the manufacture of gas. As in coal, much depends on the composition of the raw material.

Experiments conducted at the Lansingburg Gasworks, New York, with air-dried peat, not compressed, gave very satisfactory results, the light being white, clearer, and much stronger than that produced from coal in the same retorts. It stood the chemical tests well.

With reference to the purity of peat-gas and alleged large percentage of carbonic acid gas, the amount of this latter gas depends greatly upon the district from whence the peat is obtained. and can, in great measure, be overcome by the partial coking of the substance before placing it in the retorts. The absence of sulphur, moreover, renders its purification more easy. In some peats traces of sulphur, have been found, and by distillation we find ammonia. Where carbonic acid is found in any quantity, an extra supply of slaked lime is necessary, and this involves cost. But many of our most extensive peat-bogs, notably the bog of Allen, have a limestone base. In 1862 Mr. Paul stated, before the Society of Arts, that for a long time he had been lighting the works with gas produced from black bituminous Scotch peat, that it was of good illuminating power, and, for ordinary purposes, required no purification. Dr. Versemann came to the conclusion that partially charred or baked peat was a most valuable material for gas manufacture, and that it would produce from 12,000 to 14,000 cubic feet of gas per ton of an illuminating power exceeding that of ordinary coal-gas, the amount of carbonic acid not exceeding ten per cent; and although that was somewhat in excess of the average of coal-gas, yet there were advantages in peat which more than counterbalance the disadvantages arising from an excess of carbonic acid. Points in favour of peat are that the resulting coke is equal to charcoal, and that when worked in conjunction with a poor gas-coal it produces a really good gas. Abundant proof of its value, economy, and easy production has accumulated, and once the attention, energy, and inventive faculties of the gas engineer, aided by the practical organic chemist, are brought to bear on the subject, this gas must, for power, heat, and as an illuminant, be extensively used at no distant date. Here then is one other use to which we may apply the great capital which has been accumulating for ages, and has been reserved in store for this enlightened period.

Gas from peat, says the *Engineering Magazine*, is used for heating purposes in several places in Europe, but most extensively in Sweden. In that country it is used for the melting of Martin steel, while in other places it is used in glass houses and the like. The generators used are of very simple construction. In a Swedish magazine, *Jernkontorets Annaler*, Rich. Aakermann has given an exhaustive memoir on the use of gas for Martin steel-melting.

The peat used in Sweden for generating gas has the following composition:

	Per cent.
Carbon	60
Hydrogen	6·4
Oxygen	31·7
Nitrogen	1·9

Or, if hygroscopic water and ashes be reckoned:

Carbon	38·2
Hydrogen	4·1
Oxygen	20·2
Nitrogen	1·2
Sulphur	0
Ash	8·6
Water (hygroscopic)	27·7

The gases have the following composition:

	Per cent. of volume.
CO_2	6·9
CO	26
C_2H_4	·5
CH_4	4·4
H	8·5
N	53·7

The quantity of gas from 100 kilograms (220·4 pounds) of peat is about 252 cubic metres (8,900 feet). The sorts of peat here used have an excessive amount of ash and much (hygroscopic) water. In fact, ordinary peat will not have more than 5 per cent. ash, and when air-dried it will not contain more than 20 per cent. of water. Under these conditions the gas will be of much better composition.

It is not known that peat is used anywhere in Europe to produce power-gas on any particularly large scale, but the results obtained of late with the Mond gas generators, where power-gas is generated from slack coal with 60 per cent. of carbon, would tend to show that peat will give as good results.

In reality, there is no great difference between such slack coal with 10 per cent. of carbon and good peat, the only difference being the greater contents of water in the peat. But as $2\frac{1}{2}$ tons of water, as steam, are used in the Mond gas generators to 1 ton of slack coal, to regulate the process, the larger amount of water in the peat must not be considered as a drawback, but rather as tending to make the generating of steam superfluous, and thus to reduce costs.

In the figures given above, showing the composition of Swedish peat gases, nitrogen is present in rather large amount. This results from unmixed air being used for the combustion in the generators; when it is properly mixed with steam and carbonic oxide, the results obtained will prove better.

It is now well known that gas may be led economically to great distances for power-supply and for incandescent lighting. Thus, Mond gas is piped in England from central gas works to the surrounding factories, and in Pennsylvania natural gas is piped for distances exceeding 90 miles. There is no reason why gas from peat should not be used in the same manner.

It is our opinion that where the peat cannot be used in factories on the spot, it should not be transported, as costs will be nearly double those for carriage of coal; but power should be transmitted either in the form of electricity or as peat-gas, the former for long distances, the latter for shorter ones.

So far back as 1863 peat gas was produced in Holland, and since then, for making and refining iron, in the manufacture of glass, and in various other directions it has been extensively used on the Continent of Europe. For years past it has been utilized at Salzburg. In 1855 a M. Foucalt was charged by the City of Paris with the scientific examination of this gas, and, his report proving highly favourably, it is difficult to see why his recommendations were not adopted. Probably, as moulded peat was then selling at 20 francs per ton, and its charcoal at 100 francs per ton, the cost of the raw material, brought from a large bog near Liancourt, seventeen leagues from the Capital, militated against the general introduction of this gas. The result of this expert's examination was to give peat a high value as a gas producer. He found its illuminating power to be 340, while that of coal gas was only 100. The manufacture of peat gas was found to be more simple than when coal was used. If placed in an iron retort, heated to a low red heat, it immediately afforded a mixture of permanent gases and vapours, which condensed into an oleaginous liquid, the two products separating on cooling. The oil was collected in a special vessel, and the gas passed into a gasometer. This carburetted hydrogen is wholly unfit for illumination, as it gives a very small flame, nearly like that from brandy. The oil from the peat is a viscous, blackish liquid of strong odour. If it be subjected to a new distillation, it is resolved wholly into a permanent gas and hydrogen very richly carburetted. This mixture is strongly illuminating, giving a flame six or eight times brighter than the first, and of a more lively brilliancy. The two are mixed, and a gas of intermediate character obtained, which is delivered over for consumption. A mean of five tests gave for a burner of peat gas a light equivalent to twenty-three and one-fourth candles, the same burner with coal-gas six and three-tenths candles only. The illuminating power of pure oil from peat, according to M. Foucault, is *par excellence* the illuminating material at equal pressures; he found the power of peat oil to be 705, the intensity of coal-gas being 100; and with equal volumes the numbers were 756 to 100.

Some time ago, Mr. Keats, Chemist to the Metropolitan Board of Works, and subsequently to the London County Council, advised that there was a great future for the employment of peat as a fuel, also in the manufacture of gas. In the making of gas for general consumption he proposed to employ peat gas along with the ordinary town coal gas for the facilities it afforded in purification.

Professor Johnson, of Yale College, writing on the subject of peat gas, remarks :—" It is essential that well-dried peat be employed. The retorts must be of good conducting material, therfore cast-iron is better than clay. They are made of the usual form, and must be relatively larger than those used for coal. A retort of two feet width, one foot depth, and eight to nine feet in length, must receive about 100 lbs. of peat at a charge.

" The quantity of gas yielded in a given time is much greater than from bituminous coal. From retorts of the dimensions just named, 8,000 to 9,000 cubic feet of gas are delivered in 24 hours. The exit pipes must, therefore, be not less than 5 to 6 inches, and the coolers must be much more effective than are needful for coal-gas, in order to separate from it the tarry matter.

"The number of retorts requisite to furnish a given volume of gas is much less than the manufacture from coal. On the other hand, the dimensions of the furnace are considerably greater, because the consumption of the fuel must be more rapid in order to supply the heat which is carried off by the copious formation of gas."

As those of our readers who are uninformed as to the capabilities of peat may question its value as a raw material for the production of gas, we here give the results of some experiments carried out in Canada, and reported by the Bureau of Mines, Ontario.

In 1901 the perfected Merrifield peat-gas generator was designed and constructed by Mr. L. L. Merrifield, engineer to the Economical Gas Apparatus Construction Company, Limited, of Toronto. The new plant was erected for demonstration purposes at Toronto Junction, and during the autumn of 1901 a number of experiments were made, several of them under the supervision of the Bureau of Mines. Considering the intermittent nature of the tests and the imperfect installation of the plant, a satisfactory showing was obtained. A gas rich in heating value was produced at a fairly steady rate, and at small cost for maintenance and attendance. Without going into detail, it may be stated that the experiments warranted the following conclusions, namely: That, with connections of suitable size, the generator could produce a much larger quantity of gas per hour or minute than was actually obtained; that the production of gas will depend almost wholly on the quantity of fuel consumed; and that this in turn depends on the volume of the air blast. The cost of maintenance or attendance may be reduced to a minimum by handling the bulky peat and removing the ashes by mechanical means, and this would also effect a saving in time.

The Merrifield gas generator resembles the extensively employed Loomis-Pettibone plants, and particularly that one at Nacozari, Mexico, where the usual Loomis system is somewhat modified with a view of making a uniform and fixed gas out of the mixture of water and producer-gases, which will be higher in calorific power than producer-gas and lower than water-gas, the fuel employed being wood instead of coal. This result is effected by introducing very little steam with the air blast. The ordinary Loomis generator produces alternately producer-gas and water-gas for short periods of five minutes or so each way, each gas being conducted to its own holder. The Merrifield furnaces are also set up in connected pairs, with charging doors at the top. The grates are near the bottom, and below them is a tapering bottomless ash chamber, terminating several inches below the surface of the water in the ashpit. The water seals the bottom of the generators, preventing the ingress of air, and yet does not interfere with the discharge of the ashes.

Crude air-dried peat in lumps forms the fuel. By the time it reaches the generators from one-third to one-half will have crumbled into fragments and dust, making a compact and suitable charge for uniform consumption in the furnace.

The air blast is generated by a small blower operated by gas engine, taking gas from the holder. It passes first through the pipes of the condenser, where, in condensing the moisture out of the hot gases from the generators, it is itself heated up previous to entering the furnaces by way of the chamber below the grate in the bottom. The pipes for injection of steam also enter here. However, on account of the high percentage of moisture contained in the peat fuel, an internal supply of steam for the mixture of water- and producer-gas is usually assured.

After making a good fire, say of wood, in the grate, the peat is charred into the furnaces by the port holes at the top until they are full, when the caps are again clamped down. By forcing the blast for a while and heating the peat into a glowing mass the process becomes properly started, after which the volume of air is adjusted to the production of the maximum capacity of the generators.

From now on the operation is continuous except during the loading or recharging periods, covering a quarter of an hour or so once or twice a day.

Although set up in pairs the generators, like the Nacozari machines, will most of the time work as one, producing the uniform mixed gas; but should a partial production of water-gas alone be desired, the air blast is shut off and steam injected into one generator, up through the glowing mass of peat, across into and down through the hot coals in the other machine, and out thence to the condenser and scrubber. This continues for a few minutes, until the fire has cooled off, so that the air blast is again required to bring it up to the proper temperature, when the same course is again followed, except that this time the direction of the steam in the generator is reversed, entering the bottom of the second and leaving by the first.

Peat, like wood, particularly green wood, is naturally suited, on account of its large percentage of moisture, to steady production of the mixed gas, rather than to the alternate generation of first water-gas and then producer-gas, as with dry fuels such as coal.

QUALITY OF MERRIFIELD PEAT-GAS.

In these experimental runs of the Merrifield gas generator the calorific determinations and analyses of the gas were made by Dr. W. Hodgson Ellis, professor of applied chemistry at the School of Practical Science, Toronto. The gas produced on 28th October, 1901, gave the following calorific values at the different stages of the operations:

Time.	B.T.U. per cubic foot.
3.00 p.m.	96·4
3.10 „	118
3.20 „	149
3.25 „	154·6
3.55 „	159
4.15 „	125
Average,	133·7

The quantity of gas made and peat consumed was not ascertained.

The plant had been kept warm during the previous part of the day without generating much gas until this test began, and soon after gas of good quality began to appear a mishap caused a sudden termination of the test. This accounts for the gradual rise and subsequent abrupt fall in the quality of the gas.

Shortly afterwards another test gave the following quality of gas.

Time.	B.T.U. per cubic foot.
2.10 p.m.	156
2.40 „	156
3.10 „	157
3.40 „	156
4.15 „	153
4.30 „	155
Average	156

For some hours previous the generators had run steadily and continued so to the end.

In November another run was made, giving gas of the following quality:

Time.	Calories per litre.	B.T.U. per cubic foot.
10.45 a.m.	889·6	100·5
10.55 „	906·8	102·5
11.15 „	951	107·5
11.25 „	889·6	100·5
11.35 „	966·4	109·2
11.45 „	944·1	106·7
11.55 „	1019	115·2
12.5 „	1041	117·6
3.20 p.m.	1059	119·9
3.30 „	1074	121·4
3.45 „	1092	123·4
4.0 „	1113	125·7
4.15 „	1097	124·0
4.30 „	1147	129·6
Average	1013	114·0

From these determinations it will be seen that the fuel value of the gas on the day of the test rose from 100 to 130 B.T.U. per cubit foot. The analysis of a sample of the gas taken from the pipe at the conclusion of the calorimeter test, which also marked the end of the whole experiment, gave as follows:

	per cent.
Carbon dioxide, CO_2 - - -	20·5
Carbon monoxide, CO - - -	10·2
Methane, CH_4 - - - - -	1·9
Hydrogen, H - - - - -	22·8
Nitrogen, N - - - - -	44·6
	100·0

The quantity of carbon dioxide in this sample is larger than was obtained in samples taken in previous tests. In one there was but 12·4 per cent. CO_2, and in another but 7·4 per cent. An increase of CO_2, accompanied by a decrease of CO, such as the above analysis shows, would be caused by the lowering of the temperature of the retort at the end of the operation when the sample was taken.

The analysis of the peat used in the experiment is as follows:

	per cent.
Moisture - - - - - -	25·94
Volatile organic matter - - -	48·41
Fixed carbon - - - -	18·69
Ash - - - - - -	6·96

Another run of the generator was made, and the gas this time tested by Mr. J. Walter Wells. The analytical work was conducted at the gas works, but for the calorimeter determinations samples of the gas were taken in a large aspirator-can from the gas-holder and tested at the School of Practical Science laboratory in the same Junker's calorimeter as was used at the works by Dr. Ellis in the experiments previously described.

In forcing the gas out of the can by in-running water some of the tarry vapours were lost by condensation, as was apparent on examination of the water from the aspirator. In all other respects, however, the method and apparatus worked admirably.

In the accompanying table of analyses on page 95, samples Nos. 1 to 11 are of the water-gas type, made by injecting a large excess of steam with a moderate air blast over the hot peat in the generator. Samples Nos. 12 to 16 are of producer-gas made in reheating the furnace charges, which were cooled by the flow of steam for the water-gas, by reversing the direction of the air blast through the generators and shutting off all steam. On leaving the holders this gas smelt very strongly of tar, and contained considerable vapours.

Another similar Merrifield peat-gas generator was installed at the Trent Valley Peat Fuel Company's works, Kirkfield, to produce fuel gas for the dryer, but no tests were made with it, which is to be regretted, since it is said to have worked satisfactorily.

The original Merrifield generator, first set up at Toronto Junction, on which the above experiments were conducted, has since been removed and reinstalled at the Welland peat works, where, if desired, test runs may be made with it. Later, the intention is to incorporate it as part of the peat works, to furnish fuel gas for boilers and dryers.

COST OF GAS PLANT.

From the prospectus of Peat Industries, Limited, concerning this method and all necessary apparatus for the production by it of peat gas, the following is quoted:

"From one ton of compressed peat, analysing approximately: moisture, 15 per cent.; ash, 7 per cent.; fixed carbon, 21 per cent.; volatiles 57 per cent.; valued at \$1·50 per ton delivered at gas retort, figuring wages at 20 cents per hour, and yearly depreciation at 6 per cent. upon value of machinery, and in a plant capable of producing 40,000 cubic feet of gas hourly, a yield will be had of not less than 100,000 feet of fixed gas, carrying not less than 150 B.T.U. per cubic foot, at a cost not exceeding 2½ cents per 1000 cubic feet. We will supply all apparatus and material for a plant producing not less than 20,000 cubic feet of gas per hour for $5000, exclusive of freights, cartage to site, and erection; larger plants proportionately. Peat carrying up to 30 per cent. moisture may be used, but the yield of gas will be reduced about 1000 cubic feet for every additional 1 per cent. moisture."

This estimate was made for gas plants situated at a distance from the bogs, to which the peat would have to be shipped, and which therefore must first be manufactured into compressed fuel. If the use of cut-peat be made possible by locating the gas works at the bog, or only at such distances that the peat could be economically transported thereto as cut peat, the cost of the fuel should not exceed 50 to 75 cents per ton.

The above experimental runs with the Merrifield generator were made on cut peat, and the analytical tests show that it gives high results. With compressed peat briquettes the advantages over cut peat would be smaller bulk and therefore less frequent handling, lower moisture content and consequently a higher calorific value.

There are many advantages to be gained in the use of peat by converting it into gaseous fuel, many of them appertaining equally to other gaseous fuels. While the consumption of the solid fuel involves a loss of heat of 25 to 30 per cent. or more, this loss, if the fuel be converted into gas, will be reduced to from 15 to 20 per cent. When the fire-box is sufficiently large the combustion is complete, and without smoke or soot, leaving always a clean boiler surface. A properly regulated draught insures complete and even combustion. Its comparative freedom from sulphur makes possible a long life for the boiler. A better insulation may be had against loss of heat by radiation, and the hot gases from the generator may be utilised for drying the peat which is to be converted into gas.

The most important reason, however, why peat gas can be more profitably and extensively employed than

GAS MADE FROM CUT PEAT IN MERRIFIELD GAS GENERATOR AT TORONTO JUNCTION.

	Water-gas, per cent.											Producer-gas, per cent.					Mixture of water and producer-gas, per cent.				
Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Benzine and benzoles	.4	.6	.7	.3	.3	.3	.5	.4	.8	.4	.8	1.8	1.2	1.6	1.0	1.2	.5	.5	.6	.7	.8
Illuminant - -	.2	.2	.2	.3	.2	.2	.4	.3	.2	.2	.2	.2	.2	.4	.4	.6	.2	.2	.8	.6	.4
Carbon monxide, CO	17.8	17.8	17.4	17.3	17.2	17.4	17.2	17.2	16.8	16.8	16.5	13.6	13.6	7.8	7.8	11.6	15.0	15.4	15.25	16.6	16.2
Hydrogen, H - -	14.9	12.1	13.02	12.87	12.98	12.50	13.6	12.5	12.43	12.34	12.58	8.56	8.99	4.19	4.87	3.13	12.5	12.6	11.8	12.2	12.3
Methane, CH_4 - -	4.15	4.26	5.48	6.11	5.19	5.86	5.2	5.86	6.17	6.17	6.29	7.14	7.49	5.24	5.24	4.68	3.9	4.0	4.2	4.1	4.6
Oxygen, O - -	.0	.0	.0	.0	.2	.0	.0	.2	.0	.2	.2	.6	.6	.4	.4	.2	.6	.5	.85	.0	.4
Carbon dioxide, CO_2	11.0	10.8	10.3	10.7	10.7	10.7	9.5	10.5	10.8	11.6	9.7	12.4	12.0	11.2	11.8	15.2	13.3	13.2	12.3	12.1	12.2
Nitrogen, N - -	51.55	54.24	52.9	52.42	53.23	53.04	52·68	53.04	52.8	52.69	53.73	55.7	53.92	69.17	68.48	63.39	54.0	53.6	54.2	53.7	53.1
Calorific determinations (B. T. U. per cubic foot) - -						137.72															
						146.89								109.2					136.8		
						146.89								109.8					135.65		
						137.92								109.8					136.8		
						157.0								109.8					136.7		
Average - -	-	-	-	-	-	145.3								109.6					136.4		

peat in large industrial works lies in the fact that by locating a large central power station at a suitable bog the cheapest kind of peat, namely cut peat, satisfies all requirements; and the gas may then be piped for distribution, or if the place of consumption be at too great a distance, it may be converted at the bog into electrical energy.

SULPHUR IN ONTARIO PEAT.

At the Provincial Assay Office 36 samples of peat from different bogs in Ontario were analysed for their sulphur contents. The results serve to show the general character of peat in this respect.

Each sample was analysed in duplicate by three different methods. The sulphur content was found to range from 0·112 to 1·00 per cent., with an average of about 0·5 per cent. Pennsylvania anthracite contains over ·6 per cent., and bituminous coal over 1·4 per cent. sulphur.

Bogs are however to be had, as the analyses show, which carry little more than traces of sulphur, should freedom from this ingredient be particularly desired.

As a rival to electric light, gas is at present in an experimental stage, but possesses all the elements of practical success. At a late meeting of the Institution of Gas Engineers, Professor H. B. Dixon, Director of the Chemical Laboratories at Owen's College, showed by beautiful experiments that the burning of a highly-explosive gas mixture was one of the best means of developing light from gas. Coal-gas and air, he said, would not deteriorate, but coal-gas and oxygen would. Industrial (50 per cent.) oxygen could now be made by the fractional distillation of liquid air at a cost of 5s. per 1000 feet., but he could see no reason why it should not be manufactured for half that price. Coal-gas fed with such oxygen could be made to burn on a zirconia mantel and give a light, roughly, of two hundred candles for a consumption of two cubic feet of coal-gas per hour, which statement he demonstrated by an experiment which earned him loud applause. Pointing to the electric light above them, which actually paled before the brilliant light he had produced, the lecturer concluded by saying that this was only one of the developments which must flow from a study of the mechanism of the combustion of gases.

"Messrs. Ruston, Proctor & Co., of Lincoln, who are intending to build a new works, have recently been making inquiries as to the relative economy of gas-fired and coal-fired furnaces. Their representatives have visited Scotland and procured figures in regard to the weight of plates that could be heated in a certain number of hours, the quantity of coal used, and the price of coal, with a view to getting the cost of heating each ton of plates. They saw a furnace which was gas-fired, of about the same dimensions as the one they were firing with coal at Lincoln, and on the ordinary coal-fired furnace they were heating 17 tons of plates in a week of 53 hours. The coal consumed was 6 tons 14 cwts., and the price of coal was 11s. 6d. per ton. Consequently the cost of heating those plates ran up to 4s. 5d. per ton. The gas-fired furnace heated 45 tons in the week of 53 hours, and the coal consumption being 11 tons 10 cwts., and the price of coal was 8s. 6d. per ton, so that the cost of heating the plates in the gas-fired furnace was 2s. 2d. as against 4s. 5d. per ton" (*Iron and Coal Trades Review*).

At the works of Messrs. A. Macmillan & Son, Ltd., of Dumbarton, a test was lately made with regard to the time required for heating certain angle bars in a gas-fired furnace recently erected, and it was found that the angle bars could be perfectly heated in from 15 to 16 minutes, whereas previously the time for the same class of work was 35 minutes. That was distinctly in favour of the gas-fired furnace. Very similar information has been obtained from Messrs. Workman & Co., Ltd., of Belfast. They were heating channel bars 9 in. by 3½ in. by 3½ in. in 20 minutes, the length of the bars being about 60 ft. This information emphasises the fact that re-heating by peat-gas can be done more thoroughly, and in much less time, and also that a cheaper class of fuel could be used than was usually the case with gas-fired furnaces.

In connection with the manufacture of gas from peat, may be mentioned the possibilities of producing artificial colours from the tar resulting from distillation. Already, in the United States, though the experiments have been confined to the laboratory, comes proof that beautiful dyes can be manufactured from this residuum quite equal to those produced from coal-tar in Germany, the raw material being mainly supplied from this country. It certainly is a curious though not very pleasant fact, that we, owing to the lack of knowledge of the highest scientific kind, should be distanced by a foreign nation, and that we should export our gas-tar products as refuse to Germany to be employed in a highly profitable manufacture simply because we have not the "push," the brains, or the skill, to conduct the manufacture at home. It is one of the most singular phenomena in the domain of industrial chemistry that the chief industrial nation and most practical people in the world should be beaten in the endeavour to turn to account the coal-tar which it possesses. But the fault lies with our Chancellors of the Exchequer. Every manufacturer knows that the chemical and allied industries of this country are crippled, and in some instances crushed out, by the tax on alcohol which is essential to many processes. While every reasonable means should be adopted to prevent loss to the revenue, the present restriction should be modified to meet the requirements of those chemical industries in which alcohol is a requisite. Professor Green of the Yorkshire College has demonstrated that the cost of producing aniline dye in Germany is 4d. per lb. as against 2s. 4d. here. In Germany spirit for engine fuel is delivered duty free. These spirit engines, referred to elsewhere occupy much less floor space than ordinary engines, are economical in working, and can be started from absolute rest to full working power in very much shorter time than the best steam engine. Concessions in this direction would be a valuable boon to many industries, and employers would, in their own interests, be careful to prevent any abuse which might lead to their withdrawal.

For centuries the dark-coloured Irish friezes have been dyed with *dhuv,* the deep brown, almost black, resinous tar found in certain peat holes. Why could not the War Office, in order to stimulate home industries, stipulate that the Khaki dye used in military clothing should be the product of our own peat bogs? The writer has been in communication, with reference to peat dyes, with the Yorkshire College, an institution combining the high standard of a University with the practical training of a technical school. The department of dying and tinctorial chemistry, which has issued a prospectus directing attention to the special faculties existing there for research in work of this kind, from its close proximity to the great textile industries of Yorkshire and Lancashire, is *par excellence* the establishment best equipped for investigating the peat-tar products. Probably its researches and experiments will give them a value little, if any, inferior to the aniline dyes which, originally, were discovered and developed in London. At present we actually pay over £3,000,000 a year for chemical dye-stuffs which we should ourselves produce.

Dry compressed bottom peat yields at red heat 11·000 cubic feet of gas per ton. The coke retains the form of the peat, and amounts to about 9 cwts. per ton carbonized, while 15 gallons of a peculiar acid tar are obtained, as well as a quantity of ammoniacal liquor. Experiments made with compressed and dried Austrian peat, on dry distillation, produced 30 to 40 per cent. of good dense charcoal, 25 per cent. of ammoniacal liquor, 6 per cent. of tar, and 29 to 30 per cent. of gas. The tar, on distillation, yields burning "solar" and lubricating oils, paraffin, and 15 per cent. of pitch. But this peat pitch differs from the ordinary coal tar in that it possesses a distinguishing acid quality which is uniformly found in every description of peat, and which possesses properties not present in ordinary bitumen, and the pungent acid odour emitted by peat when burning testifies to the presence of this peculiar acidity. By some chemists this is pronounced to be a vegetable acid allied to the pyroligneous, by others to be of a distinct nature; and Dr. Walker observes that it resembles the sorreline, the gallic, and the suberic, and is of opinion that it is a combination of all three. Gallic acid undoubtedly prevails.

At present the recovery of benzol from the numerous coke ovens on the Continent has so increased the output of that material that tar, which used to be the only practical source from which it could be obtained, has fallen in price. When, as we anticipate, the production of the by-products of peat develops into an important industry, the output of acid tar must reach an extensive tonnage. We have already shown that it is likely to meet a special demand for briquetting low-grade iron ores in combination with peat charcoal and pulverized lime, in which process coal tar is useless. In casting about for other uses for this product, and for partially carbonized condensed peat, we have had our attention directed to a process for producing *Methane Hydrogen Gas.* The bulk of coal gas is hydrogen and methane. Although, so far, this method has not been applied to peat, there can be no difficulty in substituting this material. The process of producing this gas is similar to that employed in the manufacture of water gas—viz., by the action of steam on pure carbon, carefully screened coke, etc., the difference being that TAR, coke, coal tar, water-gas tar, creosote, or any liquid hydro-carbon is used. 20 lbs. of coke and 3 gallons of tar produce 1000 cubic feet 10 to 12 candle-power gas. The advantages of methane hydrogen as a diluting gas are well known, and where tar is procurable in large quantities its manufacture is of the greatest importance as an adjunct to gas works. Mixed with coal gas, the cost of production, into the gas-holders, is brought down 25 to 50 per cent.

As the subject appears to us of such moment to the peat industry and to gas companies generally, we give the following extract, reprinted from the *Journal of the Society of Arts*, and also reported in the *Journal of Gas Lighting*, of a lecture on "The Future of Coal Gas and Allied Illuminants," by Professor Vivian B. Lewes, Royal Naval College, Greenwich, one of the highest authorities on the subject of gas:

"In large works blue water gas will in the future be an absolute necessity, but in the hundreds of small works that supply our country towns the benefits to be derived from its use are minimised to an almost vanishing point by the extra cost of production of a comparatively small quantity of gas. I have, during the last ten years, given a large amount of time to the question of how best to supply small works with an ally which shall prove of as much value to them as the Dellwik plant will to their larger brethren.

"Acting upon the suggestions which I have made from time to time, there is perfected an apparatus which should be of the greatest possible value where the gas supply is only of moderate dimensions.

"At the present time the recovery of benzol from the coke ovens on the Continent has so increased the output of that material that tar, which used to be the only practical source from which it could be obtained, has fallen in price until many works would be glad to dispose of all they produce at a penny per gallon. Indeed, in many cases it is being used as a fuel in the works, and the only way in which the price of small quantities of tar can be kept up for special purposes is by reducing as far as possible the amount for sale. The lines on which the experiments have been working have been to take my idea of decomposing hydro-carbons, such as heavy oils, in the fierce heat of the fuel of the water-gas generator itself instead of in cracking chambers, as is usually done in making carburetted water gas, a process which demands not too heavy a grade of oil, and adapt it to the decomposition of tar, so regulating the temperature and the volume of tar that the latter is completely decomposed to carbon, methane, and hydrogen, together with small traces of more valuable illuminating hydro-carbons, and then to filter off the finely divided carbon produced by passage through the coke which is afterwards to feed the generator.

"The apparatus which has been designed for this purpose consists of an iron shell lined with fire brick, and provided at the bottom with clinkering doors. The fuel used in it is under ordinary circumstances coke, although, of course, anthracite, or even a certain proportion of bituminous coal mixed with coke, may occasionally be employed. The fuel after ignition is raised to incandescence by air blasts from jets arranged close to the bottom of the generator. These air injectors carry in their interior the steam pipes, so that when the necessary degree of incandescence has been reached, steam can be directed on the hottest part of the fuel. In the generator lining about midway is a flue provided with openings into the generator; the flue passes entirely round the generator, and has its exit into a stack pipe closed at the top by a snift valve. The top of the generator has another exit leading into the upper part of the stack pipe. In this way during the blow the products of combustion are led away through the openings into the flue, ensuring a bed of incandescent fuel of constant height, and at the same time, when steam is turned on, the resulting gases can be drawn off through either of the exits. Between the flue and the floor of the generator is a constriction, in the space below which are arranged the injectors, by means of which the tar is driven in by steam pressure.

"In actual working the fuel is first raised to incandescence by the air blasts in the lower part of the generator, and the products, consisting of little else but carbon dioxide and nitrogen, escape into the air through the flue, the snift valve being left open. When the desired temperature has been attained the snift valve is closed, and tar or other heavy hydrocarbons are injected by steam into the annular space below the constriction. Rising through the incandescent fuel both the hydrocarbon and the steam are decomposed, the former into soot and gaseous products, whilst the latter yields water gas. During this time some steam is injected through the pipes in the interior of the air jets, by which means the clinker is broken up and more water gas formed. The mixed gases then pass upwards with the finely divided carbon from the decomposition, and this latter is removed by passing through the fuel in the upper part of the generator, and being brought down as the red hot fuel sinks, it reaches the zone of action where it at once is utilised for decomposing the steam before the larger masses of fuel are acted on, on account of its finely divided condition. The gases, consisting of a mixture of hydrogen, methane and carbon monoxide, pass away through the stack pipe by a cross pipe, which is fitted with a valve, by which it is closed during the blow.

"The results obtained are that for a consumption of 28 lbs. of tar and 20 lbs. of coke, 1000 cubic feet of a 10 to 12 candle gas can be obtained, having the composition:

Hydrogen	64·4	per cent.
Methane	12·0	„
Unsaturated hydrocarbons	3·0	„
Carbon monoxide	15·0	„
Nitrogen and carbon dioxide	5·6	„
	100·0	
Calorific value	400 B.T.U's.	

"The small coke consumption due to the bulk of the water gas being made from the carbon of the tar, reduces the price of the gas, and the estimated cost is 6d. per 1000 cubic feet. It is quite clear that such an apparatus using up the surplus tar and coke in a small works would be a valuable adjunct.

"From this rapid review of the processes which are available for increasing the volume of gas obtainable from coal, so as most economically to obtain a large volume of a good quality heating gas, and, at the same time, to utilise to the full the illuminating value of such hydrocarbons as can be obtained from coal, it is clear that considerable economies can be effected. In a large works where the blue water gas could be made at 4½d. or 5d. a thousand cubic feet, it would be possible to put a 14 candle-power gas with a calorific value of 500 B.T.U.'s, or a little over, into the holder at a cost of not much more than 9d. per thousand, as against 1s. per thousand, which we may take it now costs in large works to make a 16 candle-power gas in the holder, so that an economy of about 2½d. per thousand would be arrived at in this way."

The apparatus referred to in the above lecture is simple, efficient, and economical, and is in every way adapted to the production of a cheap and suitable diluting gas. It is so arranged that explosions in the blast pipes or other parts of the plant cannot occur, and, after a few hours' instruction, any ordinary labourer can work it. It is impossible to make any mistake in working valves as there are none to manipulate. The hydrocarbons being completely decomposed into permanent gas, there is no necessity for tar separators or tar wells, and there is no offensive residual whatever. The small coke consumption, due to the gas being made from the CARBON OF TAR, reduces the cost to about 8d. per thousand cubic feet of gas. The advantages of this Methane Hydrogen Diluting Gas Producer may be summarised as:

1. The production of a large quantity of gas to meet emergencies without the necessity of lighting up retorts and injuring settings. Starting from a cold plant gas making can be commenced within two hours.

2. Economy on Capital Account.

3. Saving of ground space. Four times the quantity of gas can be manufactured in the same space as required for coal gas. Thus a plant capable of making 150,000 cubic feet per day requires floor space of 20 feet by 29 feet.

4. Saving in maintenance and repairs.

5. Absolute safety in the manipulation of the plant, together with economy of steam and power required for working.

6. Its high percentage of *Hydrogen*, 64·4 per cent., and low percentage of Carbon Monoxide, 15·0 per cent., the latter being well under any requirements of the Board of Trade.

7. Uniform height and temperature of the bed of incandescent fuel.

8. Reduction (in the case of coal) of clinker, and more efficient blast results.

9. The possibility of working without fire-bars.

10. Control of the tar markets.

We have mentioned the Brayton engine for burning oil sprayed into a carburettor at high pressure which was patented in 1872 in the United States. Since then numerous appliances for gas-making and power, mainly from petroleum or earth oils, have been brought forward. Of these are the Pintsch and Keith systems for the production of gas, under compression, for the lighting of railway carriages, lightships, floating buoys, etc., for which purposes they answer admirably. Though the oil at present burnt is either Russian Solar distillette or Scotch gas-oil, we submit that when the manufacture of peat tar on a commercial scale has been established, the burning "solar" lubricating paraffin oil procured by distillation might well be substituted for these mineral products. The Pintsch system is used exclusively on the passenger trains of the Great Eastern Railway. We would remind our readers of M. Foucault's statement that "the illuminating power of pure oil from peat, the illuminating material *par excellence*, has been found at equal pressures, 705, the intensity of coal gas being 100; and that, with equal volumes, their numbers are 756 to 100."

Where petroleum cannot be procured at a cheap rate, and where peat bogs, as in Ireland and the West of Scotland, cover large areas, the system of lighting and raising steam of the Lucas Light and Heating Company may be expected to do effective work and might be usefully adapted for lamps, rivet-heating furnaces, brass furnaces and heaters for shipbuilders, boilermakers, and bridge builders. Burning crude blast-furnace, *i.e.* coal oil, the Lucas and Giant lamps give a light of from 10,000 to 15,000 candle power, but, in fact, any oil may be used save animal oil, which is far too costly.

CHAPTER V.

ELECTRICITY FROM PEAT.

PROFESSOR GEORGE FORBES, F.R.L., the distinguished consulting electrician, Cataract Construction Company of Niagara, and, perhaps, the highest living authority on the transmission of power by electricity, asserts that he would undertake, by means of waste water power now finding its way to the sea, to run all the railways in Scotland. In Ireland also there is a vast store of water to harness which, till the Shannon Water and Electric Power Company put forward its prospectus, no serious attempt has been made. This undertaking, brought forward at an inopportune juncture when the Land Bill was being eagerly discussed and was before Parliament, met with a cold reception from capitalists and the public generally. It is recognised that electricity is destined to supersede steam as a cheaper form of motive power, and is rapidly becoming an important factor in competition with steam power. But the harnessing of water-power is a costly task, and, at certain seasons in many localities, not always constant or efficient. The contract price for forming weirs and channels, installing turbines, and erecting the necessary plant on the Shannon was £576,500, and the Company is authorized, by Act of Parliament, to afford financial assistance towards the development of new manufactories, mills, workshops, and industries. Limerick, said the prospectus, is already the centre of many industries, and boasts a population of 46,000 inhabitants, amongst the majority of whom, it may be remarked, loyalty to the paramount Power is an unknown quantity. Seeing that Government has already expended nearly £700,000 on sluices to regulate the unfailing water supply of the Shannon, it is to be regretted that this admirable and comprehensive scheme has not been favourably received, but the blame lies with the League and the sedition-mongers of the South West of Ireland. The river is by far the largest and most important water-way in the Island, and may be considered the largest river, above tidal influences, in the United Kingdom, the main stream being 160 miles long above the tideway near Limerick, which is itself 60 miles from the estuary at Loop Head. When the population of Limerick, as has been the case at Belfast and the North of Ireland, is leavened by the influx of the hard, industrious, dogged blood of Scotland, then will come its opportunity. There is at present a remarkable and steady increase in the number of Scotchmen migrating to the North of Ireland, and, possibly, at no distant date, the South West may absorb some of this migrating stream, and Limerick, with sufficient water in its docks to float 3,000 ton vessels, may become a flourishing port and a large centre of industrious energy. This Shannon water scheme was thoroughly sound, but was born out of due time. Some day it will have an existence, and a vigorous one.

A project advocated by Mr. H. B. Thwaite, C.E., has lately been put into shape by the Yorkshire Electric Power Company with a capital of £2,000,000. Here the prime motive power is coal. Briefly described, this gentleman's project is to supply electric power, generated in central stations *installed in the centres of our coalfields*, to our great industrial centres and to the Metropolis itself. The power station for serving the Metropolis would be erected on the Derbyshire coalfield; an auxiliary station to serve the Midland Counties being situated in the Staffordshire coalfield. The electrical trunk lines would serve the larger towns *en route*, including Derby, Nottingham, Birmingham, Leicester, Northampton and Bedford. Distributing, transforming, and storage stations could be erected near the Metropolis. The different Metropolitan and suburban electric light stations could be supplied with energy for distribution. Electric railways and other power stations could also be supplied. Larger power consumers could be supplied with power direct. Each vestry, not already supplied with an electric generating plant, would be invited to put down a distributing system and a receiving station. The electric energy could be sold to the different distributing companies at such a price as to enable the power to be supplied to the light and power consumer at an economic and attractive figure, or at a little over one penny per kilowatt hour. The industrial centres of Lancashire, Yorkshire, and Cheshire would be supplied with electric energy generated in two coalfield stations respectively near Wigan and Barnsley. The cost of power to the small factory owner need not exceed £5 per 3,000 working hours of one actual horse-power of energy. In the Metropolis this energy system will cost between £9 and £12. This electrical power agency permits the starting or stopping of the plant by the mere turning of a switch or the pressure of a button. Whilst the power plant is not actually doing work, there is neither serious loss nor anxiety involved. The power user is not troubled with boiler insurance or the smoke nuisance inspector; he may simply hire the electric motors, and when he decides to remove his manufacturing appliances, he has merely to return the hired motors; whereas a steam-power plant with its chimney cannot, except with a great sacrifice, be removed. If the system is carried out entirely, each machine can be driven independently by its own motor; consequently, the expensive items of belting, shafting and pulleys are almost entirely eliminated. The loss of transmission by cable is about 15 per cent.

For Coal read Peat. Here lies a primary material source of peat, one of the productions of nature, in sight, and at hand, claiming the attention of the masses as well as of the classes, spread over regions of far wider area than our coalfields, and offering promise of success to a degree rarely apparent at so early a stage of any enterprise. Most of the power distribution undertakings and electric lighting companies employ steam as the sole means for generating electric energy, and despite the heavy cost of fuel, prove remunerative. In many sparsely populated districts of the United Kingdom where, for lack of railways and other means of communication, and owing to the great distance from the coalfields, industry is latent, there is ample room for numerous industries, all of which may be served by electricity generated by peat. It is hardly possible to over-estimate the value and importance of the introduction of electricity, on a large scale, as a means for the economical application of power to the many varied factories and cottage industries these large areas are capable of running, or to hazard even a guess at the varied character of the industries we might reasonably expect to see established. Belfast stands prominently forward as an example of what the introduction of outside interest and capital can effect, and there is no reason why what has been done, and is doing, in this great centre of the linen manufacture and shipbuilding should not be effected elsewhere. Industries being essential to commercial prosperity, any enterprise which will enable manufactures to be established where none at present exist must be a matter of great and lasting importance. The introduction of electric energy upon a reliable and cheap basis must tend to bring to whole districts an industrial and commercial prosperity hitherto lacking. In the Highlands of Scotland industry is practically at a standstill, and, with the exception of Ulster, the same lamentable condition of stagnation is general throughout Ireland. Thanks, however, to such leaders of men as Mr. W. J. Pirrie, the great Belfast shipbuilder, who employs twelve thousand men and pays away £20,000 weekly in wages, Lord Iveagh, and others, who are credited with fostering a great transit scheme for "the distressfull country," commercial and industrial developments of great moment may be reasonably anticipated. The co-operation of Mr M'Cann, the wealthiest member of the Nationalist party, in this welcome but wholly unexpected new departure, may be taken as an earnest that such philanthropy shall not be wrecked by League interference or factious opposition. At an early date we may find the canals freed, the creation of a special service of boats, the construction of a network of light railways, and a service of motor-car transport all accomplished facts. In France and Belgium the canals are nearly all free and act as a deterrent on inflated railway freights, whereas in Ireland these waterways have been acquired by the Railway Companies in order to prevent legitimate competition.

The reader is counselled to peruse *Transit Problems*, a paper of considerable merit, the work of Mr. William Field, M.P,, published by the Department of Agriculture and Technical Instruction for Ireland during the current year. In it will be found some trenchant remarks on the paralising *régime* of railway management in the Sister Isle. "The Irish railways by impeding industry and penalising production have been a hidden agency in promoting emigration to a much greater extent than is admitted by their apologists, who do not analyse economic cause and effect. As a country develops it demands better transit faculties, and, as means of transport are improved and cheapened, almost in precise ratio do the agricultural produce and industrial progress of the country increase, for trade and transit travel together, and the limits of markets are frequently determined by the cost of transport. Produce or manufactures are useless unless they can be conveyed to the consumers and users." Recently a compressed Peat Company was started in Co. Sligo, the rate for carriage to Dublin was 11s. per ton, while the sale price to the consumer was 21s., *i.e.* the carrying company got more than half the cost to the consumer. We confidently look forward to an early cure for this plundering and blundering in which the English lines and Shipping Federation cooperate. The influential gentlemen who have taken the transit question in hand will brook no denial. There must be an official Transit Department armed with sufficient powers to control the railway ring. At present high railway dividends in Ireland are extorted at the expense of national prosperity and commercial progress. If the reader will provide himself or herself with the blue book referred to, much valuable information will be found in its pages bearing on the past, present, possible, and probable future of Ireland. The Industrial Conference cannot fail to achieve much good. The country, in the words of the president, the Right Honourable Sir Horace Plunkett, P.C., F.R.S., "sorely needs assistance," and the predominant partner must, if only in its own self-interests, do all that in it lies to promote, by every means in its power, technical education and education generally; to improve agriculture; to restore the wool industry, once such a source of wealth; to establish and foster the diversified industries subsidiary to agriculture; and generally to do its utmost to stem the restless tide of emigration ever setting towards the West, which saps the life blood of the Emerald Isle and carries with it her most progressive sons, the very pith and marrow of the population. Those who are interested in the regeneration and advancement of our countrymen and countrywomen on the other side of St. George's Channel should also consult Mr. W. P. Coyne's *Handbook of Art and Cottage Industries of Ireland.* The late exhibition of Irish industries at Londonderry House bore striking testimony to the capabilities of the Irish peasant in the direction of manufacturing homespuns and other woollen goods. The flocks of Down, Roscommon, Westmeath, and Cork, already produce a "clip" suitable to a wide range of fabrics. By judicious admixture of fresh blood these flocks can be graded up to wool of the finest quality. The skilful breeder overcomes all difficulties. In the hand or power looms working up native material, grown in the centres of manufacture, there are immense and immediate possiblities. With improved staple of wool there must be the newest of processes and the latest and best type of machinery. The running of machinery only fit for the scrap-heap, inferior in productiveness to that employed elsewhere, must end in ruin. The important new edition of *Ireland, Industrial and Agricultural* is an admirable review of the island's principal economical resources and a good book of reference. Parliamentary Grants founded the "Royal

Linen Manufacture of Ireland," which now runs 31,484 looms—much of the flax, to our shame be it said, being imported, though Ireland and many parts of the United Kingdom possess all the conditions of soil and climate suited to the growth of the plant. Thanks to the action of the *Congested Districts Board,* the lace industry has increased its sales, within seven years, from £4230 to £23,149. The Irish Industries Association is doing splendid work, as is the Royal School of Art Needlework. What more beautiful than the Belleek pottery ware with its peculiar tint and nacreous lustre, and yet this is now the only pottery deserving the name in Ireland. A visit to the collection of Irish Building Materials and Minerals at the Imperial Institute should convince the most sceptical that all over the county, from Belfast to Cork and from Dublin to the Atlantic shores, there is abundance of excellent pottery clays. What more promising than the samples of manufactured Terra Cotta, Della Robbia—turquoise, yellow and green, Faince, and the Scraffits wall tiles? There is, with fuel and power, a great future for this manufacture. The *répoussé* metal work of Fivemiletown is Ireland's one sample of iron or steel industry, but it has everywhere earned most favourable notice. We find at the Imperial Institute convincing proof of the mineral wealth of Ireland. There are exhibited numerous specimens of metals, building stones, flags and flagstones, marbles, granites of all colours and the finest quality, clays, sands adapted to glass manufacture, slate, and numerous other materials. There is a great future for Ireland in the working of her really splendid and practically inexhaustible granites. It is found in every colour, takes a beautiful polish, and wears well. The green variety (Dolerite) from Rostrevor deserves special attention. It is said that the patriotic Irish Americans who have departed this life take their rest more comfortably when some headstone, "sculptured urn," slab, pillar, or Celtic cross from the old country bears record to their numerous virtues and the high esteem in which the exile from Erin was so justly held. This estimable hankering after a monument from the land of one's birth is likely to open out a lively trade in tombstones, which, with capital, modern machinery, and power to drive it, can be developed to any extent. Galway and Donegal can supply New York not only with magnificent specimens of red, grey, and green granites to beautify "God's Acre," but with a variety of marbles such as Connemara green, Cork red, and Middleton pink and dove, Erne fossil, Kilkenny black and white, Galway white, and Donegal green.

There are many who believe that if diligent scientific search were prosecuted valuable minerals would be found in the Sister Isle. All will wish well to the endeavour lately set on foot to prospect in the Berehaven, Schull, Crookhaven, Kilcrohane or Sheeps Head districts, and in Galway, where some very fine copper pyrites have been discovered, malachite, azurite, and bornite are known to occur. Tin, lead, zinc, and other metals are known to exist here and there, but there never has been any persistent, well-sustained attempt to "go to the deep" for higher-grade ores. When the country is sufficiently opened up by railways, and has an efficient power supply, these minerals will be prospected and developed by modern appliances. In the past the Irish miner has not been an unqualified success, for many years ago anthracite coal mining was started in some localities, but, just when successful results appeared within reach, the miners brought out their tools and struck. The strike in one instance was not due to the Trade Union or to the work of the agitator, but was the outcome of a superstitious belief in malevolent gnomes who disputed their right to burrow into the bowels of the earth and to rob them of their treasures. It is not improbable, however, that some wholly mundane influence utilised this superstition to trade on the fears of the ignorant, easily influenced, local peasantry.

In support of the advantages to be derived from electricity, provided it can be generated at a low cost, we may instance a concern established on the Tyne. Whilst the principle of generating electric energy in central stations has already been successful, power companies, with rights over considerable areas, have not been long enough in existence in England to allow of their actual financial results being quoted. But the Newcastle-on-Tyne Electric Supply Co. has grown by various increments in area from an electric lighting business to a power undertaking of considerable magnitude, and although the supply of power in bulk is a new development, the results of the short period of working are so emphatic that they may be accepted as conclusive proof of economy in production. It may be mentioned, in support of the soundness of this new departure, that this Newcastle Company has recently obtained a contract for supply to the North Eastern Railway Company of the electricity for that portion of their system which they are now electrifying.

Important advantages of far-reaching effect must result from the extended development of electric energy, and it will have an important bearing on rural and cottage industries. The general adoption of this power will be hastened by the fact that it will, especially in conjunction with peat fuel for manufactures and household purposes, banish that intolerable nuisance the Smoke Fiend, securing a pure atmosphere and other beneficial results. Industries will spring up and develop outside the large manufacturing towns, those murky, smoke-laden centres of a fast deteriorating population.

In these pages we have endeavoured to place before and to convince the reader of the capabilities of peat both as a raw and a manufactured material. Probably, in due process of time, further uses will be found for this vegetable matter. In it we find at once a fuel and a product capable of wide and remunerative application. We shall do well to follow in this particular the example afforded by Germany, Austria, Holland, Russia, Sweden and Norway, where the most is being made of the peat deposits and where State aid is not lacking. The mammoth Yorkshire Power Company, whose prospectus has lately been before the public, proposes to use coal as the creator of its electric energy, but where peat exists in sufficiently large quantities, and of a suitable quality, why not avail ourselves of it and cause it to serve the threefold purposes of fuel, raw material, and land reclamation? The operations for winning it require no skilled, highly-paid labour. Much of the digging or graving can now be performed by the steam or electric-driven dredger, the steam sapper, or by the grab. No deep shafts have to be sunk, no costly galleries to be driven, and there is no expensive haulage. Fire and after-damp are unknown, frequent and dangerous fall of roofs cannot occur, pit props are not required, cage accidents are impossible, and an elaborate or any system of ventilation is uncalled for. Miners' strikes, with their attendant coal famines, dislocation of trade and industries, intense suffering amongst the poor, with heavy losses all round, would be troubles of the past. Peat-fuel, with its outcome of electric energy, will free us from the grasping clutches of the coal monopolists and speculators; moreover, it will tend to curb the undue influence of Trade Unionism, and keep wages within reasonable bounds. The collier will not find so much time to "play," he will be less disposed to listen to the voice of that curse of the working-man—the agitator, and such senseless strikes as that at the Denaby and Cadeby Main Collieries could not be repeated. This absolutely ludicrous, though not less vicious piece of work, accompanied by assault and intimidation, cost the malcontents more than £70,000 in wages, besides depleting the funds of the Yorkshire Miners' Union of some £30,000, causing a total wastage of £200,000. For months previous to the strike these colliers had been earning a daily wage of 9s. 1.55d for less than seven hours' work (inclusive of meal times), and were therefore paid 1s. 3½d. per hour. Expenses are largely dependent on the cost of fuel; and the price of coal, at the pitmouth, doubled between the years 1888 and 1900. Providence has placed this valuable substance Peat freely at the command of man, and it certainly ought to enter very largely into general consumption. It is surely of sufficient importance to command earnest attention not only from owner of the barren unproductive moor or bog, and the manufacturer, but from the general public, not only from its commercial potentialities and its varied application, but on the score of its adaptability to the necessaries of domestic life. The development of such a source of wealth and of general relief, lying all round on lands that are now practically worthless, calls for the serious attention of the Statesman, and invites the attention of the capitalist, the business man, the philanthropist, and the community at large. There is more in peat than is dreamed of in most men's philosophy. Lord Rosebery recently remarked that the Empire never needed loyal service so much as now, and, with the serious question of our food supply in case of war prominently before us, we consider that in advocating the claims of the neglected asset we are discharging a duty.

We have called attention to the results obtained on the Continent, and, to a limited extent, in our own country, from "moorkultur" or the cultivation of cut-away bog, and have instanced cases where, with rational treatment, vast and desolate morasses have been converted into rich pasture, smiling cornfields, arable land famed for its root crops, and luxuriant woods, and that too under conditions of position and climate none too favourable.

The amount of peat graved annually in Holland, says Mr. J. T. Tatlow, amounts to over 1,000,000 tons, and the amount of land stripped in the process is estimated at close upon 1000 acres, English, yearly. There are now, in a high state of cultivation, in Holland, over 210,000 acres, English, of this cut-away bog. "When one thinks," adds this gentleman, "of the enormous amount of capital and energy involved in this undertaking, and rendered necessary in grappling with natural difficulties which exist in Holland and do not exist in Ireland, one is amazed and dejected to think what they have done and what Ireland has left undone in the utilisation of her bogs."[1] Years ago, when the peat question was first mooted in the United

[1] This applies with little less force to the vast peat deposits in the Scottish Highlands and Lowlands, to the Western Isles, and to many parts of England and Wales.

States, a writer in the *New York Reformer*, in endeavouring to educate his countrymen on the uses of peat as opposed to, or in conjunction with, coal and petroleum, delivered himself in the following racy fashion: "What is Peat, where shall we look for it, and how shall we know it? In what is it better than wood or coal, and in what respects inferior? Is a peat bed of much value in money, and what is the history of peat? All these being questions of keeping warm and cooking, and gas and motive power, and making money, are almost asked daily; for peat is becoming a subject of active interest everywhere at present from the high prices we have to pay for wood and coal. All over the State just now, solitary individuals in high boots, and trousers tucked in, with a long pole over the shoulder, and speculation in their eyes, may be seen following a sloppy, crane-like course of life, mysteriously wading about where mostly bull-frogs do congregate, who, if they are asked what in the world they are doing out there, return a swampy kind of answer, while they hurry on and leave you as clear as mud upon the mystery of their queer accoutrements and unaccustomed advent, and their marshy ways. Yet if you become familiar with the matter but just a little, the fog will rise from the subject and you'll understand it easily, that it is peat-bogs they are looking after; and that if one should happen to exist upon your farm, it may be an excellent thing for yourself to know, as an acre of peat may be worth a thousand dollars, or two thousand even, instead of being a worthless bog and a nuisance, so given up to croakings and paludal dirges, that even abundant liquidation cannot still 'the voices of the night.' A large bed, tolerably dry, or favourably situated for draining, located near a place of great consumption, and of pure, dense quality, may be worth anywhere from a thousand to some hundreds of thousands of dollars. If, however, badly located, very wet, quite poor, etc., it would be worth something to you if it was not on your farm. There is one great advantage in looking for peat, over boring for oil, for instance; for peat you put down your well with a pole, and it costs you only a couple of wet feet; and if you don't strike peat, peat has not struck you —you are not floored—your financial eye is not closed; you can go on looking; and if at last you see it, you can start business on a fair scale with only a spade or two; and thus this is a branch of industry eminently open to universal competitive enterprise, with small means and no indorser. How much capital, by the way, do you suppose is now, after only so few years' operations, engaged in petroleum? Peat and petroleum (as their names indicate) are of the same family (Old King Coal being the head): and it would be strange if the younger brother, with the shorter name, should do the longer and the larger business after all, and become the greater favourite of the two. There is more democracy in peat, more disposition to be generally useful, not distant at all, but at home on everybody's hearth; ready to lend a hand in the kitchen, or work in the shop, or start an engine, or run a factory or an iron-mill, or if you call on him for a big job, anything a'most and without much fuss or fixing; a good-natured, industrious, valid and capable, a rather 'unwashed,' rough sort of fellow, but a fellow substantial withal, plenty of means and ready to do a good thing for you, and a big thing too, if you want it. You had better make his acquaintance immediately if he happens in your neighbourhood."

Worked-out coal fields, exhausted oil wells, and shale deposits, are worse than useless. Not so with peat bogs. When the decayed dense bottom peat has been cut away to within three feet of the pan, if a layer of the surface sphagnum be placed upon this moist bed the bog will grow again. This renovation of peat bogs is feasible, and the deposit renews itself in a comparatively short space of time. Thus the exhaustion of our peat bogs becomes an impossibility. The reader is referred to Dr. P. Dvorkovitz's remarks on this very important possibility. The owner has at his disposal two distinct methods of utilising his cut-away peat bog.

CHAPTER VI.

HOW TO USE PEAT FUEL.

THAT peat is a good and thoroughly wholesome fuel is now on the Continent, if not at home, generally conceded, but very few people have any idea how to use it. The masses and classes alike are ignorant of the method of using any fuel advantageously and economically. With plenty of kindling, an effective fire-lighter,[1] an unlimited quantity of fuel, a clear grate, and a strong draft, it is an easy matter to send a roaring blaze up the chimney regardless of expense. In burning peat we have as many characteristics and qualities to consider as in the case of coal. Some peats are richer in calorific ingredients than others. The foreigner, always ready to appreciate the benefits of an economical household fuel, and to whom our cheery, bright but costly open grate is unknown, has invented many cunningly devised continuous burning stoves, some of which are admirably adapted to the small peat briquettes, which can be supplied in any form or of any size. In this respect the peat manufacturer has an advantage over the colliery proprietor, for his output is to pattern; he is not troubled with "cobbles," "nuts" and "duff," or a variety of prices and grades. What is supplied for the furnace, the kitchen range, the greenhouse and general domestic uses is one and the same, only differing in quality according to the compound

[1] Automatic machinery for the manufacture of peat fire-lighters, turning out 12,000 in a working day of ten hours, has lately been perfected. These kindlers are in the form of perforated briquettes, ignite instantly though safe, burn with great fierceness and durability (burning for nearly twenty minutes), are clean and handy, require no "dipping," which evaporates, and can be sold at a profit at 2s. per gross.

parts of the bog from which it has been won. Coal factors and others condemn peat as rubbish. They know nothing of its merits or demerits, and it is at present their interest to decry any substitute for what brings them in their fat living. Owing to the enormous vested interests in ordinary coal, peat has been grossly libelled. Peat, either in its crude or condensed form, can be burnt in any of the present forms of grates, but, where the best and most economical results are aimed at, we give a decided preference to one especially constructed for this particular fuel, and we commend this pattern to the careful attention of our readers. It has been found that peat which is easily ignited—there is the safe, cheap and speedy kindler manufactured from peat—burns freely, leaving neither cinders or other impurities behind. One great advantage is that it can be used in smaller quantities than coal, that it leaves a small amount of white-ash, requires to be renewed less frequently when the draft is suitably arranged, and the intense heat given out can be graduated to suit the weather. As regards open grates, ranges and furnaces, it will be found that the fire-pot or well—the receptacle of the fuel—should be of greater area, and less depth than is considered necessary in the case of coal. The bars must be closer together. When peat briquettes come on the market, enterprizing stove-makers will not be slow to give their attention to peat stoves; in the meantime this, as an open grate, answers its purpose admirably. It is simple and economical, burning for ten hours and upwards without any attention or added fuel. The air supply is under complete control, without which no grate can be perfect, consequently the combustion is perfect. Being absolutely noiseless, it is invaluable in the sick room, where an even temperature may be maintained day and night. There is no iron lining within the well, no dusty ash-box to be drawn out to soil or burn the rug or carpet. A specially constructed shovel cleans out the well, which is of fire-clay on a fire-clay foundation. It is claimed, and justly so, that this is the only grate with a solid fire-clay hot air chamber, through which the super-heated air passes to the fire at will, securing perfect combustion. With good peat briquettes, or with peat and anthracite blocks, this grate can be used in London at a cost of about 3¼d. per day of twelve hours. All the heat radiates into the room, whereas in most grates the heat produced is wasted by being drawn up the chimney or flue. The grate can be purchased at from £1 10s. and upwards, and is equally well adapted to the cottage and mansion as to the school, the hospital, the asylum, and the largest institution.

Mr. T. Pridgin Teale, M.A., writing on the economy of house fires, gives the following hints, embodying the results of observations and experience as a manufacturer and user of improved fire-places. By following these simple rules the possessor of an old time grate, who may be unwilling to incur the expense of a new patent stove, may carry out alterations such as will convert the old wasteful "blast furnace" into a satisfactory slow combustion fireplace:

Rule 1. As much fire-brick and as little iron as possible. Fire-brick retains, stores and accumulates heat. Iron runs away with heat, and chiefly in the directions in which the heat is least wanted.

Rule 2. The back and sides of the fire-place should be fire-brick.

Rule 3. The back of the fire-place should lean or arch over the fire, so as to become heated by the rising flame. The heated back raises the temperature of the gases and helps them to burn, thereby lessening the smoke, and sends abundant radiant heat, the most valuable product of the fire, into a room.

Rule 4. The bottom of the fire or grating should be deep from before backwards, probably not less than 9 inches for a small room, nor more than 11 inches for a large room. In the front hob, *i.e.* raised, fire-places 12 inches is found as a rule the best "depth." Two points are gained by this unusual depth, one that space is allowed for the slanting or arching forward of the fire-place back, the other that there is plenty of room for the fire to "lie down" away from the draught of the chimney. The fire is thereby made horizontal and slow-burning instead of vertical and quick-burning, and this shallow fire in the case of peat is important.

RULE 5. The slits in the grating should be narrow—perhaps $\frac{1}{4}$ inch wide for a sitting-room grate, and $\frac{3}{8}$ for a kitchen grate. When burning peat, as no cinders are formed, the slits should only be large enough to permit of the exit of fine ash.

RULE 6. The bars in front should be narrow—less than $\frac{1}{2}$ inch in thickness, so as not to abstract much heat, and close together, $1\frac{1}{4}$ inch apart, so as to prevent the fuel from falling forward, and not more than four in number for an ordinary fire.

RULE 7. The chamber beneath the fire should be closed in front by a shield or "economizer," the object of which is to stop all current of air that would pass under the grate and through the fire, and so to keep the chamber, its floor and its walls at a high temperature. The "economizer" is simply a shield of cast-iron which rests on the hearth and rises as high as the lowest bar of the grate, against the front of which it should fit accurately.

A good household fire should burn well but not rapidly. Dr. Pridgin Teale, a well-known authority, who claims to be the inventor of the "well" fire-pot system, says: "Two things in combination are essential to the combustion of fuel—a supply of oxygen and a high temperature. If fuel be burned with a hot jacket around it, a very moderate amount of oxygen will sustain combustion; and if the supply of oxygen be moderate, combustion is slow. Burn coal (or peat) with a chilling jacket around it, a rapid conductor like iron, and it needs a fierce draught of oxygen to sustain combustion, and this means rapid escape of actual heat, and also of potential heat in unburnt gases and smoke (peat gives out very little smoke) up the chimney. This is the key to the whole position; this is the touchstone by which to test principles of fire-place construction.

For hospitals, barracks, halls, public buildings, and large rooms generally the Teale *stove* is to be recommended for burning peat briquettes. It is a back-to-back fire-place, designed to secure the maximum of heat without waste. The flues, which are separate for the two stoves, are carried either up through the ceiling or down through the floor, the latter having this advantage, that it allows a full and unbroken view of the chamber, while the top of the stove admits of artistic tiling and can be used more or less as a table. There is a ventilator under these top tiles, which, not being apparent to a person standing upright, is no disfigurement. It is designed to ensure the warming of the air passing through it, and it is claimed that the temperature of a chamber thus heated is sufficiently warm throughout every part, as well as near the stove.

After considerable search we have lit on what may be accepted, for the present, as a perfect and easily managed cooking range for burning either peat briquettes, peat charcoal, or a blend of both. A perfect and easily regulated range is a desideratum in every household, be it the humble artizan's cottage or the palace. It delights the cook and preserves the nourishing properties of food during the process of cooking. Most of the kitcheners, those especially found in houses run up by the jerry builder and in general use, are dangerously defective. For half a century, despite what advertisers say, there has been no fundamental change in the construction of ranges. The kitchener generally pawned off on the public is the same as it was two generations ago: the same old sooty flues, all alike defective, inconvenient, dirty, malodorous, fuel consuming, unscientific, a "cheap and nasty contrivance." There is the same fire-box, the same low-down baking oven without the slightest ventilation, the same old sooty flues, boilers that burst during the frost, and an over-heated kitchen. Dr. W. Whitla, a teacher of eminence and an authority in the medical schools, in his *Dictionary of Treatment*, writes: "Many cases of severe acid dyspepsia are caused by great excess of butyric acid, and the cause of this is owing to the practice of stewing fat meats for a long time at high temperature in a close oven." This deleterious resultant is of pungent and rancid odour and sour taste.

Most of us hanker after the toothsome and succulent joint roasted before the fire, and the dullest palate can detect the fine flavour of the surloin roasted before the clean bright fire from the dry, shrunken, unpalatable meat that has been baked in the ordinary closed oven. If not roasted in an atmosphere of pure air, the chemical action set up immediately heat comes into contact with the article being roasted, causes an animal and metallic odour to exude that should be instantly carried off, and its place supplied by fresh air. Hence the superiority of the open range to the close oven kitchener. But the open fire range requires skill to operate, and, moreover, necessitates constant supervision and continuous basting, because the radiated heat, impinging only on one side of the joint at a time, is required to be so intense that, were it not for the revolving jack or spit, the joint would instantly become burnt, as indeed is nearly always the case with large joints before they become "done" to the middle. Practical tests have demonstrated that the heat thrown out from the open range, indicated by a thermometer placed beside the joint, raises the mercury to 600 degrees Fahr., and this temperature cannot be lowered because the roasting is done from one side only. The meat is thus placed between two extremes of 600 degrees on one side and the temperature of the kitchen on the other, an obviously serious defect. Meat of all kinds should not be roasted in a temperature of over 350 degrees, and the heat should be equal on all sides. This new range is a close fire range answering all the conditions, theoretical and practical, desired in a thoroughly efficient cooking equipment. It is a perfect roaster, cooker, and oven, under the best hygienic conditions, requires no brick or other fitting, and is therefore a tenant's fixture, and with it the most careless servant cannot waste the fuel. When the fire is lighted it heats the hot plate, the oven, and boiler for supply of hot water, all at once. The heat is made inside the stove, and remains in it, whereas in the ordinary patterns it is driven up the chimney. There is but one damper. It burns any fuel, but is specially adapted to peat. The patentee claims that a saving equivalent to 75 per cent. in fuel is saved as compared with the ordinary open fire range, while the results are confessedly superior. In connection with this now very important question of economy in fuel the following figures are interesting:

	Open fire Kitchener.	Improved Range.
For a family of six persons, per week -	8 cwt.	2 cwt.
For a restaurant cooking for 250 persons, per week, - - - - -	28 cwt.	6 cwt.
For a public institution cooking for 250 persons, per week - - - -	40 cwt.	6 cwt.

No dust or dirt is found in the kitchen and its temperature is kept much reduced. The prices range from £15 to £175. Our War Office and Admiralty authorities will do well to establish these ranges in every barrack.

We should like to see less iron and more fire-clay in the construction of this kitchener.

Another use for peat fuel is in Commercial Horticulture and in the private conservatory and greenhouse. There are indications that fruit, flower and vegetable culture under glass is becoming a large and constantly increasing industry. Fifteen or twenty years ago the systematic raising of large crops under glass was practically unknown. The venture, first started at Worthing, where hundreds of acres under glass are to be seen, spread to the island of Guernsey where climatic advantages were in its favour, and it now has "caught on" far and wide all over England and Wales and has established itself on a small scale in Ireland. We do not venture to assert that the industry has been uniformly successful, nothing attempted by mortal man ever has or ever will be, but where failure has crept in it can invariably be traced to a lack of technical knowledge, mismanagement, bad selection of locality, high-priced land, and dear fuel. When land is worth £1000 to £1200 an acre a "crop of bricks and mortar" pays better than anything, and on the south coast, far distant from the coal fields, firing adds enormously to the cost of growing. Those whose operations are carried on within an easy distance of the large centres of consumption—say within a radius of fifteen to twenty miles—have much in their favour, for they are enabled to deliver their produce absolutely fresh and without the need of packing and railway delays. We have it in our power to beat down foreign competition, for the great superiority of the home-grown article must always secure for it a preferential market, and this is especially the case with soft fruits. Foreign fruit has to be packed when only partially ripe, and consequently cannot arrive in prime condition. It has been argued that the spread of the home industry must cause the values of the various commodities grown to be lowered to an unremunerative point. But the increase in the demand for the out-of-season fruit has developed even more rapidly than the supply, the increase being especially noticeable among the industrial classes. Market reports continue to show a steady rise in prices. Southern growers fondly hoped that their favourable climate conditions would retain the industry in their own hands, but their forecast has proved unfounded, and the area of the cult has been shifted far beyond its original home. The general tendency is towards further decentralisation. We find in the *Horticultural Trade Journal* of September, 1902, that "The produce of the Midland and northern growers is in no way inferior to the best crops grown in the south, while the actual cost of production is lower owing to the cheaper coal and the saving in freights, so that there is but little doubt that the grower of the future will cultivate his houses within easy distance of the markets he has to supply, and with the cheapening and development of the motor-car he will be independent of the railway companies for the distribution of his produce."

Why do not provincial traders organise a strike against the tyranny of London? The idea is full of promise.

The London markets are bloated monopolists, which keep the provinces in leading-strings and hamper their trade. Practically every ton of vegetables and fruit brought to this country is packed off to Covent Garden. Most of the home-grown stuff is also sent to the Metropolis. The result is that such a "glut" occurs that growers not only lose their produce, but have to pay railway expenses into the bargain.[1] If a country shopkeeper wants a supply of flowers the chances are that he will have to come to London for them. Obviously the trade is too much centralised, and London's monopoly ought to be broken up. Commercial horticulture is one remedy.

Many will be found who assert there is no profit in commercial horticulture. To such carpers we oppose the logic of stubborn facts. During the last decade nearly all the growers have largely extended their operations and many new concerns have been started. The output would not grow unless its advance be coupled with increased profit. During the last five years, despite a long journey from the metropolis, no railway opposition, and the abnormally high price of land, no less than four miles of glass houses have sprung up between West Worthing and Lancing.

To illustrate the activity in the Midland and Northern counties, we may mention that during the period under consideration the following gentlemen have either added to their existing greenhouses or have had new installations erected: Mr. Chattock, of Solihull, near Birmingham, tomato and cucumber houses; Mr. Mee, at Daybrook, near Nottingham, palm and plant houses; Mr. Knight, of Kenilworth, tomato houses; Mr. Matthews, of Shrewsbury, tomato houses; Mr. John Davies, of Hoylake, who has hitherto be mostly known for his "Chrysanthemum Maximum Daviesii," has added to his glasshouses, which are within easy reach of Birkenhead and Liverpool; the

[1] A glut, such as was experienced last season, can be met by a development of the cold air storage system. In steady, low temperatures even soft fruits keep well for several days.

"Times Horticultural Co." has built a complete installation on modern lines near Preston in Lancashire, chiefly for the supply of Southport and the northern manufacturing towns, and we understand that the results achieved have fully come up to anticipations. Another new installation of about 1000 feet has been erected in Buckinghamshire within easy reach of Northampton, and the manager is considering the question of direct motor service to that town. Mr. H. Whateley, of Kenilworth, now the largest grower in the Midlands, has at present added 2000 feet of glasshouses to his nursery, which further increases his output of tomatoes, cucumbers, and orchids. In the west of England the activity of the trade is also well marked, and amongst the firms which have extended their operations we may mention Mr. Restall, of Cheltenham; Messrs. Lloyd, of Paignton, Devon; and Mr. Bennett, of Saltash, Cornwall; while a new installation for the supply of Bath on modern commercial lines has been commenced at Glastonbury in Somerset. The rapid growth of the port of Southampton is causing the corresponding increase of glass within a 50-mile radius of that town. Mr. Fay, of Totton, and the growers near Winchester and Medstead have increased their places, while Messrs. S. Fay & Sons, of Southsea, have also added to their houses.

In a work entitled *Culture Under Glass*, written by an admitted authority, some actual balance sheets of typical nurseries are given and are worthy of examination by any one contemplating starting on the industry, which is not only a paying but an interesting one, well suited to ladies.

Balance sheet A. This nursery comprises 800 feet run of glass houses, of a capital value, including outfit, of £1400. Nett profit £290 13s. 2d., or over 20 per cent. on capital invested.

Balance sheet B. The nursery comprises 1000 feet run of glass houses of a capital value, including outfit, of £1550. The nett profit was £337 7s. 4d., or at a rate of over 21 per cent. on the capital invested.

Balance sheet C. This installation comprises 1200 feet run of glass houses of the capital value, including outfit, of £1850. The nett profit was £461 11s. 5d., or at a rate of 25 per cent. on capital invested.

Balance sheet D. In this nursery there are 1450 feet run of glass houses of a capital value of £2500. The nett profit was at the rate of over 21 per cent. on the capital invested.

In every instance fuel has been by far the most expensive item, and tubular boilers are constantly having their tubes burnt out by the sulphur in the coal. Anthracite is recommended, but as it is only won in South Wales carriage makes it expensive. It is the fuel question that has proved the stumbling block to most growers, and in those districts in the vicinity of peat deposits this artificial fuel will bring salvation. In Ireland, where delicate plants, such as can only be grown in England or Scotland under glass, flourish in the open, this industry awaits development. Not very long ago so apathetic were the dwellers in the Dublin district that the vegetables for the supply of the capital were imported from the Clyde, and at present large quantities of fruit are being sent by growers in the Channel Isles as well as by the salesmen in the Manchester and Liverpool markets. With more sunshine than any town in the United Kingdom, cheap land and labour, and reasonable rates to all the western ports, the Dublin grower should be supplying Glasgow, Liverpool, Manchester, and all the great and wealthy industrial towns in the north-west of England. The facilities are greater than those possessed by the Channel Islands, and, with millions of tons of excellent peat fuel close at hand, a very remunerative industry invites the adventurer. Swansea, Cardiff, Bristol, and from Bristol, Cheltenham, Gloucester and Bath, Plymouth, and other large towns on the coast might be supplied from Wexford, Waterford, and Cork. The "tallow peat" of Lough Neagh would furnish fuel for miles of glass houses to supply Belfast and to ship across the Channel to Liverpool. In the summer there is a keen demand at the

Lancashire and Welsh pleasure resorts. Ireland offers exceptional advantages, but with the exception of a few unimportant nurseries in the vicinity of Dublin, and at Rush, culture under glass is not. An intimate technical knowledge on the part of the grower is not absolutely necessary to success, though an aptitude for the interesting occupation is a *sine qua non.* Many of our leading growers can testify to this. The beginner, however, should procure the services of a trustworthy efficient foreman, one, not necessarily a gardener, who thoroughly understands the business of growing fruit, vegetables, and flowers under glass. The wages of such men are high but well earned. After a time, if an apt pupil, the employer will become his own foreman. This industry need not be confined to men. In it ladies will find ample and suitable employment for their time, energies, and capital. The Countess of Warwick, always practical and a born leader of her sex, has proved how that ladies can be trained to be excellent horticulturalists, and, surely, many of our daughters and sisters would find the greenhouse a more interesting and paying means of earning a living than the heartbreaking school-room, the office desk, serving behind the counter, typewriting, nursing, or many of the not very palatable indoor tasks now set them whereby to earn bread and cheese. Much valuable information bearing on the possibilities of successful fruit and vegetable culture in Ireland may be gleaned from a paper, *A Note on Fruit Growing in Ireland* in the *Journal of the Department of Agriculture in Ireland,* Vol. 2, No. 4, June, 1902. Arthur Young, who in 1775 visited Dromoland, and who, as an agriculturalist and writer on the subject, is constantly quoted, wrote: "Sir Lucius O'Brien took me to see his orchards. I never beheld such crops. The trees were covered with the most splendid fruits, and he assured me that some trees gave him a hogshead of cider. I am sending you some scions of Coccagee." Another writer, speaking of the Blackwater cider from orchards in Kerry, on the banks of that river from Mallow to its outflow, says, "In the last century (the eighteenth) it was constantly exported, and so prized in England that it commanded the highest price, and that at the Cider Congress in Dublin the judges refused the premier award to Mr. Drew until it was proved that no fine wines were used in the making, the quality was considered so superior." Ireland possessed almost an ideal climate for growing apples, pears, plums, damsons, strawberries, raspberries, black currants, and gooseberries. The soil in many districts lends itself to high-class fruit growing. The winter climate in Dublin averages four degrees warmer than Paris, yet not a single head of lettuce is forced though hundreds of dozens are imported weekly, besides all kinds of forced vegetables, especially asparagus, at the enormous freight rate of £8 a ton. Although the "forcing" of tomatoes is rapidly becoming an important British industry, the imports this season have been immense. They now amount to 1,250,000 cwt. a year, representing a value of £1,200,000.

During the last ten years many of our leading growers have adopted the travelling or movable form of glass-house, as brought out and manufactued by the Horticultural Travelling Structure Company, Limited, and now eight miles of these specialities are in use. Before their introduction it was assumed that a glass-house was a fixture, and the cost of erection and heating apparatus (often inefficient and wasteful) deterred market men from adopting it, but it is obvious, when one house is made to do duty for many, that this initial difficulty of outlay is to some considerable extent removed. The advantages claimed for this system are manifold. The travelling green-house saves shifting of plants and soil; sowing of the land; capital outlay; cost of pots and labour of potting; loss of seasons; labour of wheeling in and out of soil, plants and manure; labour of watering; and the deterioration of soil which results in a fixed green-house from continuous growing one crop year after year on the same ground. Undoubtedly these recent improvements place the grower at a great advantage as regards productive power. The ground is periodically exposed to the beneficial action of sun, air, frost, snow and rain. The more rapid succession of crops is assured. Important items these after our experiences of last summer.

These travelling hot-houses are run over level ground on small wheels and light rails, so that, directly one crop has been matured and marketed, the houses, with their heating apparatus, are removed over fresh crops as they are grown in the open ground. In this way the grower gets a crop of such variety as he deems best suited to the demand of the locality and the available markets. For instance, during the early part of the year either strawberries, bulbs or roses are forced. Directly those are marketed the houses are pushed on to the new plot of ground where tomatoes are growing, and, finally, in the autumn the houses are shifted over chrysanthemums and mushrooms. Some growers force asparagus, beans, rhubarb, lettuce, cucumbers, radishes, narcissus, etc. Large or small the houses are easily moved, the hot-water pipes and boilers travelling with the houses.

Coal, or a mixture of coal and coke, as generally used, requires frequent attention during the night. With peat the gardener need have no anxiety, it requires no replenishing for hours once the fire is properly made up. It will keep up an equable temperature through all the houses for twelve or more hours, be the weather ever so severe. Sphagnum is largely used in horticulture. As has already been stated ship loads of peat ashes are imported from Holland every year for sale to our market gardeners. *Peat and its Uses as Fertiliser and Fuel*, published by Orange Judd & Co., New York, is a useful little book. In it the author treats of the characteristics that adapt it for agricultural and horticultural purposes, as, for instance, its remarkable sponge-like power of absorbing and retaining ammonia; its effect in promoting the disintegration and solution of the mineral ingredients of the soil, and its influence on the temperature of the soil. He also treats of the various ingredients and

THIS ILLUSTRATION SHOWS TOMATO PLANTS.

P.—Plant grown in specially prepared Granulated Peat Loam. **S.**—Plant grown in Soil.

qualities that make peat a direct fertilizer; which are the organic matters, inclusive of nitrogen; the inorganic or mineral ingredients, also some peculiarities relating to the decay of peat. Peat is a highly concentrated vegetable food. The fertilizing properties of peat-charcoal are of hardly less an importance to the agriculturist, the market gardener, and the horticulturist than is its calorific value to the smelter. Florists and nurserymen retail charcoal at the rate of £20 a ton, and peat at 3s. a sack.

We here give an illustration of two pot-grown tomato plants of the same age, and from the same seed, the one raised on pure peat soil (marked P), the other on loam (marked S). The abundance of fruit, closer to the ground, on the former, is very marked, as is the comparative compactness of the plant.

We know of several who, starting with little or no experience, by their own sound sense, a certain amount of predilection for the industry but no practical experience, steady personal supervision and a "dogget does it" determination, have from small beginnings risen to the first rank of successful growers. In this volume we have referred to the charming and effective method of growing bulbs in peat-moss fibre and ground shells in pots and vases, with which Mr. Robert Sydenham, of Tenby Street, Birmingham, has achieved such marked success. As an object-lesson, proving the truth of the old adage, that "great results from little causes spring," we venture to give that gentleman's commercial history as a horticulturist and as striking example of how a hobby has grown into one of the largest establishments of its kind in the United Kingdom, boasting 12,000 separate customers. As one of the leading horticultural papers stated a short time back of this wholesale jeweller: "This at the outset only an enthusiastic amateur, has in fifteen years built up a wonderful trade, and has made hundreds of thousands of persons ardent lovers and growers of flowers who, but for him, would never have been fascinated with the pursuit, and has in one way or another enlisted an army of recruits in the service of floriculture." We take the following paragraphs from a local journal, merely premising this, that Mr. Sydenham commenced operations with eight shillings worth of hyacinths, and that during the past season he filed 20,000 orders:

"When, in 1884, Mr. Robert Sydenham disposed of a few surplus bulbs amongst his friends, the culture of which had been taken up by him purely as a hobby or pastime—a relaxation from the cares of the wholesale jewellery business of Sydenham Brothers, in which he was and is engaged as partner—he little thought that he was then and there creating the nucleus of a business which was destined to grow and grow till it became one of the largest and most reputable of its kind in the kingdom.

"Yet so it was to be, and such was the development of what was at first a pleasurable hobby, until, a couple of years ago, its requirements had so outgrown every available inch of space from cellar to roof in the extensive premises belonging to the firm in Tenby Street, as to necessitate the erection on adjoining land of a spacious block of warehouses and offices, specially planned and adapted to cope with the ever-increasing demands of Mr. Robert Sydenham's great bulb and seed trade.

"Some idea of the rapidity of the growth of this business may be gleaned from the following figures: Mr. Robert Sydenham began with a few bulbs in 1884, as before stated; his success in their culture led his friends to ask him to obtain their supplies with his own, and what was taken up as a pleasurable hobby of his spare time soon grew into a business. In 1886 his sales had jumped up to nearly eight tons in weight; 1887 saw this quantity nearly doubled, an increase that was maintained in 1888, and so it has gone on by leaps and bounds till in 1896 Mr. Robert Sydenham sent out no less than 5000 packages containing upwards of a million and a half bulbs. Since that date there has been no relaxation of the demand; on the contrary, its continued expansion has led to the

TULIP GRACE DARLING, GROWN IN MOSS FIBRE WITHOUT DRAINAGE: POTTED IN OCTOBER, IN BLOOM IN MARCH.

necessity of the erection of the special building referred to above, which was opened about five years ago, and from it during the past bulb and seed season nearly 20,000 orders were despatched to about 12,000 separate customers throughout the length and breadth of the United Kingdom and abroad."

One of the most charming methods of growing bulbs for house and table decoration is that adopted with so much success by this now experienced florist. An exhibitor at the Royal Horticultural and other kindred societies, he has been awarded medals, certificates, and cultural commendations for this really attractive and simple system, which must strongly recommend itself to the notice of those who cannot boast of a large garden, or even the conveniences of a conservatory, greenhouse, or cold frames. The "soil" used is a compost of a bushel of dried peat, weighing about 12 lbs., to 6 lbs. of ground shell. The bulbs are grown in vases without drainage. Great success has been achieved in growing Roman Hyacinths, Freesias, Narcissi, Tulips, Dutch Hyacinths, Spanish Iris, and other bulbs. Jars—a common creamery jar will do—or vases of various sizes contain, some a single bulb, others three and twelve.

The advantage of this system is that the vases can be placed anywhere about the house, in the drawing or dining room, without any fear from water or soil coming through the base of the pots. The Moss Fibre is perfectly odourless and clean to handle, and is quite as effectual as any of the fancy compositions sold at a much higher cost; it can be mixed by any lady in a large bowl on a table and leaves no dirt or stain.

In growing bulbs in these vases without drainage, it is necessary to have the fibre and the ground shell *well mixed and thoroughly moistened before beginning*; the fibre will absorb water at the rate of about *four* quarts to ever half bushel, and when moistened increases in bulk about half. First put a few pieces of peat charcoal at the bottom of the vase to absorb any impurities and keep the mixture sweet, then put from one to two inches of the compost at the bottom according to the size of the vase; place the Narcissi, Roman Hyacinths, Tulips, Freesias, or whatever is being potted, gently on the fibre, after which fill up the vases nearly to the rim. In potting, although desirable to see that the compost is well round the bulbs, it is not necessary or desirable to press it at all tightly, otherwise the roots do not work freely among the fibre, but the bulbs have a tendency to push themselves upwards as is often the case with those potted too firmly in soil. When once potted they will require little or no attention for the first two or three weeks, but after that *great* care should be taken to keep the compost fairly moist, but on no account must it be *sodden or too wet.* On the other hand, if *once* allowed to get dry, if only for half an hour, the pores of the roots, so to speak, close up and the bulbs in many cases go blind, and are ruined. They should be examined at least once a week, and a little water given when necessary; this will quickly be found out, for as soon as all surplus moisture is absorbed the fibre gets dry at the top; on the other hand, if it is thought there is too much moisture in the vase, turn it on one side and allow the surplus water to drain out. One bushel of the dry fibre to which 6 lbs. of ground shell is added, weighs about 18 lbs., but when moistened as mentioned it will weigh about 36 lbs. and will be increased in bulk about one half; this is enough for about four sets of No. 1 or two sets of No. 2 vases.

When the bulbs are potted the vases or jars should be kept in an airy cellar or room—*nothing is worse than a confined cupboard*, or small, airless dark room. When the bulbs have grown about one inch out of the composition, they should be brought into more light, and given as much air as possible, for if air is not given the foliage becomes unnaturally long, weakening and sometimes killing the flower. Where a cool house or frame cannot be used, put them on the window sill or garden path during the day, taking care, of course, to keep them from frost.

NARCISSUS MRS. LANGTRY, GROWN IN MOSS FIBRE WITHOUT DRAINAGE.

CHAPTER VII.

PEAT MOSS LITTER.

THE steady decrease of the area under wheat in this country, consequent on low prices and fierce foreign competition aided by low freights and preferential railway rates, together with the increased appreciation of straw as food for live stock, has necessitated the finding of some suitable material as a bedding in lieu of wheat straw. So some years back the late Dr. George Fleming, C.B., Principal Veterinary Surgeon to the Army, and Past President of the Royal College of Surgeons, with Professor Versmann, introduced German and Dutch Moss Litter. At first it met with considerable opposition not only at home but on the Continent, and alarmist articles and letters appeared in the agricultural press which, if correct in their allegations, should have given this substitute its quietus. Probably much of this opposition was fostered by those of our farmers who had surplus straw to sell, those especially in the vicinity of large towns; many forage contractors and corn chandlers chimed in, and not a few importers of straw found it to their interest to decry the innovation. Some asserted that it caused pneumonia, broken-wind, roaring, tuberculosis, and various diseases of the respiratory organs; others contended that it gave rise to thrush, canker, brittle, and other foot troubles. But as the respiratory attacks were ascribed to the inhalation of dust and those of the feet to constant maceration of the sole and frog through standing in wet, their logic was somewhat at fault. *Le Fermier*, a French Journal strongly opposed to Peat Moss Litter, published a letter from a Veterinary

Surgeon—Raillet by name. This practitioner, in drawing attention to the danger of the use of this bedding, condemned it as propogating intestinal worms in horses, stating that, having experienced an epidemic of these parasites in a cavalry regiment, 250 out of 500 horses having their intestines literally swarming with ascarides, he, after microscopic examination of the litter, concluded that the epidemic was due to this bedding "In this substance," writes this gentleman, "which readily absorbs the moisture, the eggs keep their evolutive faculty, and, as a large number of horses eat this litter, the condition of being infected is found to be easily realised; besides, it suffices that in stables a few animals which are infested will cause the epedemic to develop; but this condition is not absolutely necessary, for turf is often sold which has been simply dried after being used, and which will perhaps contain eggs which have been deposited in it during its former use." Such balderdash does not speak well for the stable management of this French regiment. As to horses eating their bedding we know that those suffering from a depraved appetite consequent on dyspepsia, greedy ponies, and animals affected in their wind, persistently eat their straw bedding even when soiled with dung and urine. The famous thoroughbred horse, "Doncaster," was, and the still more famous mare, "Sceptre," is addicted to finishing up their beds after the manger and hay-rack had been cleaned out, the latter, we are told, being so greedy that she has to be bedded on wood chips; but very few, save gluttons, are given to this voracious habit. A well-known English veterinary surgeon has in such cases prescribed moss litter as a change from straw, with excellent results. It may not be well known that peat enters into the composition of that excellent food—molassine,[1] and that this food, appetizer, and digestive has a marvellous effect in preventing colic, diarrhœa, and cough, and getting rid at the same time of small intestinal worms. It is a curious

[1] Thirty per cent. of peat dust is said to enter into the composition of this German horse and cattle food.

fact that in a sty where molassine is given, the well-known malodorous smell caused by butyric acid, usually characteristic of pigs, is absent, and the absence of this unpleasantness may properly be ascribed to the butyric acid fermentation either being prevented or to its absorption by the peat in the animals' intestines.

The following is an extract of a report on the use of moss litter in the stables of the Prussian Regiment of Uhlans (Lancers) No. 14, which seems entirely favourable:

"The regiment has used moss litter as a substitute for straw with the object of obtaining better and drier beds for the horses, and reserving the fresh straw for food. This object was attained with complete success. For experimental reasons the horses were not all placed on moss litter at once.

"In October, one-third were placed on moss litter.

"In November, two-thirds were placed on moss litter.

"In December, nearly all were placed on moss litter.

"The following advantages were observed:—Dry beds and dry fresh air free from ammonia; the ceilings, walls, and leather trappings remained free from moisture and mould. Moss litter absorbs eight times its own weight of urine, whereas straw absorbs only three times its own weight. The short and broken nature of the moss fibre allows of the easy removal of wet portions. Care must be taken not to neglect to turn and shake up the litter every day, and to fork it from one part of the stall to another.

"If these precautions are observed the animals find a dry bed, the horses remain clean, and their skin in activity. If properly treated, moss litter is far more elastic than straw, and affords a more comfortable bedding. The harness and saddles, as well as the boots of our soldiers, are better preserved.

"From a veterinary point of view, further advantages are observed. Catarrhs of the nose and eyes, generally the result of bad air in the stables, are less frequent; wounds on the legs heal quicker, inflammation of the glands very seldom occurs, and rotting of the frog is almost entirely prevented. In cases of contagious disease moss litter is of great value, and surpasses all other disinfectants.

"Cases of colic occurred as follows:

"October, 1881 - -	$\frac{1}{3}$ of horses on moss	1	$\frac{2}{3}$ on straw	14
November, 1881 - -	$\frac{2}{3}$,, ,,	0	$\frac{1}{3}$,,	21
December, 1881 - -	Nearly all ,,	1	a few ,,	2
January and February, 1882 - - - -	All ,,	0		
	On moss	2	On straw	36

"The consumption of moss litter per month, and per squadron of 135 horses, amounted to 180 cwt., against 280 cwt. of straw formerly required.

"Up to this date, in all a period of eighteen months, the regiment has used moss litter to its perfect satisfaction."

Not less important is the following testimony to the efficacy of moss litter and peat-mull in warding off foot-and-mouth disease:

"Herr Vibrans, of Wendhausen, has published in several papers his experience of moss litter as a preventative of foot-and-mouth disease. For this purpose he uses moss litter and 'mull' mixed with superphosphate, and has obtained the most satisfactory results. He reports that the disease did not appear at all among his cattle, while on the neighbouring farms it spread to an alarming extent. He, therefore, recommends its use in railway trucks." (*Commercial Blue Book*, No. 2 of 1893.)

No doubt some legitimate objections have, from time to time, been raised against imported litter, due to the inferior, dirty, and earthy quality of much that is sent over. Imperfectly dried samples were also put upon the market, damaging the reputation of the article. A considerable quantity of the moss litter now sold in this country is of home manufacture, and the industry is a profitable one. Now that our farmers and graziers will have to give increased attention to ripening cattle for slaughter, this sound manufacture seems certain to develop in the near future. We want all our straw for feeding purposes.

Our experience is that horses do not eat moss litter, and the statement that it injures the feet has no foundation on fact. Some object to it on the score of injury to the eyes, and this may possibly be the case where the material is not of the fibrous and clean-sieved sort, and has become unfit for bedding owing to the presence of a quantity of muddy make-weight substance resembling dried bog soil. So far from eating it—and most idle horses are generally nibbling at something—we have not found that gross feeders, some of which will clear out their boxes or stalls if bedded with straw in a night, ever touch it. The fact that horses standing on it are better in wind dispels this erroneous idea. Legs are never cooler or finer, and the feet of those constantly hammered about on the pavements and roads are certainly benefited, as are those that are fevered, bruised, or brittle. We at times come across complaints of the injurious chemical effects of peat, but as peat dust is largely used in the preservation of packed fruit and fish, and the material free from earthy matter is a disinfectant, fixing ammonia and subduing noxious odours, it is difficult to entertain such groundless objections. The vegetable growths of which fibrous surface peat is composed have dried down like air-pickled hay, but have not decomposed. So far from feet being injuriously affected, the legs of draught horses, continually filling when standing on straw, have fined down when peat has been substituted, and we are all conversant with the close affinity of feet and limb and their mutual sympathies. The "Monday morning leg" is almost certain to be accompanied by some heat of the sensitive structures within the hoof. Shoeing smiths speak favourably of the action of peat moss litter on the hoof, stipulating, however, that the foot between the sole and the web of the shoe and the clefts of the frog be picked out at each grooming. Horses certainly rest better and are "down," at nights especially, longer on it than on any other bed. It is said to be cold in the winter, but of this there is no proof; fabrics manufactured from peat fibre are certainly warm. Animals that have not lain down for months or years on straw, avail themselves of this resilient bedding, and the season of the year appears to make no difference. For sick stables it is invaluable. It covers the tile, brick, or cobbe flooring better and more evenly than straw, and does not work up into lumps; in fact the bed, when properly laid and attended to, is as soft and springy as a pile carpet. The absorptive power of peat is marvellous, being far before anything at the horse-owner's disposal. While straw, sawdust, wood chips, and similar materials only take up $3\frac{1}{2}$ to 4 times their weight of urine or water, and are not deodorizers, moss litter absorbs nine times. To put it more exactly, and from actual experiment, while one hundred parts of the latter will absorb 895 parts of water, one hundred parts of wheat straw, cut into lengths such as are found in a well-worn bed, and therefore well adapted to the process of absorption, will only absorb 389 parts of water, while 100 parts of soft wood sawdust will only take up 368 parts of water. It further has the property of preventing the decomposition of urine, thus keeping the atmosphere of the stable comparatively pure and odourless, and this power of absorbing and sealing up ammonia and its carbonate is a very strong recommendation, in that it not only minimises the liability to diseases of the eyes, lungs, and hoof, but adds to its manurial value. Bulking less than manure made from straw, manure resulting from this litter exceeds in richness not only the ordinary stable and farmyard kinds, but, for some crops, compares favourably with the various high-priced artificials. Baron Von Liebeg held it in high estimation, and that profound chemist's opinion was endorsed by the late Sir J. B. Lawes, to whose researches all agriculturists are so deeply indebted. Writing in the *Agricultural Gazette*, the latter expert said:—"I have tried peat moss dung against London dung on a large scale, and I consider that the peat is superior. The amount of clover it brings up in the pasture is very striking. The superiority of the peat manure is due to its power to absorb a large amount of urine. There is one other point we might mention, which is, that peat manure should be used at once; if kept in large heaps it heats violently, and much of the ammonia will be lost."

In 1879 and 1880 Dr. Arnold made experiments at the Hanover Royal Veterinary School, which show the extraordinary power it has of absorbing ammonia and ammonia carbonate. A two-stalled stable, floored with asphalte, 11 feet wide 13 feet long and 14 feet high, was laid with moss litter to the depth of 5 inches. The stalls were kept constantly occupied by horses, and it was not until after the sixth day that any trace of ammonia could be detected in the air of the stable, though the finest tests were applied. When compared with a similar stable in which straw was used, the amount of ammonia in this in six days was as high as the moss-littered stable after fifteen days. The moss continued in use for thirty days (the straw had to be changed at the end of a week), and the stable, besides being free from bad odours, was always clean and the floor dry." A Veterinary Surgeon in charge of a large London establishment owing 2000 horses, stated that whereas previously his clothes and hair were so impregnated with the offensive smell of the stable that he had to bathe and change his clothes immediately after visiting the stables, on the introduction of peat moss litter he no longer found this cleansing process necessary, the air being completely purified. The immediate action of peat moss on grass land is astonishing; it can be daily carted away and applied fresh. The following is an analysis of a sample of manure taken from a heap, and this would have been still more satisfactory if the moss had not been allowed to heat:

	Per cent.
Phosphoric acid - - - - - - -	·48
Equal to tribastic phosphate of lime - -	1·05
Sulphate of potash - - - - - -	·42
Nitrogen - - - - - - - -	·90
Equal to ammonia - - - - - -	1·10
Equal to sulphate of ammonia - - -	4·24

This manure is much sought after by market gardeners, horticulturists and florists. It can be with great advantage made up into a heap, thin layers of mould alternating with the peat. It is well worth 10s. a ton. Thus, by the sale of moss litter manure for agricultural and horticultural purposes, those not requiring it on their own land, after it has served its bedding purpose, can partially recoup themselves for its original cost; also, it is a valuable base on which to compound various other manures.

Now as to cost. It is economical because more lasting. The Chairman of the General Omnibus Company, in one of his official reports, stated that by using peat moss litter a saving of £2,000 per annum had been effected. Some idea of its durability may be gathered from the following communication from the agent of the Myton Hall Estate, Helperby, Yorkshire: "Being a good absorbent of ammonia, it causes the boxes to be always fresh, sweet and clean, with an occasional sprinkling of fresh litter; and I may add that we have a large box, originally intended for storing artificial manure, without drains, in which we usually keep three or four cart colts. It was bedded two years ago with peat moss litter, and has kept perfectly sweet and clean with the addition of a very slight sprinkling of fresh moss." The following instructions should be carried out: In stables where a system of drainage exists the traps should be carefully closed, otherwise much solid matter will get into and choke the drain. The bed evenly spread all over the standing to a depth of 4 inches will require one-third of a bale for each stall, and one-half for each box. Each morning before dressing the horse the droppings should be lightly but carefully raked away, and any portions of the bed which may have become saturated removed. If economy has to be studied, these soiled portions, if spread out lightly on a wire, bamboo or lath grating in the air—peat dries thoroughly and speedily in a shed where there is a good draught—will soon be fit for further use. The rest of the bed is shaken up and brushed to the other side of the stall, none being allowed under the manger. When the horse is out at exercise the litter is spread over the full extent of the stall or box, any damp portions being removed. In bedding-down for the the night the litter should again be gone over and shaken up, a small quantity of fresh moss being sprinkled over the surface. With a careful man an addition of 28 pounds a week for each horse should suffice to make good the waste and retain a comfortable and healthy bed. At each dressing the feet should be thoroughly picked out. With such an absorbent material it is important that no water be spilt on it. The droppings should be picked up frequently during the day, and the oftener the bed is forked up or raked over, and so aerated, the better.

Unlike straw, moss litter does not soil or stain the horse's coat, and is so far incombustible that, though it will smoulder when freshly laid down, it does not burst into a flame, and will not, after a day or two, even burn, and this is a feature which should not be lost sight of. Straw, on the contrary, is eminently combustible. The danger of fire in the stable need not be enlarged upon.

The Board of Trade returns of 1884 showed an import of over 110,000 tons. The selling price in London varied from 18s. per ton to 45s. In 1893 the average wholesale price was about 25s., and in 1890 the imports had in the first ten months reached 180,171 tons.[1] The marked success of the Moss Litter Charcoal and Manure Company, which was credited with having earned 58% on its paid capital, directed attention to this remunerative industry, so several concerns were started and a war of extermination commenced against foreign competitors, these operations necessitating a considerable cutting of prices. Till then the manufacture of turf litter had not become the systematically conducted industry it now is. Even in Germany and Holland the people employed in peat litter and fuel manufacture work at it only in the intervals snatched from farm labour. Some idea of the importance the industry has assumed may be formed from the statement that in the Netherlands, where, with a population of 4,391,000 (that of Ireland in 1881 was 5,174,800), no less than 40,000 tons of peat are annually consumed, and that during the summer the native labour in this field is supplemented by 100,000 Prussians and Hanovarians. Keen competition beat down prices, but, despite

[1] The present price as from 28s. to 30s.

heavy importations, our manufactures increased in number, and slowly but surely, aided by improved machinery and an abundant supply of raw material of uniform grade, to some extent elbowed out the foreigner. The machinery now used in pressing, drying, and baling the litter is a vast improvement on the crude plant of twenty years ago. Factories capable of turning out 40,000 to 50,000 tons annually have been established.

As an example of the profits that may be made in an enterprise of this nature, attention may be called to the fact that the British Moss Litter Company, which is capitalized as follows: viz., £250,000 in ordinary and preference shares, and a debenture issue of £95,000, earned on its first year's working a net profit of £63,139. This allowed a distribution of 10 per cent. on the ordinary shares, and 6½ on the preference shares, after providing for debenture interest, laying aside £20,000 for redemption of debentures and depreciation, and carrying forward the substantial sum of £9683. An *interim* dividend of 6½ per cent. per annum for the six months ending August 31st, 1894, has also recently been declared. See *Financial News*, September 11th, 1894.

The total earnings of the Company, in its first year, were therefore equal to 18 per cent. on its ordinary share capital. During the current year the British Moss Litter Company made a trading profit of £32,566, an increase of £9,483 on the profit of the previous year. The dividend on the ordinary shares was 10 per cent., with £5,338 carried forward. Many of these companies being over capitalized, the profits are much less than those earned where the moors and bogs have been acquired at a reasonable price on co-operation terms, lease or royalty. The shares of Richardson's Moss Litter Company, Ltd., are, as stated in the preface, quoted at 300 per cent. premium.

Though averse to the immigration of aliens, we must admit that much saving has been effected by the introduction of the Dutch peat-cutter, who has acquired proficiency in the drainage and graving of peat bogs. Peat-cutting is something more than a casual industry. The Thorne district, South East Yorkshire, and parts of Lancashire, now number their Dutch population by hundreds. These people, who give a good day's work for a good wage, have a high reputation for skill in this moist and not particularly pleasant occupation. Some of the Irish are equally handy with the slane, where, but for the iniquitous railway rates and the closing of the internal water-ways, this business would have developed more rapidly. Perhaps at no distant date we may, like Germany, Holland and Sweden, be exporting moss litter to the United States.

The method of cutting the moss for litter is precisely the same as described for peat fuel, but only the surface peat, that lying immediately under the heather or ling, is adapted to this manufacture, and it is seldom found at greater depth than four feet. The high level moors furnish the best, and these should by degrees be drained as thoroughly as circumstances will admit. The best peat is that which is known as "red," and in Ireland as "horse-flesh." It should be, when dry, of a bright golden tan colour, fibrous, springy, and free from earthy matter. Imperfectly dried moss litter means loss. A great difficulty is encountered in wet summers, by no means infrequent, and in damp days this loose fibrous moss takes up a great deal of moisture. There must be no evidence of decomposition, the substance cannot be too elastic. In the process of drying, such material contracts very little. When cut and torn the vegetable fibres are readily freed from the retained water by gravity or evaporation, and can further be forced, by compression between suitable rollers or presses, to yield up a large proportion of their liquid contents. In the manufacture of fuel it has been found that nine cubic feet of raw peat, condensed by the machine into six cubic feet of prepared peat, still contains 40 per cent. of water, and this is further dried and compressed into one cubic foot of black, dry, fossil, vegetable stone, of about 1·5 specific gravity, which can be sawn, planed, and even polished like cannel coal or jet. But such extreme pressure is not desirable in the case of litter, all here necessary being to squeeze out as much of the water as possible, to air dry it, and to pack the manufactured article into convenient sized bales of uniform weight and measurement. In this moist climate moss litter exposed to the air will always retain about 20 to 25 per cent. of hygroscopic moisture.

When artificial drying, either of moss litter or peat fuel, must be had recourse to, the Stauber system, on account of efficiency, despatch, and economy, claims to be the best. It possesses one very important qualification—it does not change the chemical composition of the peat. By this method peat containing 80 per cent. of water can be quickly reduced to 18 to 20 per cent. at a cost per ton depending on the amount of waste steam or heat available, but by the previous use of rollers such an initial amount of moisture need not be introduced to the drying chambers. When tested at the Imperial Testing Station at Charlottenburg, peat briquettes, the result of this system, contained 45·12 per cent. of fixed carbon, 4·54 per cent. of hydrogen, 29·34 per cent. of oxygen, and 9·09 per cent. of ash, and a thermal value of 3806 calories. The process is that of rapidly drying the moist peat by means of heated and compressed air within a closed chamber or channel communicating with pipes in such a manner that heat is forced through the drying chamber, or chambers, and cold air through the outlet pipe. The cold air quickly absorbs the hot saturated air out of the drying chamber, condenses it, thus greatly stimulating the process of evaporation by which the material is dried. The drying chambers are of boiler form (cylindrical), and in a large plant these chambers can be simply multiplied as any number of machines can be worked with air currents generated by the same engine. The raw material is run in trucks into these receptacles, and run out when the desired dryness has been obtained. A convenient size of these chambers is one that can produce 5 tons of dried fuel or moss litter per diem. The entire cost, including that of raw material, as well as of depreciation of machinery and administration expenses is about 7s. 6d. a ton for either briquettes or litter. The thorough elimination of all dust or earth must be insisted on; the presence of either seriously depreciates the market value of the litter. A horizontal shaker or sieve rapidly gets rid of these particles. An up-to-date peat litter factory turning out 288 bales daily has a working staff of fifteen hands, and of these many are women and children.

We are convinced, except in cases where a large amount of waste heat is available, that, from an economical point of view, sun and wind must remain the sole means of drying. Sun we cannot command, but, by the aid of the latest type of wind engine, an almost continuous penetrating stream of air may be, during the greater part of the year, depended on, and air is more effective as a dryer for peat than even the sun's rays. Moss litter when properly torn up by the "devil," is such an open material that the wind, especially when driven by fans, penetrates the entire mass, driving out the moisture.[1]

The machinery used in the North of Germany in the preparation of moss litter and powder is simple, requiring no skilled labour. It is altogether under cover, so that it can be worked in all weathers. The refuse of the bogs, inferior light peat, moss litter, etc., which is not suitable for fuel, is either carried or brought up by means of the tramway into long drying sheds. Here it is gone over by women and children, who pick out roots, etc., and spread it out to dry. When sufficiently dried two women shovel the stuff through an aperture in the wall of the shed, through which it falls down into an elevator. The elevator raises it to the upper floor of the mill and throws it into a machine which tears it up. From this machine it falls into a sieve. The fine stuff or torf-mull falls through the sieve on one portion of the floor, while the rough material, suitable for peat-moss litter, is shaken

[1] A wind engine, lately patented, gives results far in advance of any windmills, European or American, as yet produced. By the application of *volute* sails or slats to the wheel the power is largely increased.

out of the sieve into another portion of the floor, the two being divided by means of a wooden partition. Two women, one in each compartment, then shovel the stuff through two trap-doors in the floor. One of these trap-doors is for the peat-moss litter, the other is for the fine mull. The two classes of stuff fall down through wooden funnels into separate boxes, oblong in shape, beneath the floor of the mill. When the oblong boxes are quite full, the bottom of each box is pushed up from underneath by means of an elevator, so that the stuff rises until it is about three feet above the floor of the mill, and passes into the presser. Here it is compressed by machinery into a compact mass, sewn up in an ingeniously simple and rapid manner by a man and a boy, with a wire passed thrice round it at equal distances, by means of an iron needle. The bale is shoved out of the presser into a truck, and one sees a bale of peat-moss litter ready for transport to Ireland or elsewhere. These machines turn out over 200 bales per day.

The following is a report published by the Agricultural Department of Ireland detailing a visit to a peat farm and factory in Holland. We quote from it as it appears to supply an object lesson which we in the United Kingdom may profit by. It may be mentioned that the estate is owned by a company which for the last few years has paid a dividend of from ten to twelve per cent., and that the rate of wage paid to the hands in the factory and for cutting sods is about four shillings a day:

"The process of reclamation has gone on for sixteen years, with the result that about one thousand acres of the bog have been reclaimed and are now practically a garden for the production of peas, beans, mangels, and cereal crops. The farm is situated within easy reach of several cities and large towns; and, as owing to the canal systems, there are great facilities for export, considerable quantities of peas and beans are exported to the United Kingdom. The production and the marketing are done on co-operative principles. The land is divided and let in small holdings, for which the rent averages from three pounds to four pounds per acre; the Company provides manure and does draining whenever it is wanted, and gives other assistance to the workers. The land is tilled like a market-garden, and seems to produce very large crops, and the cultivation is done in a thorough fashion. We were much struck with the freedom from weeds in all the crops. The farm was divided by the main canal, and there were branches from this to various parts of it. The reclaimed soil was firm and easy to cultivate, being dry and friable.

"The dwelling-houses of the labourers were provided by the Company, and are let at a rental of about two shillings per week each. These houses are about forty-eight feet long, by twenty-four feet wide. One-half is utilised as a small granary and as a house for a cow, calf, and pigs; the other half is used as a dwelling-house. They are substantially built and slated, and a door from the scullery, which was off the kitchen, opens into the cow-house. There are, besides the kitchen, a living-room, two bedrooms, and a small store. The house is a very advantageous one for a labourer, it being so easy to attend to the stock, especially in the winter time. There was also a school on the property; the number of workers engaged was about four hundred, most of them at farm and garden work. Other buildings in the group consisted of two or three cottages for labourers, an overseer's house, a large cattle-house with granary overhead and sheds for carts, machines, and the various implements used on the farm. In the cow-house were a good many well-fed bullocks, which were used for draught purposes; the bedding was moss-litter made on the farm, and the place was very clean; no liquid was lying in the gutters, as all had been absorbed.

"Having inspected the farm and farm-houses we went to the factory, and saw the peat-moss litter prepared and baled; some of this was being shipped to America and some to the United Kingdom. The former, in addition to being bound with hoops, was wrapped in rough canvas. Mynheer

Van der Blocquery stated that he was receiving about sixteen shillings per ton for the litter at the factory; in addition to moss-litter he manufactured moss-fibre, and also peat-dust, which is used for many purposes. He said the fibre paid him better than anything else. The machinery which is used for tearing the peat-moss and baling it was of a rather antiquated pattern, driven by a steam engine, the boiler-fire of which was fed with machine-made peat fuel. The quality of the peat-moss litter we saw at the factory did not strike us as being particularly good.

"The factory where the moss litter was made stood in the bog about a quarter of a mile from the farmstead, and as it is a good example of an inexpensive building, suitable for such a purpose, a few details may be interesting. It is sixty feet long and twenty feet wide, roofed with shingles, the sides being open wood-work, made of slats or laths placed three inches apart. Over this is a loft which extends the full length of the building, and leading to the loft was a straight gangway, up which barrow-loads of sods could be wheeled and piled, then passed through a trap in the floor to the litter-making machine beneath, and as this took up little space there was plenty of room to store the manufactured article on the ground-floor, until it was required on the farm. The machine in use was driven by horse-gearing, at one side of the building. The doorways at both ends were so large that a horse and dray could pass in and be loaded under cover."

Though peat moss litter, as well as the various other products of peat, are in their infancy, our engineers—those of them who have thought the industry worthy of their attention—have designed automatic machinery for the thorough and economical preparation of a marketable commodity, which, with the right material and due facilities for transport, assures a paying business. Even with the inefficient plant with which many of the Dutch mills are equipped, a satisfactory profit is realized, though the article produced is of inferior quality. Though the improved machinery is simple, it, by its continuous automatic arrangement, materially decreases the cost of preparation whilst producing a superior article. The saving in cost is said to be 30 per cent. and the output doubled. The necessary machinery consists of a tearer or "devil" and shaker-seive combined, an elevator of the scraper type in which screens are inserted, automatic weigh box or boxes with scale beam and steel leverage, bifurcated breeches-piece or shoot from weigh box to press-heads, wrought-steel press to take 2 cwt. of the lightest peat upon delivery from the weigh box and compress it into a 17-inch bale, with arrangements for the retention of the battens in their places, and for the fixing and fastening of three, four, or five wire lashings. The raw but dried peat, free from dust, save as to fixing and lashing of the pressed bale, should not require to be touched by hand from the time it is fed to the hopper of the breaker until it is delivered from the press in the form of a bale. The question of strength in the wrought-steel press must be amply provided for, and all the parts should be interchangeable, so that the press or presses can be removed to any position on the moor. Such a press is capable of turning out 300 bales per day. When four presses are run in conjunction with each other it is possible to increase the output to about 380 bales per day per press. All parts of the breaker should be easy of access. The actual cost of pressing should not exceed one shilling a ton but it can be done for eightpence. The bales, when delivered from the press, fall upon a conveyor, level with the floor, and are so carried and delivered into trucks or stacked as desired. Immediately the press is empty and ready for restarting the operation is immediately and automatically repeated. No skilled labour is required. The motive power may be steam, oil, gas, or electricity generated *in situ* at the bog.

Most of the low-lying mosses of Great Britain and Ireland, France, Germany, the Netherlands, North Austria, Scandinavia, and Russia are covered with varying depths of a fibrous peat, mainly on the surface and rarely exceeding four feet, though in some few localities it is found in "pockets." In its natural state, before being cut and dried, it is invariably a soft, porous, spongy, and elastic substance, composed of various mosses and aquatic plants in their original form and organized state. Poiret detected the roots, stems, branches, and leaves of the following plants in this mossy and aquatic peat: *roseaux, scripes, carex, souchets, joncs, mousses, hypnum, et sphagnum,* the last two being most prevalent. The characters are sufficiently marked, and may be easily distinguished. Some varieties are so tough and elastic that they turn the edge of the keenest and hardest tool, and can only be cut with difficulty; others give a sharp edge to the stone or spade. The water squeezed out generally effervesces with chalk, and when evaporated, if the surface be free from a covering of mould, leaves little sediment.

When dug and dried, good peat-moss, if it is to command a good price in the market as litter or as fibre, should be of a bright golden tan or warm sepia tint, specifically lighter than water, easily torn asunder, and resilient. When burnt it should give out little smoke, and that of a light grey colour, with little flame and little heat, the ash being of a whitish grey, light, and free from salts. This fibrous formation or genus is termed "*gramineous peat*" by Dr. Walker; in France it is known as *tourbiere.* It is the *groos* or *hey torf* of the Netherlands; and in Ireland, where it is found in vast quantities on the so-called red bogs, it is flippantly termed "*old woman's tow.*" On many bogs, notably on the Pennines moors, in the peat district of Derbyshire—Holme Moss, Buckstones Moss, Harden Moss, Featherbed Moss, Close Moss, Shelf Moss, and Field of Mosses—these plants are dominated by one or other of the two cotton grasses (*Eriphorum vaginatum* and *E. angustifolium*). There is a hairy, wiry variety of surface turf which for bedding purposes, textile fabrics, or the manufacture of paper is utterly useless.

We have, in the preface, mentioned that to some extent the home manufacture of peat-moss litter is now in competition with the import trade. The two largest firms, who aim at a monopoly and the control of the market, do not confine their operations to British and Irish material, but import largely from Holland. Moss litter is now being largely shipped from Rotterdam to Ireland, as well as to the Thames and to our east coast ports—Goole, Hull, Newcastle-on-Tyne, Leith, etc. The freights from Rotterdam to Dublin are 12s. 6d. a ton, and to Belfast from 15s. to 17s. 6d. This trade is surely an illustration of carrying coals to Newcastle. What is to prevent the bogs of the Western Isles, of the West of Scotland, of Wales, Exmoor, Dartmoor, Cornwall, and of Ireland from joining issue ?

CHAPTER VIII.

PEAT AS A MANURE.

PEAT ashes have, on analysis, been found to contain all the inorganic principles of plants which are insoluble, together with traces of soluble alkaline sulphates and of free alkali. They are fully appreciated by the market gardeners and florists of the metropolis and the suburbs, and are largely imported from Holland for manurial purposes. It has been ascertained that air-dried peat, bulk for bulk, does not, from a manurial standpoint, differ greatly from grass-fed cow-dung. Professor Dana, an American writer and expert, in his useful handbook *The Muck Manual*, gives the following comparative weights and composition of a cord of cow-dung and a cord of two separate descriptions of peat:

	Weight.	Soluble Geine.	Insoluble Geine.	Total Geine.	Salts of Lime.
Dung, -	9,289 lbs.	128 lbs.	1,288 lbs.	1,416 lbs.	92 lbs.
Peat, -	9,216 „	376 „	673 „	1,049 „	91 „
Peat, -	9,216 „	519 „	529 „	1,048 „	81 „

Peat ashes abound in carbonate, sulphate, and especially phosphate of lime. "It is certainly," says the Professor, "a very curious coincidence of results, that Nature herself should have produced a substance whose agricultural value approaches so near to cow-dung—the type of manures. The power of producing alkaline action in the insoluble geine is alone wanted to make peat good cow-dung, and the question arises, how is it to be given to peat (a substance which, in all its operators, is so nearly allied to cow-dung) that lacking element—ammonia? How is it to be supplied? Without it, cow-dung itself would be no better than peat, not so good even; for in peat nearly one half of the geine is already in a soluble state. By the addition of alkali to peat it is put into the state which ammonia gives to dung, and it is found that, for all agricultural purposes, the desired result is obtained by adding to every cord of fresh dug peat 90 to 100 lbs. pot or pearl ashes, or 60 to 65 lbs. of soda, or 16 to 20 bushels of common wood ashes. Abundant testimony is afforded that a cord of clear stable manure, composited with two cords of peat, forms a manure of equal value to three cords of green farmyard dung. Of peat it has been aptly said "it is among manures, consisting chiefly of geine, what bone dust is to manures consisting mainly of animal matters."

Mr. Henry Turing, our Consul at Rotterdam, in an official report to the British Minister at the Hague, stated that "the 'fine' litter is used for mixing with sewage, and a mixture of equal quantities produces a dry, dark, earthy substance, which can be turned over with a spade, and is entirely inodorous. As a manure, this product is quite as valuable as the stable moss litter; but whilst the latter in its original state is extensively used in all European countries, and also in America, the mixing of 'fine' peat with sewage is but little known, although in some cities such as Bremen, Brunswick, and Oldenburg, the product is largely used by the authorities. In Gothenburg in Sweden, the 'fine' peat has been utilised for a number of years, whilst in Belgium a company has been formed for the purpose of collecting the sewage of the several towns and mixing it with moss litter, and thus producing a mercantile article."

The fine grained granular product can also be used in the so-called dry-earth closet, a convenience which, as at present constructed, is misnamed, for in this household apparatus the solids and liquids are not separated as they should be, and can be, by a very simple arrangement. The system known as the Gongleton, *i.e.* peat moss litter, or mull, in pails, treated with sulphuric acid, has worked well. In conjunction with this pail system is the manufacture of POUDRETTE. This is a valuable manure, a preparation of sewage, or rather night-soil, with sulphuric acid, and in the manufacture of this powerful fertiliser peat-charcoal might readily take the place of soot as now employed. The process is simple, but, on account of the offensive vapours evolved, must be conducted within a closed building. The acid is generally added to the excrement in the pails used to transport it to the works, and the whole is then tipped into a Milburns desiccator, from thence it is removed to a drying floor heated by flues from beneath. It is subsequently passed through a disintegrator, preparatory to being packed for sale. Sometimes a more complicated system is pursued. (Spon's *Encyclopedia,* p. 1271.) "The pails are emptied upon a strainer constructed to allow the liquid and fine suspended matter to flow through, while retaining the solid fæces, etc. The filtrate is pumped into an elevated tank, for the supply of a boiler capable of dealing with 550 gals. of liquid matter at a charge, and provided with a stirrer to prevent incrustation, the boiler being charged with 80 lb. of dolomite, containing brown sulphuric acid. The fœtid vapours evolved in the saturator are carried through a worm-pipe in the supply tank, partly for condensation and partly to warm the contents of the tank before running them into the boiler. The condensed vapour is run off into the drains. The sulphate of ammonia thus made is evaporated in a shallow open leaden vessel, on the top of the saturator, and as it chrystalises is drawn out and set to drain. Only $\frac{5}{8}$ of the ammonia is boiled off. The residue in the boiler, when this proportion has been collected, is run off by a valve at the bottom, and is stirred up with superphosphate in large wooden vats. The product is then dried either by ordinary means or by means of pressure. The solid matters originally separated by the straining are mixed in a mortar-mill with the superphosphate and soot or waste charcoal.

"To prevent nuisance arising from this manufacture, the whole process must be conducted within a closed building. The interior of the desiccator should communicate with a blower, creating an in-draught, sufficient to prevent the escape of effluvia through the crevices of the cover, or while charging the machine. Flues must be provided, so that the blower shall drive the vapour through the fires used for heating the drying-floor, before they escape into the chimney of the works."

One of the most ingenious machines for making poudrette is the "Concentrator" of Herr Levander. This machine is to be seen at work near the Municipal works of Gothenburg. The solid or dry drainage, mixed with peat, is burned in great rotating cylinders, the gas issuing during combustion being simultaneously burnt by a small fire. This *poudrette* meets with a rapid sale, and no offensive vapours are perceived in the vicinity of the works. The prevention of the vapours evolved in the process, described by Spon, from becoming a nuisance under the Noxious Vapours Act is easily accomplished by draining off all the vapours set free into an enclosed den by means of a fan and then passing them through a condenser and furnace. As compared with other manufactures, when the manufacturer does not make his own sulphuric acid, the capital required is very small, and the work can be conducted on a small scale suited to villages, hamlets, as well as large institutions.

Unfortunately the prejudices of our countrymen lead them to poison the air of their cities and towns, and the waters of their rivers, with substances which, if rightly applied, would crown their fields with golden harvests, would drive pauperism from the land, and render the United Kingdom independent of foreign food supplies. An acre of peat moss will absorb something like fifty tons of night-soil annually for years. In time, of course, the power of absorption decreases, but when this stage is reached the power of full agricultural production begins. The importance of artificial manure in modern agriculture cannot be over-rated, by far the largest proportion of the vegetable products of all civilized countries at least being grown up by their aid. The fact that peat, though it does not actually destroy pathogenic germs, possesses the property of retarding the multiplication of lower organisms, has led to the extensive use in many German towns of "mull" for earth closets, public latrines, slaughter-houses, etc. The application of peat refuse for disinfecting purposes was strongly recommended by Dr. Scharlau of Stettin, over half a century back, and a similar practice was known in Norway more than 40 years ago, being compulsory in the town of Christiania. In the beetroot-sugar factories this waste product has been largely employed in absorbing the lye resulting from the treatment of molasses with strontium. It is forbidden to drain this liquid into the rivers, and, consequently, manufacturers had to encounter great difficulties in the disposal of this lye till the value of peat mull was ascertained. Twenty-five parts of mull absorb one hundred parts of this product, yielding a valuable and easily transported manure. Mull has also been used as an admixture with salts in powder as chemical manure to prevent concretion or hardening into lumps. The mechanical condition of the materials is of the utmost importance in promoting beneficial effect from fertilizers, inasmuch as proper distribution is possible only when the manures are in a fine state of division. If the material be put on the land in a lumpy form it will not only be found that parts of the soil have failed to receive their due share, but, what is equally objectionable, the spots on which the lumps fell will have been poisoned and injured. An addition of 2½ per cent. of the peat mull to the mineral salts is found sufficient to ensure of fine pulverized condition and to prevent concretion. In the salt works at Stassfurth 4 lbs. of mull are mixed with each sack. The manure from used moss litter contains a larger proportion of readily soluble nitrates as compared with that produced from wheat straw, and, on light sandy soils in particular, the former establishes its superiority in the proportion of 10 to 7; the phosphates in either coming out about the same.

The open court, unless beasts are undergoing the process of fattening or ripening for the butcher, is considered the manure factory of the farm. We regard these cold, unsheltered muck yards as relics of barbarism, costly to the farmer and grazier, and injurious to stock. How can a beast be expected to thrive or throw up flesh in such surroundings and standing month after month up to its knees in liquid manures exposed to all weathers? That animals feel this treatment is certain as evidenced by unthrifty coats, and by the fact that the poor brutes crowd together wherever there is a bit of dry standing. We advocate airy, light covered courts with moss litter to stand on as substitute for the present careless and extravagant system. Keep an animal healthy, comfortable, and warm, and it will pay for doing so. Though the feet of our pedigree Shires, Clydes, Suffolks, and agricultural horses have, thanks to the exigencies of the show yards, much improved of late years, those of the rank-and-file are faulty, and the fault arises from the pernicious system of wintering the foals, colts and fillies in these saturated manure yards, by which the horn of the hoof becomes macerated and weak, and the frogs rot.

Provided it be kept dry, peat moss-litter and mull are to be recommended for the floors of covered-in poultry runs and for nests. The fowls delight to scratch the material about in search of grain, thus keeping themselves clean and healthy. Parasites are warded off. The droppings are soon worked up into impalpable powder, and, mixing with the vegetable matter, the resultant manure becomes most valuable for the garden. There is no better bedding for the kennel than this moss, which, if attended to, remains sweet and clean, keeping the dogs' coats in bright, healthy condition. The manure from the pig-sty, especially if the pigs be partly fed on molassine, is also very valuable. On account of its getting into the fleece, it is not adapted to sheep.

Ammonia, converted into sulphate of ammonia as already stated, being one of the most valuable by-products of peat recovered from the gas by washing with a weak solution of sulphuric acid is one of the most potent manures known, and the best purely nitrogenous material for all crops save clover, beans, peas, and legumes, drawing their nitrogen from the air. It has proved itself to be of immense value, in fact the only other manure practically comparable with it is nitrate of soda. At its present price it is much the cheapest source of ammonia in the market, costing about 7s. per unit of ammonia, while each unit in the best Peruvian guano costs from two to three times that amount. Even when selling at 20s. per ton, the price it commanded some years back, it compared favourably. Mr. Chris Middleton, a practical farmer of repute, and what most farmers would be if they desire success—a "soil scientist," found an ample return from this seemingly expensive fertilizer. Though the intrinsic manurial value of sulphate is 20 per cent. greater than nitrate of soda—the former contains nitrogen equal to about 24 to 25 per cent. of ammonia, while nitrate contains only 19 per cent.—we manufacture only about 213,000 tons of sulphate, two-thirds of which are exported, whereas from 1,300,000 to 1,400,000 tons of nitrate are yearly produced and used. In coal-coke manufacture the sulphate of ammonia is the by-product *par excellence* sought for, and with the output possible under the Mond, the Otto Hilgenstock, and Dvorkovitz processes, it has been thought that the supply must at no distant date exceed the demand. This apprehension, however, may be dismissed. It is probable that the nitrate fields will be completely exhausted in twenty-three years, provided that the yearly production be maintained at the same level as in recent years. If, owing to the failure of the supply, the need of nitrogen as a fertiliser can no longer be sufficiently met as at present by the application of nitrates, it is clear that it would then become imperative to very largely increase the production of nitrogen—that is to say ammonia. More than ourselves, the

German farmer is alive to the uses of artificial manures, and yearly uses 160,000 tons of sulphate against our 68,000 tons. The joint efforts of the Sulphate of Ammonia Committee (4 Fenchurch Avenue, London, E.C.) and of the Ammonia Syndicate of Germany are by degrees, slowly but surely, impressing farmers with the high value of ammonia as a fertiliser, and ere long the price of nitrates may be governed by that of sulphate. Of late there has been an increasing demand for this fertilizer from the sugar-beet growers of the Continent, and at the Azores and elsewhere the producers of cane sugar are more and more convinced of its value.

It costs no more to manure rationally than to treat the soil and crop irrationally, so it lies with the farmers to practically study the "The New Soil Science," or "Soil Life," to choose between right and wrong, to convert a bare, precarious living into a good percentage on invested capital. Our soil, cropped now for many generations, is exhausted, and requires generous treatment. We have to contend against the produce of rich virgin soils brought to these shores at low freights. When the value of sulphate of ammonia, and its effects on soils and crops, becomes to be more widely known and appreciated, the production will keep pace with the largely-increasing demand. At present it is mainly derived from gas works, coke ovens, the blast furnaces, shale-oil works, and to a slight extent in the manufacture of animal charcoal. In France a certain amount is derived from the ammoniacal liquids of cesspools. Proposals have been put forward to add to the output by the destructive distillation of wool refuse, horn, feathers, blood and soot; but peat, as has been proved, is almost as prolific a source for the production of this salt as coal, and when we consider the low cost at which it can be graven, must, with suitable plant, prove the cheapest source. Out of thirty-one different analyses of various coals from different fields, the highest percentage of ammonia was 0·344. The coal averages were from the Otto By-product Oven, and that gave them an undoubted advantage. From the rich West of Scotland bituminous peats and the "candle peats" of Lough Neagh better results than these would have been obtained.

But irrespective of the large growing demand for sulphate of ammonia as a fertilizer, another use has lately been found for this by-product in a compound of ammonia and petroleum, soluble in water, a disinfectant dust-layer now much used in Berlin, Dresden, and Frankfort, for laying the dust-fiend, and which from experiments made on the Old Windsor road is likely to be used in this country. It is said to improve the roads generally, and will enable motor cars to travel without raising the clouds of septic dust now so much complained of. This compound can be applied to a thirty-foot road at the cost of £10 a mile.

It is possible that the coming into operation of the Sugar Convention, and the consequent removal of bounty on foreign-grown sugar, may give a stimulus to the cultivation of sugar beet in the British Isles. A century ago there were 100 sugar refineries in London alone; to-day there are but two. Our climate and soil are said by experts to be well suited for this root crop. The weight, no great advantage however, is greater than that of the German crop, and the saccharine in the juice not less. With suitable manure there is no reason why the Silesian beet-sugar crop should not prove remunerative to the British and Irish farmer. On yellow turnips, swedes, mangels, potatoes, and other roots, sulphate of ammonia gives better results than can possibly be obtained from the alkaline nitrates, the produce being heavier, sounder, of better keeping and feeding qualities. The keeping quality is an important item. Wherever tried it has been found that by using this slow but sure fertilizer the best results have been obtained, not only as regards the quantity of sugar yielded by the plants, but also in the percentage of chrystallisable and more marketable sugar. Much might be done by following some of the methods in vogue in Hungary. On the great sugar estate of Szerencs, where 1750 tons of sugar beet are worked up daily during the season, with an output of 220 tons of sugar, employing 1500 hands, every root selected for seed is tested for its sugar-yielding quality by cutting out a small section for analysis; if not up to 14-15 per cent. standard the plant is removed from the field. By this selection a considerable increase in the sugar is brought about, and 19 per cent. is common, while some varieties of beet show a percentage as high as 20 to 23. When the works are idle the hands are employed cultivating the crop. The beet has a double use, being crushed for sugar, while the refuse pulp is siloed and used during winter and spring for cattle food.

Professor C. M. Aikman, M.A., D.Sc., in his work *Manures and Principles of Manuring,* in writing on the position of nitrogen in agriculture, says:—

"Of manurial ingredients, nitrogen is by far the most important, and on the presence and character the nitrogen contains, the fertility of a soil may be said to be most largely dependent. Most soils, as a rule, are better supplied with available ash ingredients than with available nitrogen compounds. The expensive nature of most artificial nitrogeneous manures also gives to nitrogen the first position from an economic point of view. A thorough study, therefore, of the different forms in which it exists in nature, of the numerous and complicated changes it undergoes in the soil, by which it is prepared for the plants' needs, of the relation of its different forms to plant-life, and of the natural sources of its loss and gain, is of the highest importance if we are to hope to understand the difficult question of soil-fertility." He adds:—"*Of all soils, peat-soils are richest in nitrogen.*" Professor S. W. Johnson found the nitrogen in fifty separate samples of peat to range from ·4 per cent, to 2·9 per cent., the average being 1·6 per cent. On the other hand marls and sandy soils are the poorest, the analyses of a number of these soils showing only from ·004 to ·83 per cent. for the former, and ·025 to ·074 for the latter. As a general rule most arable soils contain over one-tenth per cent. of nitrogen. Manures are rich in proportion to their quantity of nitrogen. The application of caustic potash to peat will convince the most sceptical of the presence of ammonia, but though it is there in the proportions quoted, it has lost the power of generating ammonia.

Peat, in the form of Moss-Earth or *Oxygenated-Peat*, as it was aptly termed by that exact chemist, Lord Dundonald, is vegetable matter that under the influence of sun and air, heat and cold, moisture and drought, has been subjected to putrid fermentation and been converted into a form of vegetable mould. The superabundant hydrogen has been expelled in the form of gas. The acids it contained have been washed away in solution, and the bituminous oils have been almost entirely carried off by this means, and have found a resting-place in the "creeshy clods," the "bears' grease" found in pockets at the bottom of some bogs, and go to form the highly bituminated variety, which, when newly dug, feels fat and greasy, and in which neither plant nor shrub will vegetate. This peat-mould differs from earth-mould in appearance and in qualities. In its *natural* state it differs from bituminous peat in that:—

Moss Earth is:—	Bituminous Peat is:—
Friable like mould, fine in texture.	Tenacious.
Pervious to water.	Impervious.
Found often covered with succumbent Herbs.	Seldom.
Worms, insects and animals can exist in it.	None found.

When dug and dried it is:—

Rotten and friable.	Tenacious.
Burns with difficulty, yields little flame, little smoke, and a considerable quantity of ashes.	Burns easily with much flame and smoke and fewer ashes.

When distilled it:—

Yields a small proportion of oil and throws off only a trace of hydrogen and carburetted hydrogen.	Compact and "Stone Peat" always yield a considerable quantity, the bottom or highly bituminated varieties double, and sometimes treble of that known as compact, *i.e.* that underlying the fibrous variety.

It is of a dark, often black colour, and is found in the declivities between hills, and especially such as are under the influence of the sun. As a basis on which to compound various fertilizers this substance cannot be excelled. There are several waste products from various factories at present utterly valueless, malodorous, and difficult to get rid of. These possess considerable manurial value, and, in combination with Oxygenated Peat, are completely deodorized and converted into a powerful plant food.

A well-known horticulturist, Mr. James Kennedy, of the Nursery, Greenbrae, Dumfries, writing to *The Scottish Peat Industries*, last year, adds his practical testimony to the value of granulated peat loam manufactured by that company. "In reply to your enquiry regarding my experiments with your Peat in the growing of tomatoes, I am pleased to say that it proved most thoroughly satisfactory, proving much superior to our ordinary soil inasmuch that the plants grown in peat were much sturdier and short-jointed, giving trusses of bloom often less than four inches apart with a good set of fruit, while those grown in our ordinary soil were tall and lanky and long jointed, which at the same weight had not half the fruit, thus proving the superiority of peat, as the great object of tomato growers is to secure sturdy plants with a superabundance of fruit.

"I much regret the season was so far advanced before you suggested the experiment, especially as the season has been a most unsatisfactory one, or the results would have been better and more conclusive.

"Considering the fact that it was on July 17th that the plants were potted, the photo taken on October 19th proves the success of the experiment, also that a good crop of tomatoes can be grown on peat in little over three months. We are still gathering very fine fruit (Nov. 14th, 1903), and will for some weeks from these plants.

"There are other reasons that induce me to recommend peat beyond the facts already mentioned; these are, from the fact of the drying, compressing, and grinding there is no fungus or disease, wire worm, or weeds; also, it requires less watering than other soils. The above facts are of great consideration to the grower. I have also further experimented with the fine peat-dust sent me, and most successfully in packing and ripening green tomato fruit. Green fruit packed in boxes three weeks and three days were turned out in fine condition, thus proving that many tons of green fruit usually wasted in the late autumn, can, by being packed in peat, be preserved and turned into money.

"I am so satisfied with the results already obtained that I intend to test peat as a good material for growing other plants as well as tomatoes and have every confidence of recommending it to other growers."

Equally satisfactory results are vouched for by another capable nurseryman, Mr. W. Byers, of the Jessiefield Nursery, Dumfries, N.B., who adds the following, which must prove of interest to florists:—

"I have been growing a large quantity of tulips, daffodils and narcissus in your specially prepared granulated peat-loam and find that those grown in above were much superior in quality and colouring to those grown in soil. The foliage was stronger and the plants more erect. I have every confidence in recommending it for the culture of bulbs, and I am so pleased with it that I am going to grow a quantity of tomatoes in it." The peat-loam is equally valuable in growing melons, cucumbers, ferns, chrysanthemums, bulbs, etc. These are by no means isolated cases, and when all interested in the products of the soil come to give these cheap and very effective manures a trial they will be rewarded with bumper and good keeping and feeding crops of high quality. Aided by the intelligent, exact and competent agricultural chemist, the large range of compounds now available can be manufactured to suit every soil and every crop, and the fact that plants grown in peat-loam as a basis require little watering is a factor of some value. Care, however, must be exercised in the selection of moss earth. Some varieties contain in themselves the best material and the best manures for their improvement. These stand in need of no adventitious aid. Others are absolutely sterile. The reliable chemist and experimental station, carefully conducted on practical and scientific lines, will guide the enquirer as to the essentials. For the development of the peat manure industry we want an experimental station organized and conducted on the principle so successfully carried out by Lord Rosebery on his home farm at Dalmeny. No one soil can differ more from another in consistency and chemical qualities than fibrous from pyritous, or bituminous peat from peat earth. What may be food for one may prove poison to the others. There is no panacea in the manurial art. It is from want of attention to this, the misapplication of manure and the labour, that in the past so many costly failures in moor reclamation and the cultivation of the mosses have been experienced.

There is another genus of moss, apart from that previously referred to, and which in the hands of the chemist may be converted into a valuable and commercial asset. We refer to Salt or Marine Peat, or the *braack torf* or *darry* of the Dutch which, despite the intolerable stench it emits when burning and the dangerous effect it produces on human beings, contains a rich treasure of manure. Whether wet, dry, burning, or reduced to ashes, it possesses features distinct from every other kind of moss. It often contains marine plants. Dr Rennie, who has studied those vast deposits, points out that they cover an enormous area and have been discovered on the south-east and west coasts of Britain, in south Ireland, and in the Western Isles. This peat is found in Cornwall, and in Kent at Romney, where in digging ditches, rudders, large nails and nautical instruments have been found imbedded. The whole of Marshland, a vast tract of now most fertile country, is said to have been won from the sea. Large deposits have been discovered in Cumberland, along the shores of Solway Firth, along the coast of Wales, and in Somersetshire round about Weston, Shapwick, and Collington, now nearly cut down to the water level. The whole of Sedgemore, or more properly Sedgemere, between Bristol and Gloucester is of this formation. In Sussex we find it at Rye and Eastbourne, in Kent near Sandwich, along the banks of the Thames, on the Sussex marshes—famed for their fattening properties, and along the sea-board of Norfolk, Lincoln, and York.[1] The shores of Holland, Denmark and the Baltic abound with it, and the whole of the valley of Somme in France is a vast reclaimed moss built of marine plants. The salt peat mosses found by Professor Lineck along the coast of Spain are composed chiefly of the stolochaenus, juncus acutus, and juncus maritinus, mixed with roots of the helodes freely blended with sea shells.

When fresh dug this marine peat has a bitter, fœtid smell. It burns with difficulty, with a blue flame and a disgusting malodorous stench. It is not only a repulsive but dangerous fuel, due no doubt to the sulphur it contains. It always communicates a livid cadaverous hue to the countenance, accompanied with a sickly nausea, sometimes faintness and syncope, when burnt in a close room. The higher percentage of sea salt found in it the more fœtid and dangerous is the smoke. A whitish yellow afflorescence, indicative of sulphur, clings to any iron pot or vessel placed over it when burning. A considerable quantity of magnesia, soda, or their salts, is found in the ashes. At one period the inhabitants of Aberdeenshire used the ashes of peat in place of salt, and to this day the braack torf of Holland is burnt to recover sea salt.

Mr. Douglas Archibald utters the warning that in the wheat yield Great Britain is bound to encounter during

[1] We have lately discovered this marine peat at Dunwich on the Suffolk coast.

the next seventeen years a total loss of £19,000,000 from what we might expect on the average yields of 1886-1902.

Apart from any question of preferential tariffs there is one means by which our wheat production could be increased by 50 per cent., and by which the country could be enriched without a shilling being spent abroad. As Sir William Crookes said in his presidential address before the British Association in 1898, we are content to hurry down our drains and watercourses into the sea fixed nitrogen to the value of no less than *£16,000,000* per annum. Practically the recuperation of this nitrogen and other valuable fertilizing properties of sewage has in most cases failed owing to the unintelligent way in which attempts have been made in the past to solve the problem by sewage farms and the pressed sludge of precipitation. These have both been abortive, and for very obvious reasons.

A solution of the problem has, however, been effected, by which the solids of sewage are converted into a dry powder at the rate of 1 cwt. per head per annum. From twenty years' experience it is found that 5 cwt. of this species of manure per acre raises the average yield of wheat thirteen bushels per acre above the normal for the United Kingdom, which for that period was thirty-one bushels. On 1,500,000 acres this would mean an increase of 19,500,000 bushels and the utilisation of the sewage of 7,500,000 persons, or only a little more than the population of Greater London. Moreover, this extra amount of wheat would meet the requirements of over 3,000,000 persons.

PEAT ASHES.

The value of properly prepared peat ashes as a cheap and effective, though not very lasting, fertilizer have long been acknowledged. Our moor farmers who, previous to the building of railways and the working of our coal measures, used to burn turf, had a proverb "the better the fire the richer the farmer." So sensible were these thrifty people of the efficiency of this manure that they procured all the ashes from the hearths of the householders and cottagers and spread them on the land. Many owners of large tracts of peat reaped a good income by burning quantities of turf, which was sold at seven, eight, and ten shilings a load. Peat ashes are extensively employed in the Netherlands as a manure, from whence, as already remarked, they used to be shipped in large quantities to the Thames for the London and Kentish market gardens. They are carefully preserved by the householders who burn turf and are sold to the farmers by the bushel. We have given the analyses of various peat ashes. Davy, who gave much attention to the subject, came to the conclusion that they owe most of their fertilizing properties to the presence of gypsum (or sulphite of lime) the effect of which is so apparent in crops of clover, sainfoin, and on grass lands. In 1728 the celebrated Earl of Stair sent from London several hogsheads of peat ashes to his steward, Robert Ainslie, with directions for their application, recommending them as an admirable top-dressing for grass, and even arable land. Accordingly this simple manure was used with great success on the pastures and tillage on his lordship's estate of Culhorn in Wigtonshire. So convinced became his intelligent lowland reeve of the value of these ashes to grass and barley crops that he immediately followed the precept of Virgil, "Nor hesitate to scatter the dirty ashes over the exhausted lands," and as Mr. Cuthbert W. Johnson, F.R.S., the well-known agricultural authority, informs us, immediately began to burn turf, moss, and peat in considerable quantities for use on the Wigtonshire estate. This writer in his important work *Manures* mentions that in the valley of the Kennet, Newbury, Berkshire, where peat ashes are made in considerable quantities and are used by the farmers as a manure for grass and turnips, they are sold at the rate of threepence a bushel, and are applied at the rate of forty or fifty bushels an acre broadcast. "On most grass lands" he states "there is no dressing equal to them; and on some soils near Hungerford they produce the most luxuriant crops of grass, when the effects of common farm-yard manure are hardly perceptible. As a manure for turnips they answer best in wet seasons." This Newbury peat ash Davy found to contain one-fourth to one-fifth of gypsum, and the Wiltshire peat showed the same proportions, that of Stockbridge in Hants containing a still larger percentage of this valuable sulphite of lime. Leibeg contends that the nature of gypsum consists in its giving a fixed constitution to the nitrogen, or ammonia, which is brought into the soil, and is indispensable for the nutrition of plants. He says that 100 lbs. of gypsum give as much ammonia as 6·250 lbs. of horse's urine would yield of it. 4 lbs. of gypsum, he affirms, increases the produce of the meadow 100 lbs. or twenty-five fold, (*Organic Chemistry*, p. 57). "These peat ashes" writes Davy "are used as a top-dressing for cultivated grasses, particularly sainfoin, clover, and rye grass. I found that they afforded considerable quantities of gypsum, and probably this substance is intimately combined as a necessary part of their woody fibre: if this be allowed, it is easy to explain the reason why it operates in such small quantities; for the whole of a clover or sainfoin crop, on an acre, according to my estimation, would afford by incineration only three or four bushels of gypsum. In examining the soil in a field near Newbury, which was taken from a footpath near a gate, where gypsum could not have been artificially furnished, I could not detect any of this substance in it, and at the very time I collected the soil, the peat ashes were applied to the clover in the field. I have mentioned certain peats the ashes of which afford gypsum; but it must not be inferred from this that all peats agree with them. I have examined various peat ashes from Scotland, Ireland and Wales, and the northern and western parts of England which contained no quantity that could be useful; and these ashes abounded in silicious albuminous earths, and in oxide of iron. Lord Charleville found in some Irish peat ashes sulphate of potash. Vitriolic matter is usually found in peats; and when the soil of the substratum is calcareous, the ultimate result is the production of gypsum. In general, when the recent potash emits a strong smell resembling that of rotten eggs (sulphuretted hydrogen) when acted upon by vinegar it will furnish gypsum" (*Agricultural Chemistry*, p. 336).

Some care is necessary in the preparation, storage, and application of these peat ashes. In the first instance it is necessary to ascertain by careful analysis if the chemical qualities of the raw material be suitable or not. The cost of this test if carefully and exactly conducted—not a mere finger and thumb investigation—will be amply repaid.

Instances of the misapplication of large sums of money and labour are not wanting, which have provoked the sarcasms and sneers of the dubious. But, given due attention to the chemical composition of peats, which differ one from the other in quality as one soil differs from another, we assert that moss of every kind has its use in the form of manure or fuel, or can be converted into some economical article of importance.

A Lancashire agriculturist, writing on this subject, impresses on his readers the necessity of careful burning and subsequent treatment. Peat ashes, in his experience, purposely and properly burnt for a manure, are noble improvers both of corn and grass land; but the substance from which they should be obtained is the under stratum of the peat, where the vegetable fibres are well decayed. Indeed, the very best is procured from the lowest stratum of all. This will yield a quantity of very strong ashes, in colour (when first burnt) like vermilion, and the taste very salt and pungent. Great care and caution should be exercised in burning these ashes, and also in preparing them afterwards. In the first place, the peat should be consumed as slowly as possible, the fire being just kept smouldering and never suffered to flame out. If in the morning it should be found too low and in danger of being extinguished, either in consequence of rain or by too close covering up and consequent exclusion of the air, the heap should be stirred up with a stake and enlivened by thrusting in some dry turf or brushwood. One man suffices to keep a dozen fires going, and these, properly attended to, will, during the summer months, produce a large quantity of these valuable ashes. About the middle of September (before the autumn rains come on) the fires should be smothered out by laying on every heap a large covering of soil or of heath parings, so as to effectually exclude air and in order that the heap may cool gradually. As soon as the ashes are cool enough to be carried, they must be stored in a heap, under cover, protected from wind and sun. Being in a very fine state of division and light, they are best transported in bags. Thus burned and preserved, they will be found an excellent dressing in the following spring, either for corn or grass land. Being so fine, they naturally insinuate themselves in the soil. Their effect is not lasting, but as every year brings an unlimited supply at very little cost, the farmer need not concern himself about this lack of permanency. The first rain washes them in, and the next summer never fails to testify to their fertilizing effect. The peat is cut in the usual manner, viz., by means of the slane or spade, the turves being "footed" or "rowed," then clamped or pyramided on the moss, and finally built up in stacks, which should be roofed with thatch. A year's seasoning in the rick greatly improves the material. Should the summer be wet, a re-clamping on the moor may be necessary, but when the peat is highly bituminous this will not be called for. Working on a large scale with the power excavator, the cost of graving is greatly diminished, and large quantities can be got to bank from the lowest strata, so that advantage may be taken of fine drying weather. All the burning should be over by September or October. The ashes should, before being housed, be riddled, so as to get rid of any stones or half-burnt turf, and the heap covered over with a layer of soil. This sifting ensures certainty and equality in the action of the manure. The large particles are best suited to strong clay land.

An extensive employer and strong advocate of peat ashes, one who had many years' experience of their good qualities, writes: "The sulphurous and saline particles with which these ashes abound have a most happy effect in promoting vegetation, and, if used with discretion, the increase produced by them is truly wonderful. All ashes being of a caustic nature, they must, therefore, be used with caution; but with respect to peat ashes, almost the only danger may be anticipated from laying them in too great quantities in improper seasons. Nothing can be better for dressing low-lying damp meadows, spreading from fifteen to twenty bushels to the acre. This work should be done on a still day, not later than January or February, so that the fine particles may be washed down to the roots of the grass by the first spring rains. If spread in the autumn, and rain should not speedily follow, the application would be apt to burn the pasture. The damper and stiffer the soil, the greater the quantity of ashes; but on grass land, permanent pasture or seeds, the quantity should never exceed thirty bushels, and on light warm soil half this amount should suffice. On wheat crops these ashes are of great service, but must be applied with discretion. If applied in full measure to winter wheat, at or immediately after the time of sowing, they, by inducing a too rank growth, would do more harm than good. A compromise, therefore, is adopted. About the beginning of November, before the hard frosts set in, it is good practice to treat heavy clay lands with eight bushels of the coarser ashes, giving light warm lands only half that quantity of the fine divided quality. This winter-dressing, trifling as it may seem, has been found to be of great service. It appears to warm the roots, to bring the plant moderately forward, preserves its colour, and disposes it to obtain a latent vigour such as enables it to push forward its growth at the first call of spring weather. About the latter end of February, or early in March, the lands get another similar dressing, an extra two bushels being apportioned to those of lighter description. These ashes, laid on in the spring, are of the greatest service, without any probability of danger. If it rains or snows within a few days after the dressing has been applied, it is washed in, and has a beneficial effect on the succeeding crop, co-operating with the manure that was laid on in November. If, on the contrary, dry weather should set in, the first winter application will produce its full effect, and the quantity laid on in the spring being so small, the possibility of its burning or injuring the wheat is very much reduced."

The authority we refer to states that he found this excellent manure of great use to the root crop. In the case of turnip, it is very beneficial in overcoming the ravages of the fly, this pest evidently finding the caustic taste of the ashes disagreeable. "When," says this old West Country farmer, "I sow my turnips, I have eight bushels of these ashes broadcasted on every acre, and when the plants show their first leaves I sow on every acre four bushels more. By this management my crops seldom fail, when at the same time some of my neighbours sow their turnip land three or four times over." The farmer must use this manure at first with great caution till repeated experiments have made him acquainted with its action on various crops and soils. In the case of peas especially, for this crop, though it succeeded admirably in one season, has on the next following, owing to variable weather, on the same soil and in another part of the same field, proved disappointing. In the case of barley and oats, these ashes are not so certain a manure as with winter corn. These crops, being quick growers, occupy the land but a few months, and this energetic manure is often apt to push them forward too rapidly, causing them to run to straw, with a lean, immature yield of grain. Oats, however, are not so apt to be damaged as barley. The best results with barley have been obtained when following on turnips, which, as stated above, have had two light dressings of ashes. When the turnips are fed off, or drawn, the field, season permitting, gets a good ploughing. If the roots have been fed off, the land will require no more ashes; but if they have been drawn and carried on to other ground for sheep feed, or given to beasts being yard or stall fed, each acre, after the ploughing, should get five bushels of ashes, leaving them to be washed in by the first rains. The land is left to lie till it receives a second ploughing before being sown. Contrary to the experience of others, this old West Country farmer "finds that the effect of this manure is distinctly visible for three years, and it does not, like some others, leave the land in an impoverished state when its virtues are exhausted and spent." He likens it, in its effect on the several crops, to that produced by soot, one of the most powerful manures in the class composing geine (decomposed organic bodies) and salts of potash, ammonia and soda, and is of opinion that it is the stronger of the two. In concluding a long and explicit memorandum on this cheap and effective fertilizer and its salutary effects on the soil, this practical agriculturist says: "It is chiefly to the fertilizing quality of these ashes that I owe the ease I now enjoy." Being so light, one cart-load suffices for the treatment of two acres. Despite our almost prohibitive railway rates, these ashes are within the reach of almost all our farmers, market gardeners, and horticulturists.

Brewers, distillers, tanners, dyers, chemical manufacturers, and others have long had before them the difficult and costly problem of how to get rid of surplus yeast, pot-ales, spent washes, and other troublesome effluents which under the Rivers Pollution Act may not be run into rivers, or where the privilege of using public sewers for the discharge of these waste products at present accorded by Local Authorities is liable to be withdrawn at short notice. Attempts of various kinds have been made to solve this important and far-reaching question. Most of these residuals are possessed of a commercial value. A paper read about a year ago before the Federated Institutes of Brewing by Mr. Julian L. Baker, F.I.C., F.C.S., on "The Utilization of Waste Yeast in Breweries" has directed the attention of the trade to its neglect of this valuable material which is now daily got rid of often with some difficulty and frequently at some cost. It certainly is a blot on our scientific enlightenment to find that surplus yeast—a substance rich in nutritive properties, of proved commercial value as a fertilizer, and as a good discolorising agent for tan liquors—should be put to no better purpose than to be unceremoniously turned down the sewer or drain.

Brewers are at present heavily handicapped by the difficulty of carriage of their yeast as compared with that of the patent article, to which latter preparation some medical scientists ascribe the alarming prevalence of cancer. Brewers' compressed yeast rapidly liquefies, and in any bulk becomes unmanageable. In order to overcome this transportation difficulty the objects kept in view must be the removal of the moisture from the mass, and thus inhibit putrefactive change.

Mr. Baker gives particulars of numerous processes which since 1888 have been published and patented having for their object compounds as substitutes for meat extract, meal and cake for cattle, milk, etc., at the same time referring to the medicinal properties of yeast which, though they have been recognized from the earliest times, have only recently been systematically investigated. These researches have confirmed its beneficial results in cases of boils, anthrax, and skin diseases originating in derangements of the digestive system. It is also of value, as a lotion or injection, for various malignant discharges. Internally, dried yeast suspended in beer is prescribed in doses of 1 to 3 teaspoonfuls before meals. As a lotion fresh yeast is suspended in a fermentable solution applied to the parts. The value of yeast cannot be gainsaid. But, outside these varied applications, there are other uses to which this product may be converted, the chief of which, from a commercial point of view, is as a material, in conjunction with peat, in the manufacture of compound manures or as a fertilizer to be used by itself. In this industry stale or dirty yeast can advantageously be employed on account of its richness in phosphates, nitrogenous matter, potash, etc. A sample of dried mild ale yeast was analyzed with the following results:—

Moisture, - - - - - - -	7·00
Organic matter, - - - -	81·40
Phosphoric acid, - - - -	5·60
Lime, - - - - - - -	0·50
Potash, - - - - - - -	3·50
Nitrogen, - - - - - -	8·20
Equal to Ammonia, - - - -	9·96

Taking the present price of ammonia at 10s. per unit, potash at 4s. per unit, phosphate of lime at 1s. per unit, the value of the sample of yeast, having the composition given above, would be:—

Ammonia, - - -	$9·96 \times 10s. = 99·6s.$
Potash, - - - -	$3·50 \times 4s. = 14·0s.$
Phosphate of lime, - -	$12·2 \times 1s. = 12·2s.$
	125·8s.

or a total value of £6 5s. per ton.

Several processes have been devised for the direct conversion of peat into a manure, but its true economical use will be found, after evaporation, in the manufacture of compound manures. J. S. Johnson (*Eng. patent* 20,660 of 1897) having by pressure or evaporation deprived yeast of a large portion of its moisture, thoroughly dries it, pulverizing the product. This is used either alone as a fertilizer or mixed with dry loam, phosphate, or other suitable material. The preliminary evaporation is best performed in a vacuum vessel, provided with a steam jacket and mechanical stirrer, the final drying being effected by exposing the material on trays in a current of warm air. As the preparation when required for storage needs a proportion of suitable antiseptic, we suggest the addition of granulated peat. By the addition of this cheap deodorizer and antiseptic the latent moisture in the mass would be absorbed, and the fermentative properties of the yeast must practically disappear.

For converting yeast into a fertilizer, top dressing, or fly and wire-worm preventive, A. J. Oxford (*Eng. patent* 5936, 1901) heats the yeast, or it is mixed with unslaked lime, powdered, and mixed with kiln dust, dried malt culms, or other ingredients. Here again the use of peat mull suggests itself. Mr. Julian L. Baker, the author of this valuable *résumé* connected with the brewing industry, is at present working in this direction, and has obtained encouraging results. His *modus operandi* is to treat pressed yeast with small quantities of sulphuric acid, heating the liquefied mass for a short time to 212° Fahr. and then nearly, but not completely, neutralizing with carbonate of lime or a mixture of carbonate of lime and carbonate of potash. A copious evolution of carbonic acid occurs, rendering the mass very porous and spongy. In this state it can be dried with ease and readily powdered. The cost of treatment is small, and there are no difficulties arising from the disengagement of malodorous gaseous products, as all the volatile nitrogenous constituents are fixed by the sulphuric acid. The phosphates are also made soluble. This utilization of yeast for manurial purposes is in no sense speculative, and is a subject of vast importance to the brewing industry. A material having the composition mentioned above has a definite market value per unit of ammonia, potash, and phosphoric acid. It is produced in enormous quantities. It would not, perhaps, pay any single brewery to convert its surplus yeast into manure, but in large cities and towns, where the output of beer is considerable, it certainly would be profitable for the brewers to work on the co-operative principle, and to send their surplus yeast to a central factory to be there treated. We are confident that by composting their waste product with peat an enriched fertilizer would result, accompanied by reduced cost of the process of manufacture, enhanced keeping qualities, and free division of particles. Certainly it would banish the carriage difficulty which, at present, is the lion in the path.

A plant lately installed at a distillery in the Highlands for the purpose of evaporating pot-ale has proved entirely successful, and from this it may be concluded that, so far as regards this effluent, the question of river pollution has been satisfactorily solved. We have no particulars as to the cost of this process, but as the waste heat of the distillery is utilized it cannot be heavy. A mixture of desiccated peat with the pot-ale syrup has also been attended with good results, as it enables a hitherto very difficult material to be dried at a comparatively low temperature. Formerly a temperature of 350° Fahr. was necessary, for if dried at a lower heat the matter became deliquescent on exposure. The pot-ale is injected into the evaporator in the form of a fine spray. The resulting manure is worth £5. 10s. a ton. One large distillery produces weekly some 600,000 gallons of this waste effluent or spent wash.

CHAPTER IX.

PEAT BRICKS AND EARTHENWARE.

By the mixing and thorough incorporation of fibrous, nodulous, and powdered peat with clay or clayey loam a worthy and cheap competitor as against building-bricks, filtering material, stone, and lumber, can be manufactured. It is a cheaper product than ordinary building-brick, lighter in weight by from 50 to 75 per cent., and remarkable for its non-conducting qualities of heat, cold, sound and electricity. It serves admirably for filtering and refrigerating purposes, and, combined with the chemical compound referred to under the head of cement, becomes waterproof and practically indestructible by fire, acids, or age. It is a well-established fact that brick structures outlast those built of stone. To a great and appreciable extent this plastic material carries its own fuel, thus effecting a considerable saving in firing in the kiln—each block or brick containing sufficient vegetable matter to bake the brick-earth or clay. In burning, all that is necessary, after kindling the fire in the usual brickmakers updraught kiln—for which purpose peat fire-lighters may be conveniently used—is to continue the firing only till the whole of the interior of the kiln, as viewed through the peep holes, is in a state of incandescence. All the vegetable matter in the bricks or other material must be thoroughly consumed, but the combustion must be gradual. Over-firing must be avoided. When the contents of the kiln are fairly alight throughout draughts must then be closed, a cherry red heat, of 950° Fahrenheit and no greater, being maintained by guarded admission of air through small flues or apertures until combustion has entirely ceased. The kiln must not be opened until thoroughly cool.

Clay of any variety, free from grit, may be used. For ordinary purposes surface clay is preferable to fictile or kaolin clays, the former being easier to work and baking with less heat. With the pulverized clay, ground or rolled in any manner practised in ordinary clay working, the peat, either fibrous or nodulous, or a mixture of both, is thoroughly intermixed or incorporated, the proportions varied according to the description of brick or earthenware to be manufactured.

If long pieces like joists or beams are required, say up to ten feet in length (which may be further strengthened to resist tranverse strains by the addition of metal cores, which are made subsequent to firing by running molten iron in longitudinal holes created by the die when the material is in a plastic state) only fibrous peat, chopped into lengths of two inches or thereabouts, is used in the mixture. Nails may be driven into this material, but it is not susceptible of tooling by ordinary methods. If a product of great porosity be demanded, which may be advantageously wrought with wood-working tools subsequent to firing, then granular peat may be used in the mixture. Mixtures which will afford products intermediate in strength and porosity between these two extremes may be had by varying the added quantity of peat of either or both sorts described. For instance for sills, girders, fence posts, and like constructions (which may be further strengthened with iron cores, and which are penetrable by nails) two parts of peat and one of clay by measure are the usual proportions. Blocks to build outside walls of buildings to resist moisture must, before erection, be coated with a thin slip of cement; or for underground construction, as for example pavements, pavement foundations, electrical insulations, tunnel linings etc., the materials are impregnated with boiling asphaltum. The formula recommended is two parts by measure of clay, two of granulated, and one of fibrous peat. For chimneys, chimney-flues, sheathing for roofs, to which slates may be nailed, cement, metal and other coverings applied, and for columns, and all interior work, such as partition walls, ceilings, furring or lining of exterior walls, and sub-floors, and other class of work upon which it is desirable to apply cement or mortar by trowelling, a mixture of two parts of clay, three of peat dust by measure accompanied by a sprinkling of fibrous peat best serves the purpose; and for boiler jackets, steam pipe coverings, filtering slabs, and safe and vault linings (in which the latter material may, or may not be injected with alum water or the like) as high as two parts of granulated peat to one of clay by measure, to which a sprinkling of fibrous peat may be added or not, affords the proper mixture. The products of the two last described mixtures may be wrought with common saws, and edged tools, and will hold nails, or screws, measurably well. The earthy and vegetable matters in measured proportions are adapted to the subsequent use of the product as described, intimately mingled together, with the addition of sufficient water, to make the compound plastic by any of the various tempering or pugging processes known to brick making; which by thorough incorporation thereof will afford homogeneity of mass, a qualification absolutely demanded when tooling subsequent to firing is required. The simplest method, however, is to measure and evenly distribute over and upon each other the prepared earthy and vegetable matter in alternate layers, proportioned in quantity, to the supposed demand for future use of the product, and dampened as the layers accumulate over each other, by sprinkled water. A pile thus composed of dampened alternate layers may be built up to a height of several feet, and upon completion must be covered with old bagging, blankets, or carpeting, thoroughly wetted to prevent evaporation, and to ensure an even distribution of moisture through the mass, and may be suffered to stand untouched for forty-eight hours or more.

Two principles of pressing are utilized in the formation of products of clay, to wit "compression" and "expression."

Machines of the former are used to fill stationary moulds with plastic clay, as is done with brick, roofing and floor tiles, filter blocks, slabs and the like. Of the latter, to press the clay mixture while in motion by pushing it with great power through hollow dies. If the pile prepared as described be within convenient distance of the press, its contents may be shovelled directly into the hopper. If not, they may be thrown upon an endless belt, and conveyed thither, first being dislodged from the end or side of the pile by workmen with sharpened shovels, who cut off thin sections down from the top through the intermediate layers to the bottom, taking care to intermix the ingredients composing the individual layers by gentle agitation, shovelling over and over before the mixture is thrown into the press. The latter, which may be of the "auger" variety, is a large iron cylinder horizontally mounted, and gently tapering from its receiving end, on which there is located a hopper to receive its load, toward the delivery end, the mouth of which is blocked by a die attached thereto with bolts, and which is easily removable, and interchangeable with others of different patterns. A screw or auger is adjusted to its interior, the blades of which are attached to a horizontal revolving shaft, and pitch forward toward the delivery end of the press at an angle of thirty degrees.

Pushed forward by the revolving screw the mixture is not only "pugged" or worked together into a plastic condition in its passage, but is compressed with great power, a compression greatly enhanced when the resistance to its progress offered by the die is met. The friction thus encountered causes the fibrous particles to arrange themselves longitudinally and parallel with the axis of delivery. Around and through the die the contents pass and emerge beyond upon a receiving table in a solidly-pressed compact column, corresponding to the form of the die. Moving forward with constant steady motion, the column is divided into gauged lengths automatically or by an attendant workman, and carried to the drying yards or rooms. If the mixture be of fibrous peat and clay only, these lengths may be as great as ten feet or more. If of granulated peat and clay only, from twelve to sixteen inches. If of clay and both varieties of peat, of a length intermediate between the two, depending upon the proportion of fibrous matter intermixed.

Those pressed blocks or slabs may be dried, when the climate and season will allow, upon racks under out-of-door sheds in winter, within the house by heat artificially applied. Unlike green products of pure clay, sudden application of heat does not cause the block to warp or crack even when submitted to a heat as high as 185° Fahrenheit as it comes from the press. Drying by artificial means has for years been carefully considered by practical brickmakers, so that every description of brick may be dried and burnt all the year round and a substantial saving effected in labour, time, fuel, and production generally. The kiln tunnel, or drying chamber, the invention of Messrs. A. H. Higginbottom and A. B. Lennox, ensures rapid and expeditious drying at a low cost, yielding to the makers also a considerably increased proportion of "best" bricks.

With efficient plant porous-partition sound-proof walling bricks can be manufactured at the cost of ordinary "stock" bricks. Samples were made for the writer by the late Mr. Ward of Manchester, a well-known expert, and were submitted to leading architects both in that city and in Liverpool, general approval and large orders following. Peat plaster or cement anchors itself to their surface with great tenacity, forming a solid wall. The sound-proof qualities of this material, as well as its lightness, is a strong recommendation. Next-door neighbours cease from troubling.

These bricks are extensively used in Denmark. The heat from the kilns can be used in the drying tunnels, thus effecting a material saving.

An attractive waterproof roofing and hanging tile, about the same weight as oak shingles, and of any pattern or colour, can be made from this compound. A close-grained material is used, the pores of which are hermetically sealed up by an imperishable, hard, flinty substance completely indurating the manufactured tiles, etc., thereby preventing decay and safeguarding them against atmospheric influence and fungoid growths. There is no exfoliation, no discoloration, no damage from frost. The weight and strain of the wood-work of a roof is, by reason of the lightness and water-resisting qualities of those tiles, much reduced, and with it the cost of construction. An external brick wall, consisting of 12,000 of ordinary bricks, is capable, when saturated, of holding 15,000 lbs., or $6\frac{1}{2}$ tons, of water. Rain runs off these tiles like water off a duck's back. There is no necessity for counter lathing; no felt, no pointing with plaster or cement, is required to make a thoroughly sound, dry-roof. It is more effective and much more attractive than slate at about the same price. These tiles are also adapted for hanging purposes or for linings. They are quickly and easily laid on the light roof and secured with or without nailing, the joint of the pattern recommended excluding drifting rain or snow and preventing wind stripping.

A peat earthenware known as "Torbite," the invention of a sanitary engineer, is now largely used in the construction of latrines. It is non-absorbent, and with an occasional flushing or scrubbing remains in a perfectly sanitary condition, free from all malodours.

As a fuel free from sulphur and a long flame with little ash are essentials in firing glazed pottery work, and as the cost of firing forms a large ratio of the cost of manufacture, Peat, whether in the form of briquettes mull, or gas, offers an excellent and economical form of fuel not only for these especial productions, but for every description of pottery, earthenware, glazed bricks, tiles, and sanitary goods. Though at present Ireland imports almost all her domestic ware, paying the heavy cost of freight, yet she possesses within her own borders adequate and suitable supplies of the raw materials. She thus possesses all the means, saving skilled labour, necessary to resuscitate her lost clay-working and pottery industry. Good delft ware was manufactured in Belfast two hundred years ago, and in these later days what is more beautiful than Belleek china?

PAVEMENT.

From time to time experiments have been made with a view to converting peat into pavement. Seeing that granulated cork, with a matrix or bind of bitumen, compressed into flooring blocks, has been laid down at Messrs. Tattersall's well-known establishment at Knightsbridge, and in many other stables where the wear and tear from hoofs is considerable and constant, and that this flooring has given great satisfaction, it has been reasoned that peat may equally well answer the purpose. Now that wood pavement in the Metropolis is giving place to greasy, slippery asphalte, the possibility of substituting peat blocks for those of imported timber—the supply of which all over the world is running short—has been exploited and verified. The original process was to add 15 per cent. of well-dried fibrous material to coal tar, and to boil this compound for several hours until the entire mass had dissolved into a viscid liquid, which, when cooled, presented a solid mass resembling asphalte. An improvement on this was an artificial asphaltum composed of carbonate of lime and coal tar, the result being a solid and somewhat elastic block forming a roadway or pavement in many respects superior to any compounded of native asphaltum. The tendency of this artificial mass to crack, disintegrate, or run is counteracted by the strong fibre of the peat, which, added to the chalk and tar while warm, acts as a bind throughout, the cool mass overcoming its brittleness. Asphalte pavement costs 5s. to 6s. per square foot, according to circumstances, the price of mineral pitch being over £2 per ton delivered. These crude methods have now been discarded, chemical research having discovered an effective and economical bind enabling blocks of pure peat pavement to be manufactured at a price bidding defiance to imported wood or asphalte. These peat paviors can be turned out at about 2s. the square foot. Numerous practical tests have proved that the chemical combinations of certain cheap materials produce, in conjunction with raw peat, a tough, durable, uninflammable, and waterproof material, which will resist atmospheric influences for any reasonable length of time. Rain and horse urine cannot penetrate it. As this material can, in the form of cement or plaster, be run in or grouted into the interstices or joints, and it hardens like adamant, a perfectly water-tight and sanitary road or path, affording firm grip and foothold, is formed. Such a road is an ideal highway for auto-motors and cycles, and for every vehicle with rubber tyres. There is no tendency towards contraction, the blocks being firmly anchored by the cement one to the other, forming a homogeneous whole. As a flooring for railway stations, barracks, hospitals, warehouses, workshops, granaries, coach-houses, stables, and buildings generally this compound can be strongly recommended. It can also be used as panelling, paraquet flooring, etc., and it takes a high polish.

CEMENT AND MORTAR.

Another application of the mineral binding material above referred to is that of manufacturing cement and mortar from peat. This material solidifies in two or three days, gaining increased strength with age; in three days it stands as great a crushing strain as Portland cement at eighteen. It possesses all the good qualities of the various known cements, with none of the drawbacks; owns several important properties that none of them can claim, and is more economical to use than any. It works well, and as it solidifies slowly the work need not be hurried. After a day or two it dries, and then sets hard with great rapidity. It adheres firmly to weather boarding and other structures, making them absolutely weatherproof and waterproof, even in the most exposed situations subject to storms of drifting rain. Mixed with fine granite, slate dust, or even sea sand, it does not chip or wear. A wooden frame-work covered with canvas forms an air and water-tight dwelling much more comfortable than our military huts, the canvas becoming hard as rock. A strip of calico saturated with this admixture proves a perfect joint for leaky hot-water pipes.

Run into moulds all sorts of useful and decorative work can be turned out with this material—such as chimney-pieces, cornices, picture frames, and mouldings generally. For wood-work on board of ship—such as cabin bulk-heads, decks, bilges, and floors—it, on account of its lightness, durability, and fire-resisting qualities, should prove an efficient substitute for timber and cement. It does not crack, and is vermin-proof. As a covering for boilers and steam-pipes, to minimise the radiation of heat, this cement answers well.

PEAT PAPER.

Though Mr. Tatlow scouts the idea of peat being converted into paper or cardboard on a paying commercial scale, and instances cases of the manufacture being abandoned as impracticable, we are not disposed to agree with him. The failure of Tschormer & Co., of Vienna, though the *fiasco* brought many to grief, proves nothing except that the process was worthless and the scheme rotten. When methods are bolstered up by high falutin paragraphs in a subsidised press they usually "pan out" worthless. That people still have faith in the possibilities of the manufacture is substantiated by the starting of another company in Vienna, with a factory at Admont, the object being to manufacture paper from 90 per cent. of peat and 10 per cent. of the cheapest cellulose, without any chemicals whatever. This patent—if there be a patent such as can hold water?—is, we are told, to be exploited by the Peat Mill-board Company, with a capital of £100,000, to which we wish every success. The prospectus we have not seen, but, presuming all to be "square and above board," and that the rapacious promoter or underwriter has not taken undue care of himself, we wish the venture every success. But why this huge capital? It is claimed for this process that the lowest class of cardboard made thereby ranks with the imported straw and wood-pulp boards now selling in the market at £5 and £7 a ton. Nearly five million pounds worth of paper was imported into England last year.

In some paper mills, and in the manufacture of celluloid, peat fibre and bog-cotton (*Eriophorum Vaginatum*), which grows more or less abundantly on all bogs—in some to the extent of 60 to 70 per cent.—and is frequently found immediately underlying the red-peat, are largely used. At no distant date wood pulp threatens to become dearer and dearer, and the substitution of sphagnum and this bastard cotton promises to develop into an important demand. Linen rags are dear also, and it is predicted from present statistics that unless something be done towards replanting, at the current rate of consumption the forests capable of supplying pulp will all have been felled within the next thirty years. The world's newspaper press alone devours 11,000,000 tons a year of paper, and in all countries supplies are being rapidly depleted. So acute is the dearth of timber in the United States, that proposals are before the Department of Agriculture at Washington for regulating and systematizing the cutting of woods and forests. The late coal famine has brought home to the Americans the dire results of their thoughtless and prodigal waste of timber. The broad tide of immigration now in full flood from East and South into Canada must, year by year, tax her forests. The axe of the lumberer is ever busy, and pulp mills multiply. In Sweden and Norway the vast woods are rapidly disappearing. Of all the substitutes peat, for the stronger and coarser papers in particular, appears to be the cheapest and readiest to hand. If, as Herr Geige asserts, peat wool of the sample we have before us can be manufactured at $1\frac{3}{5}$d. per lb., then in price it should come out well. For very strong packing paper, such as is used by ironmongers, an expert suggests the addition of hop fibre, which is of great strength and easily prepared. Brown packing papers made entirely of peat, or blended with other fibrous material, such as old gunny bags, submitted to the writer, were very tough, and the boards were in every way superior to those tender and easily torn German straw boards. As peat charcoal is an excellent bleach for vegetable dyes, it is quite possible to manufacture a snow-white paper from the grey surface peat mixed with bog cotton. Furriers whose losses from the moth are very serious, and who have not yet found a paper capable of keeping these fretting pests out of their goods, will do well to turn their attention to peat paper, for it will not harbour moths. The housekeeper will find it useful to lay it down under carpets. Treated with Velvril, the new substitute for india-rubber and gutta-percha, it can be rendered water and grease proof by adding the mineral preparation referred to at page 187. It can be used as roofing, lining for walls, packing-cases, etc. The pulp can be moulded into any shape.[1]

Experimenting with peat a few years ago, the writer's attention was directed by a well-known expert in paper manufacture to a novel application of certain vegetable substances found in peat adaptable to that manufacture and the improvements to be obtained therefrom. It is a binding and stiffening substance, the action of which, though identical with that of starch, does not contract and cause that brittleness which the latter is apt to produce. Numerous kinds of vegetables also produce this binding substance, but none, so far, have been found capable of yielding it regularly and at all seasons at such a low cost

[1] From this pulp, by a process we may not here describe, it is commercially practicable to manufacture unbreakable ware extremely light, hard, tough, and elastic, with a remarkably smooth surface, which is capable of standing the hardest and roughest wear and tear. For naval, military, and colonial service, being so light of carriage, in institutions, asylums, hospitals, and for general household purposes it is unequalled. The price at which this ware in its numerous useful forms can be placed on the market brings it within the reach of all, and suggests a special industry.

and in practically inexhaustible quantities. Though now decomposed, this deposit originates from a very leafy vegetation, and when prepared it again becomes soft and pulpy. In the process here referred to the aim has been to solve the problem in as simple a manner as possible without necessitating additions to or rearrangement of plant, or involving any complicated handling. There is always a strong opposition to any interference with vested capital in this country. In America the manufacturer, when he considers his plant antiquated or behind the times—not up-to-date—does not hesitate to uproot it, "lock, stock, and barrel," and consign it to the scrap-heap. Not so with us. Here it is extremely difficult, and takes a long time and much insistency to succeed in the introduction of new methods. Innovations, even of the simplest character, are discountenanced in running installations, and it is almost impossible to prevail upon those interested in established works to take up any new idea, be it ever so promising, if heavy inaugurative expenses or elaborate manipulation are thereby entailed. Happily this process steers clear of all these drawbacks, and works out the solution in an exceedingly simple way, requiring no disturbance of machinery and involving no costly skilled labour. This vegetable matter chemically combines with the fibrous and mineral matters contained in the pulp without in any way injuring their properties, grasping and interlocking the irregularities of the fibres, contracting them in the process of drying into a horny condition, and thus gluing them together, the result being a strong cohesive paper. Starch being so susceptible to mineral substances, and differently affected by almost every kind, so that in the ordinary way the minerals considerably interfere with its action, very uncertain results are produced. Not so with this substance, which so perfectly binds the mineral matters that large proportions of these may be employed without corresponding deterioration of the paper or interference with the other sizing agents which it may be necessary to employ. All that is required is to add certain proportions of this bind to

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the pulp in the beating engine. The materials at this stage being loose and in an extremely fine state of division in the water of the pulp, much of which now runs off with the water, are by this addition retained, and on this retention much depends.

To Mr. W. M. Callender, of the Celbridge Mills, Co. Kildare, belongs the credit of having established the first peat paper mill in the sister isle. "Making paper from the soil of 'Old Ireland'" is now an established industry, well advanced beyond the theme of academic discussion. This development of the Irish bogs deserves all the support and generous advocacy it can obtain. The Irish public is taking its share in making this new departure a success. At a recent meeting of the committee of the local branch of the Gaelic League it was resolved that—"As a mill has been recently established in Celbridge for the manufacture of paper actually made from the soil of the country, and that such mill is giving considerable employment in the village, and will give considerably more employment in the immediate future, it is the duty of all members of the League to give such support as they can to this mill. Resolved, therefore, that each member upon purchasing any article in a shop, or otherwise, request that the parcels be wrapped up in the Celbridge Irish peat paper, and that all the shopkeepers be asked to request their wholesalers to send all their parcels packed in the same paper, and thus encourage an Irish industry and give employment in our village, cause an increased circulation of money, and in consequence put a stay to emigration." If the League is prepared to second the endeavours of those bent on developing the island's natural resources in this active whole-hearted manner, then there is a future for the industrial activity of the distressful country.[1]

Started with barely sufficient capital the company, after equipping the huge factory on the Liffey with suitable machinery, found itself hampered by a shortage of working capital. A futile attempt to wreck the infant concern was

[1] Peat-paper is also being manufactured in Sweden.

happily defeated, and additional ways and means having been found, mostly from local sources, the concern, free from all encumbrances, now finds itself in full work, with more orders on its books than, with the present plant, it can meet. Seeing that the paper manufactured contains 75 per cent. of peat, and that in consequence the mill has a distinct advantage of about 10s. a ton in cost of raw material (waste paper is much more costly, from £1 to £5 a ton), the company, under efficient management, cannot fail to become a dividend-paying concern.

At present the operations are confined to the manufacture of a series of wrapping papers of the description technically known as "ochre glazed." This article commands a universal market, and is at present manufactured in Germany and Scandinavia from ordinary material, and, of course, imported into this country in enormous quantities duty free. These peat wrappers are not brittle, as might be supposed, but on the contrary are strong and tough, equal in every respect to the product of the best foreign wood-pulp, and quite as attractive. Later on it is proposed to treat the waste liquors for the extraction of a valuable dye, and probably the manufacture of mattresses, rugs, carpets, and other coarse goods will be added to the programme. The following description of the works is from the *Freeman's Journal*, December 30, 1903:—

"The Callender Paper Manufacturing Co., Ltd., have just started at Celbridge, Co. Kildare, a new Irish industry of considerable importance. They are utilizing peat for the manufacture of paper by a process at once interesting and ingenious, and the success with which this highly novel transformation is achieved promises much for the future of the new industry. The peat bogs of Ireland have long been regarded as possible fields for industrial development. They have formed the material for many suggestions of a more or less utilitarian kind. But for want of the necessary initiative nothing was ever done with them to the present day, if we except the labour that is annually expended by the agricultural population of the country for the purpose of extracting from them quantities of turf for fuel, and they practically remained—what they always were—mere vast stretches of waste land, almost as extensive as prairies, but at the same time as desolate and unproductive as barren wildernesses. The idea of manufacturing, not fuel, but an article of such universal use in the commercial world as paper, from all this raw and waste material may seem at first sight somewhat fantastic. Still, the fact remains that by the application of a skilful scientific process, the wonderful metamorphosis has been successfully accomplished, as anyone may see who visits the new mills at Celbridge. There the peat is brought in huge quantities from the adjoining bogs, which, in ages extending back to the uttermost epochs of the dim and distant past, were covered by great primeval forests, and after having been subjected to the necessary treatment in the large factory established by the Callender Manufacturing Company, it emerges from the process in the form of wrapping paper of splendid texture, admirably suited for the requirements of the shops and warehouses of our towns and cities. This industry deserves and needs all the notice and publicity it can obtain. It has been the means already of giving a great deal of employment in the district. If adequately supported it should ultimately prove to be an industry not only commercially important and remunerative, but beneficial from a national point of view. The Celbridge factory is now at work night and day. It is equipped with a fine stock of machinery driven partly by steam and partly by water power, the adjacent Liffey being harnessed to a 200 h.p. turbine for the latter purpose, and this powerful turbine drives a dynamo, which, by means of cables, communicates the power to motors, and from these the motive force is conveyed to the different machines. When the peat reaches the factory it is placed in immense revolving boilers, where, under the influence of chemicals, it undergoes what may be described as a process of cooking. Then it is teased and torn, and, in the language of the factory, scarified until it is ready for the transfer into the beating machines, in which it is quickly converted into pulp. Next, it passes through a marvellously constructed machine, weighing about 150 tons and fully 100 feet long, and out of this it ultimately appears in the form of paper, which is at once wound up on reels. In this shape it goes to the polishing machines, where the paper is glazed and cut into the requisite sizes. Afterwards it is sorted and tied up in bundles of various weights by the girl workers who are employed for the purpose. No more interesting sight could be seen anywhere than the process by which the raw peat is converted in this factory into finished paper. The evolution goes on under the eyes of the spectator, and the astonishing skill with which the wondrous change is accomplished cannot but be regarded as a great scientific and industrial triumph. The paper, coloured brown after the prevalent fashion, is neat in appearance, strong and tough in texture, and durable in quality. It is satisfactory to be able to state that the Dublin wholesale houses are supporting the new enterprise by taking in supplies of the paper, which, it is to be hoped, will find a large and remunerative market."

PEAT-PULP can be moulded into Papier Mâché of great strength, and which is quite as light and wears as well as that prepared from the refuse of cotton and flax mills. It may also be found useful for mouldings. In Australia, where French tiles are used for roofing, the question is being discussed as to whether a better tile could be made of paper pulp. The objection to the French tile is its weight, its tendency to absorb moisture, thus increasing its original weight and creating a growth of vegetation that speedily discolours it. A peat fibre tile would be much lighter, be moisture-proof, preserve its colour better, be less liable to break than either slate or tile, suffer less from expansion and contractions through variations in temperature, and be free from the rattle in a storm characteristic of corrugated iron.

Those who think of applying for patents to manufacture paper from peat will do well to remember that, in 1854, Mr. J. Lallemand of Besançon, France, procured a patent for producing paper from the fibrous portions of peat mixed with five to ten per cent. of rag-pulp.[1]

For the consideration of paper makers we would suggest an admixture of hemp with peat. If this blend be found useful, it might tend towards the resuscitation of the growth of the plant as a field crop in this country. There never was a better opportunity, for, though we can grow the best of hemp, most of our supplies come from abroad—mainly from Italy. It is now forty per cent. dearer than it was three years ago, dearer than it has been for the last five and twenty years, and likely to remain so. To land foreign hemp at our mills costs about £3 a ton in transit, and to this £3 must be added for commissions and intermediate profits, so that the margin of profit to the grower is assured. The *Department of Agriculture for Ireland* has resolutely set to work to ascertain, by actual experiment, the most profitable methods of cultivating this crop, also of obtaining flax for our market. With this end in view, careful tests are being made as to the application of the various manures, as well as the retting and scutching of the plant so as to secure the highest market price. The value of different descriptions of seed is being tested. So far these experiments are not final, but we may safely anticipate therefrom the solution of various problems affecting our home flax production and industry. In their present stage they go far to prove that we have much to unlearn, for, in the application and selection of artificial fertilizers, what has been found to hold good in most other farm crops is curiously reversed in the case of flax. Possibly what applies to flax may also hold good in the case of hemp.

In connection with paper manufacture we see great possibilities in a blend of peat and of those common reeds,

[1] A Dresden expert has succeeded in manufacturing timber from peat. This imitation shows the best features of some of the hard woods, can be easily worked, takes a high polish, and is from 33 to 50 per cent cheaper than oak. It wears well, can be moulded into any form, and is particularly suited to panels, parquet flooring. No insect will touch it.

the Phragmites *communis* and the Bulrush, the Scriptus *lacustris*, which grow in abundance in all damp situations, and are by the thrifty peasants of Schleswig turned to good account. Wherever, especially in the West of Scotland and Ireland, there is stagnant water, and along the muddy banks of rivers, these reeds would grow in profuse abundance, and during the long winter evenings could be made to serve as a supplementary industry. We commend the cultivation and preparation of these reeds to the Congested Districts Boards, both of Scotland and Ireland. We gather from an article in *The New Ireland Review* ("An Industry for Ireland," by J. Tissington Tatlow) that the so-called "Schilfrohr" cultivation and industry, which extends more or less throughout the entire province of Schleswig-Holstein is well worth the consideration of every owner of a swamp, and the possessor of a tract of marshy ground along the seashore. The plants grow luxuriantly on the margin of the numerous marshes and ponds which are found in these Isles. In this simple but paying industry we have presented to us an object lesson of the ingenuity and perseverance of the frugal, hard-working, German in turning everything and anything, no matter how small and apparently trivial, to account. Nearly every resident on the damp and bleak shores of the Baltic, be he farmer, peasant or mechanic, assists his hard struggle for subsistence by some "side industry" supplementary to his regular calling or during periods of enforced idleness from his professed avocation. Many turn their attention to the growth and utilization of these rank reed growths with profit; and from the middle of November, all through the long winter till early days of spring, their busy hands find plenty to do, first in harvesting the Schilfrohr, and then in converting it into several commercial uses. Towards the end of autumn the plants, we are told, under the influence of sharp frosts, change colour, become paler in the stalk, the ornamental waving plumes becoming of a dark, dull, leaden hue. Then the marshes are invaded by jack-booted reapers, to protect them from the damp and from dangerous snakes. Armed with scythes these reapers cut down the reeds, and bands of harvesters, mostly women and children, following in their wake, gather them, tying them in small sheaves and stacking them on the dry ground. The harvested reeds are indifferent to all weathers, defying the elements, though they are the better for being stacked upright in the open for a few days, and then being left to dry before being scutched or combed by a very simple process. After Christmas the farmer prepares the Schilfrohr for the factories which are to be found in various parts of the province. The wholesale price paid for the combed material is about £8 per thousand bundles of nearly two feet in circumference. The scutcher is usually a very primitive implement, consisting of a long board armed with a number of teeth or pegs placed upright as in a hayrake. Through these the reeds are drawn several times in order to free them from broken and decayed bits, and to arrange them all parallel one to the other. An improvement on this rough and ready process is adopted by owners of a factory, the Johannisburg, about ten miles from Schleswig, one Herr Jons. Probably our mechanics are capable of still further improving on this method. The handling of this fibrous material cannot present many difficulties, even to the most ordinary labourer, for the writer saw it efficiently carried on by the inmates of a small branch of a district lunatic asylum, where a number of patients reside who are able to engage in basket industry. Visiting an almshouse he found the inmates thereof—a man with a wooden leg, three deaf old women, and two dumb children—all cheerfully working at this "binsen" industry, the man working at the frames making mats, the women doing the plaiting and sewing.

The uses to which Schilfrohr may be applied are numerous, and, as already suggested, its application as a cheap and tough paper material appears to us full of promise. The refuse is used for bedding for horses and cattle, its manurial value being considerable, as it contains 8·33 per cent. potash as against 0·7 to 1·0 per cent. found in straw. Prepared fibre is extensively used by builders as a substitute for laths for ceilings, plastered walls, and partitions, for which purposes it is said not only to be much cheaper, but more lasting. A smart workman can, in a few minutes, cover a ceiling or wall with it, preparatory to floating on the plaster. The price to the builder is one penny per metre (1 yard 3 inches). The coarser samples are used for thatching purposes; in fact in the province of Schleswig-Holstein a straw thatched house is never met with.

The treatment of the common Bulrush, though also very simple, differs somewhat from that applied to the Schilfrohr. Immediately before being used this reed, known as Binsen, is steeped in warm water to render it more pliable. It is platted into long strips or woven on frames into mats as coverings for footstools, seats for chairs, and such like. The strips, when stitched together, make capital carpets and matting, being warm, comfortable, neat, and fresh-looking, and certainly very inexpensive, quite a large strip being purchaseable for sixpence. Every acre of cut-away bog, every bog-hole, can grow Binsen and Schilfrohr, and furnish profitable employment during the winter to many hands.

SOAP.

Yet in another and not unimportant direction can "the sombre genius of the moor" be brought under contribution. Elsewhere we have referred to a new system for the low distillation of Peat. An excellent antiseptic, healing, and cleansing soap can be made from these distillates; and though at present the compound is offered in a somewhat crude tentative condition, hardly coming up to what chemists term "an elegant preparation," we venture to predict that some soap-boiler will make a fortune out of it. These emollient vegetable detergent oils and tars, in combination with a high-class dehydrated soap, exercise a marvellous effect on the skin and scalp of "the human form divine," and have been found most useful in preventing the spread of infectious and contagious diseases due to the presence and multiplication of minute germs. The soap is strongly recommended for cleansing the bodies of fever and other patients, the balmy sensation from the application of this detergent being refreshing and much appreciated. Certainly its effect on the skin is very marked, for it keeps the epidermis in a thoroughly healthy condition, soft and free from cutaneous eruptions. In cases of Acne and Eczema (that most irritating of skin diseases) in its various forms, psoriasis (dry-scale), herpes, sloughing sores and ulcers, it is of extraordinary efficacy. Travellers in the tropics, though often forced to bathe in water as foul as that of "the Holy Gunga" at Benares, in which loathsome lepers, those afflicted with itch and other cutaneous diseases, added to most of the ills to which mankind is heir, are constantly bathing, may by the free use of this soap escape contamination. It has been found most useful as a preventive of that annoying rash known as prickly-heat, in severe cases of sunburn, and inflamed eyelids. Many suffering from ophthalmia have derived great benefit from this non-irritant balm, and its free use in Egypt and Arabia, where ophthalmia is ever rampant, is strongly recommended. In Egypt every person appears to suffer more or less from this disease. Little children stone-blind swarm in towns and villages, their eyes blotched with the "white plague." Numbers of men and women blind from their birth—the disease has now become hereditary—may be seen led about by their more fortunate brethren. Superstition decrees that the poor suffering children should not disturb the flies from setting on the corners of their streaming, matter-laden eyes; hence the disease is carried by these loathsome pests far and wide to a calamitous extent. Sir E. Cassel, with his usual considerate liberality, has placed £40,000 at Lord Cromer's disposal for the relief of the suffering in Egypt and for the training of qualified men for such Samaritan work. The officials who have the expenditure of this generous grant should certainly give this peat-soap a trial, and, if successful, enforce its use. Though not warranted to produce a fine crop of hair on a billiard ball, or to fledge the frog's back, this soap certainly renders the hair soft, pliable, and brilliant, banishes dandriff, and leaves the scalp in the best condition for the reception of any *bona fide* hair restorer. In cases of ringworm it effects a cure. The only drawback at present is that it is not free from the peculiar, but no means offensive peat odour, and that it discolours the water, without, however, staining the skin. In due course the chemist may be trusted to eliminate these objections without sacrifice of the curative and cleansing properties.

In the form of an ointment these distillates are effective in the treatment of piles.

The acid-tar bye-products of peat find wide application in veterinary practice not only in the form of soaps of varying strengths, ointments, etc., but as a sheep dip and a smear for scab. Large fortunes have been made from well advertized sheep dips. The owner of one in particular has, from very humble beginnings, piled up a huge fortune. The active principle in most of these dips is that virulent poison—arsenic, often fatal to the lambs and to sheep grazing on the pastures where the dipped animals have stood to drain after their immersion. Corrosive sublimate, and mercury in other forms, is also employed. The "Turbarium" dip, the base of which is an extract of peat, is perfectly safe. Its natural antiseptic and cleaning qualities are intensified by the addition of a kindred substance, which, though non-poisonous and non-irritant, may with safety be taken internally, is as powerful an insecticide as corrosive sublimate or mercury in any form, or pure phenol (carbolic acid). This dip improves the wool and may be safely left about. In handling wool, the fleeces of sheep dipped in this compound, the sorter, comber, and carpet manufacturer may banish all fear of contracting that fatal malady anthrax. A smear or ointment compounded from a somewhat similar formula is a certain cure for the scab, and rapidly heals cuts, wounds, and sores. In conjunction with the free use of the soap it is a sovereign remedy in greasy heels, mange in dogs and horses—even the follicular variety —and will be found most useful wherever stock of any kind is kept. Though we cannot speak from experience, it suggests itself to us as a fitting cure for that deadly pest the cattle-tick of New South Wales. Dogs frequently washed with the soap in tepid water, the lather being permitted to remain on for some time, are free from all external parasites and from the objectionable "doggy" smell, and carry fine glossy coats. There are none of those ill effects so often produced by the application of carbolic compounds. In respect of cost and economy, these preparations compare favourably with any now in the market, and, being home-made products, deserve recognition.

The Lancet, *The Hospital*, and other medical journals write in the highest terms of peat wool, commending it for its marked powers of absorption and its marked elasticity, which is little impaired by moisture. It has the capacity of checking fermentation and putrefaction. In every respect it is superior to all the medical preparations of tow and cotton-wool or other material used for the dressing of wounds and as padding. However badly and carelessly treated, it never felts or becomes sour and malodorous. This dressing is largely used in French and German military hospitals. Experiments made in the naval and military hospitals at Kiel with peat-wool antiseptic bandages produced good results. As a padding for splints in cases of fractured limbs the wool, on account of its consistency, was found to do better than any other similar material known to surgery. The present retail price of this wool is 1s. 6d. per lb., and as it can be manufactured at the cost of $1\frac{3}{8}$d. there remains a very handsome profit. In the direction of wadding for stuffing palliasses there ought to be a great demand for this sanitary wool, and, doubtless, this demand will spring up when the article is put upon the market at popular prices and is better known.

An improvement on this wool of French manufacture are the compressed sheets, broken moss, felt, and hygenic towels of Sphagnum manufactured by Mr. W. Martindale, 10 New Cavendish Street, London, W., as used in the largest hospitals in the United Kingdom. In these surgical dressings only the surface grey peat is used. The material is soft, springy, highly absorbent, and antiputrescent; it may be teased out, when it forms excellent elastic hygienic pillows and packing for splints, particularly in cases where there is fracture complicated with flesh wounds.

BEDDING MATERIAL.

Hitherto peat moss has only been used, to any extent, as a litter or bedding for horses and cattle, and it was not till we had perused a paper lately read before the Congress of the Sanitary Institute at Glasgow by Mr. Peter Fyfe, Sanitary Inspector of that great city, entitled "What the People Sleep Upon," that we recognized the practically illimitable field lying open to properly prepared peat fibre in remedying the appalling conditions infesting the beds, bedding, sofas, couches, and cushions used by our middle and humbler classes, and not infrequently by the upper circles. The existing state of the sleeping arrangements of full 78 per cent. of our population is almost indescribably filthy and unsanitary. It would, said the lecturer, "be manifestly safer to sleep on a bed filled with sewage than on this material (*flock*), upon which, as I have shown, this large percentage of our humbler fellow-citizens are reposing."

For the purpose of ascertaining the kinds of bedding the majority sleep upon, about 2300 houses were visited, in which special investigation was made into the composition of 3163 beds. The following was the result: Hair beds, 22; feather beds, 115; clean flock, 37; cotton clippings, 103; straw, 371; chaff, 39; shavings, 4; old clothes, 1; and *common flock*, 2471. Common flock prevails mainly on account of its cheapness, but nothing bad is cheap. Of what is this pernicious death-dealing substance composed? Of filthy rags gathered from every quarter of the globe, the off-cast of all the pariahs of humanity, saturated with the germs of plague, cholera, small-pox, leprosy, cancer, enteric, loathsome skin diseases, and all the ills that human flesh is heir to. Add to this agglomeration of abomination the discarded clothing of the classes and the masses from the "Upper Ten Thousand" down to the verminous vagrant, tramp, and alien. In order to conduct his investigations without "fear, favour, or affection," Mr. Fyfe personally visited some of these flock manufactories, and gives the following description of the *modus operandi.* "To explain to you," he says, "in parliamentary language, what I observed in some of these torn garments would be impossible. It is better left to the imagination. Only those pieces soaking wet or too damp for the 'Devil' (*N.B.—The Devil, in this instance, is a toothed revolving tearing-machine generally employed in the preparation of shoddy for the cheap clothing industry*) to tear into shreds were cast aside to be stoved either beside the steam boiler or in a special drying chamber heated by steam. Nothing in the nature of cleansing or disinfection is attempted. All goes into the machine if sufficiently dry. At the other end it comes out as 'flock,' shredded so finely by the spikes or teeth on the periphery of the drums as to appear a fluffy wool of a dark grey, black, or brown hue, depending on the colour of the rags passing through the machine. The great mass of dust and finely-powdered filth which is set free by the 'Devil' is blown by a fan attached to it into a dust chamber, out of which it finds its way into the surrounding atmosphere."

Careful examination and tests, applied by Dr. Buchanan, the Corporation chemist, proved that the material as it came from the machine contained more solids than the crude sewage of the city. The average sewage contained 24·4 grains per gallon, whereas the bedding reached the alarming figure of 227·07 grains per gallon. The difference between the *live potential dirt* in the dirty, unwashed flock costing 1s. 9¼d. per bed and that known in the trade as woollen mill-puff at 10s. per cwt., a difference of 2s. a bed, is trivial.

This higher priced and apparently clean grey mill-puff is kept moving in a stream of pure water for three-quarters of an hour, but is in no way disinfected. It is clearly against the public interest that this vile material should be dispersed broadcast over the country. Even the makers themselves—no doubt strict chapel-going people on a Sunday—admit that the material is filthy and dangerous, and wonder that the manufacture has not long since been put a stop to.

But it is not only in the slums and in the tenements of the poor that we find this combination of evils. The bedding of most of our private hotels, lodging-houses, apartments, and servants' rooms is, from a sanitary point of view, little removed from that found in the common "doss" house. In thousands of private houses, too, the mattresses, bolsters, and pillows are teeming with bacteria—the above-mentioned "*live potential dirt*," calculated to bring disease into the closest proximity with those reposing on these filthy nests. At our, often costly, rooms or apartments at fashionable watering-places and seaside resorts, where in the season the visitors are so unmercifully plucked, the bedding is full of microbial impurity. With the Chief Sanitary Inspector of Glasgow, we hope that the facts now known will prompt the Government to lose as little time as possible in passing a measure which will enable all Local Authorities to *sample bedding* both in the presence of the flock manufacturers and in those who sell beds, sofas, couches, and cushions, and that punishment may follow every sale of every such material as does not conform to a certain standard of cleanliness and freedom from microbial impurity—the standard being fixed by biological experts. The bedding of every hotel, lodging, and boarding-house should be subjected to frequent and rigorous inspection. This is not one of those combinations of evil against which no human energies can be made to stand. It can as readily be dealt with as the water supply, the sewage system, the safeguarding of our flesh, fish, or meat supplies, and as easily brought into operation as the Contagious Diseases Act or any other preventive measure.

Flock at its very best, even when manufactured from high-class material, is not well adapted for bedding purposes. Stoved at a high temperature for cleansing and disinfection the fibre becomes brittle and crumbles. Even when only washed and dried it, under pressure, soon runs together, becomes lumpy, and concretes. It lacks resiliency. Saddlers when stuffing the seat and panels of a saddle with flock (their flock is generally made from combed-out bath blankets) enliven it by running through it a proportion of curled white horse hair, thus retaining the spring and counteracting the tendency to felt. We confidently suggest the substitution of peat moss fibre for flock. The peculiarities of this sanitary fibre will be found fully described under the headings of Peat Moss Litter and Peat Textile Fabrics. The addition of a little white curled horse hair might be advantageous. No insect would harbour in this bedding. It will be found—we write from experience—to be comfortable lying. An occasional opening up of the ticking, and the exposure of the material for an hour or two to sun and air, is easily accomplished, and is a preserver of sweetness. On the score of cost the balance is largely in favour of peat. The common unwashed flock costs 90s. a ton. At less than half this cost a superior peat-fibre bedding, entirely free from dust or any objectionable particle, could be manufactured and sold at a satisfactory profit.

CHAPTER X.

THE GERM-DESTROYING ACTION OF PEAT-MOSS LITTER, AND PEAT-DUST TREATED WITH ACIDS.

Of the many uses to which peat and its products may be applied, and the power it possesses, in combination with acids, in securing protection to man and beast from certain infectious diseases and epidemics, is a subject well worthy of consideration. In this cheap and effective germicide our sanitary authorities and the public in general have at hand a powerful and easily applied means of putting into practice the old adage that "prevention is better than cure."

We do not advocate the claims of this compound without due and reliable support. We produce the views and opinions of some of the highest authorities, of men well known in the world of chemistry and agriculture—practical and scientific—who have given this important matter close consideration. We are enabled to give a few short extracts from the work of the German Agricultural Company on *The Germ-destroying Action of Peat-dust,* quoting particularly from the contributions of Professor Dr. Stutzer, director of the Agricultural Experimental Station, Bonn; Professor Dr. Fränkel, director of the Hygienic Institute, Marburg; Professor Dr. Gärtner, director of the Hygienic Institute, Jena; and Professor Dr. Löffler, director of the Hygienic Institute, Greifswald.

This work with explanatory notes was compiled and edited by Dr. J. H. Vogel, managing director of the German Agricultural Company and president of the Agricultural and Chemical Analytical Laboratory, Berlin. Experiments and tests carried out on a sufficiently large scale and with exactitude at the Agricultural Experimental Station at Bonn, also at the Hygienic Institute of the Universities of Bonn, Marburg, Jena, and Greifswald, have incontestably proved that peat-dust, mixed with certain inexpensive acids, has the property of destroying the germs of infectious diseases found in the fæcal matter of human beings and live stock generally, and especially in cases of cholera and typhus, *at the same time favourably influencing the plant-feeding properties contained in the excrement.* These competent and exact investigators unanimously confirm the fact that peat fortified by acid has a powerful germicidal effect both on solid fæces and urine. This important question may therefore be considered satisfactorily answered, and the profitable utilization of night-soil in agriculture and horticulture may now be deemed not only practicable, but, from a sanitary point of view, absolutely safe. Not only is protection secured against the propagation and dissemination of infectious diseases inimical to mankind, but, by bedding our animals on specially prepared moss litter, our live stock may be safeguarded from many of the plagues which thin our stables, byres, and piggeries. When we add to this immunity the increased value of the manures thus obtained, the importance of this new departure is evident.

The Agricultural Department of Ireland, in a late communication to the writer, appears never to have heard of such a thing as peat manure, but peat is not one of its hobbies. The German Agricultural Society (Breeding Department), wiser in its generation, has made further experiments with moss litter treated with acids. It has come to the conclusion that by using this bedding the spread of such epidemics as foot-and-mouth disease, swine fever, etc., can be checked. We may venture safely to extend the category to influenza or "pink eye," abortion, milk fever, navel-ill, mange of various species, ringworm, and to many other diseases now so prevalent in our stables, stock yards, and folds. Professor Dr. Stutzer of Bonn and the director of the Veterinary Department of the University of Jena has devoted much time and attention to this litter question, and confirms, after careful bacteriological research, the statement that peat powder mixed with acids destroyed swine fever and swine pestilence (the nature of the "pestilence" is not stated).

Dr. J. H. Vogel, of Berlin, previously referred to, writes: "As already mentioned, it is indisputable that both peat litter and peat dust possess powerful and extensive capacity for absorbing fluids, that being from nine to ten times the weight of the peat. With an average sufficient strewing of the peat in the closet there is never a surcharge of moisture in the peat. Experience teaches us that never from such dung heaps, whether in the closets, the manure pit, or the manure heaps in the open air, do the liquids escape, and in that form percolate through the soil, reaching and poisoning the wells." The value of this retention of urine in the heap can be appreciated when we consider that urine putrefying for a month contains double the ammonia of fresh urine, and that unless mixed up with loam, peat, or swamp muck, or where kept in tanks with its bulk of water, it loses ammonia. Rivers of fertilizing riches run to waste from the ordinary farmyard or field manure heap. Each man, it is calculated, annually evacuates enough salts to manure an acre of land. There is scarcely a single element in human urine which is not essentially an ingredient in all plants. Even heavy dews are greedily absorbed by peat manure heaps. With anything approaching to careful handling and storage, this certainty of freedom from evaporation and leakage may be regarded as absolute. It is certain that malodorous and dangerous gases cannot escape from peat dung with an ordinary temperature, the peat itself being a greedy absorber of gases. Further, there are means of assisting this absorptive capacity by the chemical mixing of these gases, means which rationally tend towards the better utilization of the nitrogen in the peat manure, which should be and will be used in every form as additions to this fertilizer—*e.g.* phosphates and potash, materials which represent plant foods—and so highly increase the value of the compound. A correct treatment of the peat dust results in a moisture which has no ill effect on the breathing organs and has no objectionable odour when stored. In conclusion, it follows that the storage of this manure, whether in closets, dung pits, or manure heaps, neither offends the eye nor the sense of smell, and it remains perfectly cleanly to handle; in fact, it is so completely unobjectionable that for transport and application to the land so rich a manure cannot be obtained under other conditions.

The question, therefore, of the adaptability of peat dust for the provinces and small towns with manufacturing and agricultural populations is completely answered, and the value of the substance for mixing with excrements is fully established, for it helps materially in purifying the earth, air, and water, ensuring these results without in any way offending the people's senses. In such places it is self-evident that, in the case of an outbreak of disease, the existing night soil should be removed as speedily as possible, so that it may not become a centre of disease germs. Under such circumstances, and as a temporary measure, some more speedy and certain method of killing the germs may be substituted for this system, or it may be adopted in conjunction with it. The peat-dust process answers here all the demands of hygiene if properly applied, and therefore the use of peat-dust closets for the open country and in small towns can be pressingly recommended. Where the system prevails of removing the ordure in buckets or pails to some central dumping ground, by using peat closets the atmosphere will remain untainted, the earth and wells free from contamination.[1]

We now come to the acids mixed with the peat dust and the proportions used. On this subject the Professor states:

"During the investigations I often took the opportunity of placing myself in communication with the experimenters, and of discussing with them some variations of the *modus*

[1] We venture to commend these important facts to all interested in the Garden Cities project. To them it is of vital moment.

operandi. As it appeared indubitable from the first experiments that satisfactory results could only be looked for from very acid material, some peat dust thoroughly impregnated with sulphuric acid was included in the experiments. After a preliminary examination conducted by Professor Dr. Pfeiffer, director of the agricultural analyst station at Jena, at the suggestion of Professor Stutzer, of the firm of Fedor Wolff & Co., of Bremen, manure manufacturers, he succeeded in compounding a mixture composed of 100 parts peat dust, 2 parts sulphuric acid (of 60 Bé), to which were added 10 parts of water. The external condition of the peat under this treatment did not appear to be altered—at least, the preparation had no difference in appearance to that of ordinary peat. The composition of this preparation was:

3·60 % sulphuric acid (H_2SO_4), of which
2·67 % free sulphuric acid (H_2SO_4), answering to
2·18 % sulphuric acid anhydrid (SO_3).
0·93 % sulphuric acid in form of salts.
69·46 % dry substances."

Professor Dr. Stutzer, director of the agricultural experiment station at Bonn, writes: "Our attempts must be directed not only to the destruction of cholera bacteria, but also to the carbonic acid ammonia existing in privies, and to (Agens), or sprouting substance, which carb. ac. amm. creates anew, as by the presence of a minimum mixture of carb. ac. amm., the cholera bacteria receive a new impulse. In our opinion this destruction is best accomplished by the addition of a small quantity of sulphuric acid or muriatic acid, which is to be mixed with the excrements in such a manner that the entire mass undergoes an acid reaction. Additions of kanite or gypsum, either to old or fresh excrements, have, in accordance with the conclusions of former experimenters, proved themselves quite inactive. The treatment of old excrements with free phos. ac., or phos. ac. in the form of sup. phos. lime, is equally inefficient. Phos. acid, when one does not employ it in important quantities, is too weak an acid. On the foregoing grounds we must go deliberately to work to annihilate the ammonia bacteria existing in excrements if one would effectually fight the cholera bacteria, and success is best obtained by sulphuric acid and muriatic acid. Nevertheless, we must not renounce the use of peat dust, if only for the reason that this material renders the ordure practically inodorous, removes the nasty repulsive appearance, and (what particularly for small towns and the country is most important) really improves the agricultural value of the night-soil. In addition to this, peat dust is a most effective means of absorbing the quantity of sulphuric acid or muriatic acid necessary for disinfection. A quantity of peat dust impregnated with 1½ °/ₒ or 2 °/ₒ red sulphuric acid will be quite sufficient, after being mixed with the excrements, to kill all the cholera bacteria. Concentrated sulphuric acid or muriatic acid cannot be entrusted to every one, as these acids are too powerful, and inexperienced persons may easily do damage with them, while, on the contrary, peat dust impregnated with 1½ °/ₒ to 2 °/ₒ sulphuric acid is quite harmless."

In his report, Professor Dr. Gärtner, of Jena, says: "The extermination of cholera and typhus bacilli takes place quickly and certainly when to the peat is added more than 20 °/ₒ sup. phosphite of lime (calcic superphosphate containing about 15 °/ₒ to 18 °/ₒ phosphoric acid and sold at about 4s. 9d. per cwt.—author), or when 2 °/ₒ sulphuric acid anhydrid is added; on this condition, however, that a thorough mixing of the disinfectant is made with the excrement."

"The proportion of acid," writes Professor Dr. Fränkel, "is, therefore, the decisive point on the bacterial effect of peat. If this be raised, then the germ-destroying power is enhanced; on the contrary, reduced or limited in its specific effect by the presence of feeding substance—then its acting influence is appreciably lessened. Thus it follows that it must be our aim to artificially enhance as much as possible the acid properties of the peat and avoid all that might lessen them."

We may here observe that though the presence of some acid is the distinguishing quality of all peat mosses, different acids have been discovered in different mosses. The smell of most burning peats certainly points to the presence of an acid allied to the pyroligneous, resembling the sorreline, the gallic, and suberic. Distillation certainly gives out the acetic, but Dr. Jameson, in his treatise on peat moss, is of opinion that in some species suberic prevails. The acidity of moss dust distinguishes it from vegetable mould, though both are formed from nearly the same materials. In some bogs the sourness is due to sulphuric acid. When, therefore, peat has to be considered as to its manurial capabilities, it is of importance to supply chemical tests to determine what acid prevails and its proportion. The clays at the bottom of certain peat deposits are strongly impregnated with sulphuric acid. Some authorities consider that the acidity in peat is due to a distinct acid of vegetable origin. Dr. Fränkel, after a long series of experiments, pronounces strongly in favour of a compound containing 100 parts of peat dust, 2 parts 60 °/$_{\circ}$ sulphuric acid, and 10 parts of water, and confirms the already impressed opinions that the admixture of the acid in no way detracts from its fertilizing value, and does not alter the absorbent capacity of the peat. This expert's careful and very important report closes thus:

"From the foregoing reported experiments it is shown, with sufficient distinction, that the disinfecting capacities of peat-dust over cholera germs in a mixture of excrements or urine is entirely a question of the reaction arising therein. As a rule, peat-dust impregnated with 2 °/$_{\circ}$ sulphuric acid destroys in two, or at most seven, hours the cholera bacilli contained in the excrements. This operation is not, however, absolutely certain, and can be exceptionally altered under certain conditions, *e.g.* when the influence of the acid is worked upon by the action of alkalis. In practice these unwished-for happenings need scarcely be feared if one takes the precautions of avoiding a long keeping of the excrements, thereby excluding a prolonged fermentation. On this account it is recommended, when using peat-dust closets, to remove often and in small vessels. Facts show us immediately in what way we may succeed in strengthening the germ-destroying power of peat. It can be done by raising the proportions of the sulphuric acid, which may be considerably increased without damaging the agricultural value of the preparation. A very important item remains to be noticed, viz., that the raising of the proportion of free acid does not reduce the powers of the peat to absorb ammonia."

It is important that the United Kingdom in the economic struggle between the Old and the New World, and in the agricultural crises from which we are now suffering, should be in a position to resist successfully the keen competition of the United States, Russia, the Argentine Republic, and other cereal growing countries. It is manifest that this struggle which has driven so many thousands of broad acres out of cultivation, in which virgin soil contends against often worn out land, is being carried on under conditions, the gravity and extent of which, under the gospel of "the free fooder," will increase rather than lessen in future. We leave the theoretical Cobdenite and the practical economist of the day to fight the fiscal battle out between them, devoutly praying that the so-called free traders may be defeated all along the line and silenced for ever. We would, however. with M. Georges Ville, the famous French agricultural chemist, experimentalist, and authority on manures, point to the lesson to be learnt from our cousins over the water, and remark that the experience of to-day goes to condemn the fallacies of those who preach the doctrine, and who, for party reasons, pin their faith to the heresy that one-sided free trade is a certain and unalloyed blessing to the nation. After a prolonged civil war, almost unparalleled in history, the United States of America found itself suddenly confronted with a debt such as would have swamped most of the nations of Europe. Obliged to face the position and to provide immediate resources, the Americans cast the theories of classical economists aside, and though the "bunkum" of so-called free trade was only then being found out, with an utter disregard of existing opinion, they unhesitatingly, and contrary to all expectation, levied an almost prohibitory tax on all foreign products. This was forty years ago; what is the position to-day? The effects of these measures were immediate. Her new import duties and taxes rescued her from her pecuniary difficulties. Protected from foreign competition her manufactures sprung into life, and to-day she rivals us in almost every item of trade and commerce, and, thanks also to low freights and carriage, in a large measure contributes to our national food supply. We must protect ourselves. This is one means by which agriculture may once more resume its commanding and proper position in these Islands, the other is cheap and effective home manufactured fertilizers.

It is an undeniable fact, that, except under rare and altogether exceptional circumstances, farming operations carried on solely with the aid of manures produced on the farm itself, have for a long time ceased to be remunerative. "The farmer who uses nothing but farm-yard manure infallibly exhausts his land, for the manure has the soil for its source, and if he only diminishes the loss the soil has suffered he cannot in the end repair it" ("Artificial Manures," by M. Georges Ville). When farm-yard manure only is used, the improvement of the land requires length of time and an enormous outlay of capital, whereas with chemical manures the result is more rapidly arrived at. From these efficient substitutes we may almost immediately obtain large crops from comparative barren soils, thus realizing a profit at the outset. To obtain certain profits we must have recourse to manufactured manures of ascertained and guaranteed standard. The profits to the manure manufacturer which are all too heavy are a burden on the farmer. We have one or two large co-operative societies the object of which is to obtain for local co-operative societies and their members all descriptions of agricultural and garden requirements of the best quality at the lowest market prices. These associations offer to compound farmers' own prescriptions to suit various soils and crops, analysis and condition guaranteed. But this movement does not go far enough; the agriculturist, market gardener, fruit grower, and horticulturist must combine to manufacture their own fertilizers.

How is this to be done? The difficulty of manufacture may be urged as an insuperable obstacle. In Great Britain and Ireland there are about 8,073,694 inhabited houses each occupied on an average by 5·16 persons. Our estimated population is 42,373,000. Of our 32,550,882 acres in 1903, 5,455,142 were under corn crop, 2,338,099 green crops, 2,822,079 rotation of clover, and grasses, 13,581,178 permanent pastures, 916 flax, 47,938 hops, 68,968 small fruit, and 337,059 acres were under bare fallow. Thus we had last year over 11,000,000 acres under cultivation all requiring plentiful and continuous manuring with a suitable and reliable compost. In practice it is considered that the application of 16 tons of farm-yard manure every two years is sufficient for all ordinary purposes. Straw at its present price is too costly for mere manuring purposes in the muck-heap or the open court. The nitrogen present in manure expresses its true value. In farm-yard manure the nitrogen exists in the excreta and in half-decomposed straw, etc., which cannot be assimilated as plant food until it has undergone a process of decomposition, which completely changes its condition. Nitrogen can only be assimilated after it has been transformed into ammonia or nitrate. The previous decomposition, therefore, results in the loss of from 30 to 40 per cent. of the nitrogen which the manure originally contained, which escapes into the air in the elementary form. Not so with chemical manures from which the whole of the nitrogen may be assimilated direct. Peat, as has been shown, has a remarkable power of absorbing and retaining ammonia, and in promoting the disintegration and solution of the mineral ingredients of the soil; moreover, it is a direct fertilizer. "The urine of one cow for a winter, mixed up as it is daily collected, with peat, is sufficient to manure half an acre of land with 20 loads of manure of the best quality, while her solid evacuations and litter for the same period, afforded only 17 loads, whose value was not half of the former" (Dana). Experiments conducted by order of the Saxon and German authorities at Dresden and Berlin, with the object of testing the effect of the sewage of these towns on the barren soils in their vicinity, established the fact that if a soil without manure yields a crop of 3 for 1 sown, then the same land, dressed with cow dung yields 7 for 1 sown, with horse dung 10, and with night soil 14. Each adult, as already stated, evacuates enough yearly to fertilize an acre of land. The value of good *poudrette* (*i.e.* human ordure mixed with sulphite of muriate of lime and dried) depending on its ammonia, is, compared with green cow dung, as 14 to 1. All night-soil from vaults or cess-pools has begun to evolve ammonia, hence the advantage of mixing ground peat with the material before drying.

Though with our modern W.C's. and the elaborate system of town sewage by which the night soil, much diluted by various mixtures, finds an outlet on the sea, pollutes our rivers, or is, in some instances, utilized on sewage farms, a very large proportion of this invaluable plant food is lost to us, still there is ample room for the dry peat-closet. In England and Wales alone over 1,200,000 adult males are engaged in agriculture, as artizans, labourers in our great building yards, on our railways, down the mines, at the docks, and in the hundred and one trades and manufactures. At the various works there must, of course be conveniences for this huge army of labour. There is no reason why the rich evacuations of these people should not be saved without creating the faintest nuisance or offending the strictest hygienic principles. Were peat more generally employed as a fuel the ashes would be found to be a valuable manurial, as well as mechanical adjunct, for they abound in carbonate, sulphate, and especially phosphate of lime. Some well-considered economical scheme for collection, treatment, storage, and destruction would have to be thought out. The co-operation of the county and town, urban and rural councils, as well as of the local agricultural societies, would have to be secured. A dry earth closet on an improved self-acting principle, lately brought out by an enterprising firm of sanitary specialists, should be generally adopted. In it the valve, which in other closets is liable to get out of order and to close, is dispensed with. With a perforated shovel as a spreader, certain automatic action, with equal and sufficient distribution of the deodorizer, is secured. In other closets the distribution of the deodorant is imperfect. A chamber for containing the dry material is formed at the back. When the convenience is being used the weight of the occupant, depressing the seat about an inch, forces down rods on either side of the seat, these raising toothed levers, which in turn throw back the perforated shovel into a compartment under the peat chamber, where it receives a charge of the deodorizing material. When the seat is relieved the weight of the lever throws the shovel quickly forward, spreading the peat evenly over the excreta. A strong substantial closet, in its simplest form, designed for public works and workmen's houses, can be supplied for £3. This firm also manufactures a material from peat for the construction of urinals, which, as it needs no stream of water, and possesses special sanitary features and economy in cost and maintenance, promises to have a wide application.

The manufacture of chemical manures involves no great outlay in expensive plant. The operation of mixing the various products in their due proportions without being difficult requires care. A co-operative association working on a large scale should secure the services of a thoroughly practical and exact agricultural chemist. To such a factory there should be added experimental fields on which all classes of the community may witness verification of results. The results would arouse the interests of the surrounding population, would excite their energy and lead to analogous trials. Such "proving fields" would appeal to the eyes and the senses. Peat as a basis on which to compound can now, by land or water, be brought within the reach of all, and many spent, now useless, products turned to good account.

The establishment of such associations, under careful and intelligent management, would result in the annual saving of millions of pounds, and, through that economy and the general use of chemical fertilizers of superior quality, the increase in production would amount to from forty to eighty millions sterling annually. We may safely calculate upon a saving of 20 per cent. in cost of manure to the farmer, and an increase of 10 per cent. to the crop.

Among the mixed manures, *poudrette* has been mentioned as ranking next to night-soil and equal to guano. There is another form of what in France is also termed *poudrette*, and which is a powerful fertilizer. It is almost one-third animal matter, and is formed, without any offensive evolution of gas, by boiling the offal of the slaughter-house by steam into a thick soup and then mixing the whole with coal ashes into a stiff paste and drying. If putrefaction should have set in, the addition of ashes sweetens the mass, and the prepared "animal coal," as it is termed, or poudrette, is as sweet to the nose as garden mould. It is transported from Paris to the interior. The ashes of anthracite coal contain carbonate of lime, alumina, and oxide of iron, and are valuable so far as they abound, but for mixing with animal matter preference is due to peat dust or peat ashes. For Paris, read London, Liverpool, Manchester, Bristol, Glasgow, and all our great cities and towns. Every slaughter-house and knackers' yard in the kingdom should be put under contribution. Blood is an excellent fertilizer. Flesh, fish (thousands of tons of decomposed fish are thrown away yearly from Billingsgate and the fishery ports), and all animal solids—muscle, gristle, skin, sinews, etc.—evolve vast quantities of ammonia. A dead horse can convert twenty tons of ground peat into a valuable manure.

CHAPTER XI.

HEALTH-GIVING PROPERTIES OF PEAT.

Those unacquainted with peat-bogs naturally regard them as insalubrious manufactories of intermittent fevers and rheumatism. On the contrary, all over Europe, America and Canada, with one exception, the Welland bog, Ontario, the air and water of peat mosses, as evidenced by the health of inhabitants, are peculiarly free from malaria. They are not liable to fever and ague prevailing on the low lying swampy lands in their immediate vicinity where there are no sphagnum mosses. If there be one spot more than another on the face of the globe the visitor to those uninteresting parts would condemn as a deadly, fever-laden, gloomy quagmire it is "The *Great Dismal Swamp,*" *of Virginia.* An officer who served in the memorable Civil War, a stranger to this vast morass, writes: "The water of the *Great Dismal Swamp,* though of a dark-reddish colour, is clear and fit for all domestic purposes. I have often used it to quench my thirst, in preference to the water of the springs and wells of that vicinity. Indeed, the people near the swamp believe it to possess medicinal qualities, and declare that those who steadily use it will not be troubled with ague or the bilious disorders incident to the summers in that region. I have heard the inhabitants of that neighbourhood repeatedly affirm that to visit the swamp and to partake of the waters beneath the dense shade of its luxuriant magnolias, lofty junipers, and white cedars, was as invigorating as a trip to the sulphur springs or the healing waters of Saratoga. We smile as if the idea was absurd; but certain it is, that the juniper water, as it is called, possessed astringent qualities at least—and the experience of the army abundantly proves that it is much more wholesome to those not acclimated—than the waters of various villainous properties drawn from the wells of that torpid locality. To us the huge, strange swamp itself was much less dismal and unpleasant than the half-tilled borderland of our own encampment." Another officer, who also served in this region, said: "One peculiarity of this swamp is its entire freedom from malaria. While on the open lands surrounding it ague and congestive fevers prevail, none has ever been known within it, although there are lumbermen now at work who have spent fifty years among its recesses. During the prevalence of yellow fever in Norfolk the swamp proved a safe retreat for hundreds of people. There is no doubt that the salubrity of the climate is due, in a great degree, to the balsamic nature of the principal trees with which this vast area was once entirely covered. The water of the lake and swamp is of the colour of sherry, and although perfectly quiescent it never stagnates, but remains perfectly pure and sweet. For a great many years the naval authorities at Gosport have been in the practice of filling the water-tanks of all vessels bound on long sea voyages with the juniper water, and the sailors have never known it to spoil." As further testimony to this "sweet water" Mr. Leavitt said that water taken from this swamp remained in a barrel for thirty years and at the end of that period was perfectly sweet and clear. It must be remembered that Virginia is "down South" and that during the summer months the climate is almost tropical. The Virginia Condensed Peat Company, reporting on this region, says: "Negroes have been known to live for years in the swamp enjoying excellent health and strength. The lumbermen are of opinion that the quantity of pine and other resinous trees that grow there impart a balsamic property to the water. This juniper water is sweet and healthy and used for all culinary purposes."

Rain or river water, when allowed to stagnate, becomes putrid. Not so with peat water, which possesses astringent antiseptic properties. Rosier observes that the air of peat-mosses is always salubrious; that by a wonderful provision of nature oxygen is exhaled and hydrogen absorbed; and, by reason of the low temperature of the moss, carbonic acid is not evolved, so that by this means the air is never infected with these deleterious gases. Other observers have remarked that though stagnant water in the fens, in warm weather especially, occasion intermittent diseases, no such ill effects are formed from peat water. The moors and mosses in Scotland and the turf-bogs in Ireland are inhabited by as healthy folk as any in the world. The red peat undulating bogs which form so remarkable a feature in the great central plain of Ireland, on which are found branches of fir, pine, oak, yew, and hazel, contain a good deal of iron deposited in a thin layer at the bottom. This metallic pan is known as bog-iron ore, and has its origin in the various heaths and heathers, which are said to contain a larger percentage of iron than any other plants. The peat, doubtless, owes its colour to this oxide of iron. The bogs of Scotland contain a very large proportion of turpentine from resinous plants, and, consequently, produce a fatter fuel than most other varieties. This remark applies also to Hatfield Chase, now worked by the British Moss Litter Company. The odour emitted by burning peat is occasioned by an essential oil, and is useful therefore for the lungs; indeed, there is a traditional opinion among the Irish that those who use peat are less liable to tuberculosis than others. The Scottish crofter, too, holds "peat reek" in high esteem for all diseases of the respiratory organs. Its antiseptic properties are abundantly proved by the high state of preservation of animal substances found submerged in bogs in various parts of the world, and the amount of resinous and vegetable matter in some peats, those especially in which bog oak and pine are found, apparently points to it as an excellent substance for tanning leather. The condition of preservation in which the remains of human beings and animals that have lain for centuries imbedded in peat is conclusive proof of its capacity of converting skins into leather, and of the presence of tannic acid. In *Philosophical Transactions* we find that the bodies of two persons buried in moist peat in Derbyshire, about a yard below the surface, on being brought to the surface showed no signs of decay, the colour of the skin being that of persons immediately after death, but slightly tanned. Professor Lyall says: "One interesting circumstance attending the history of peat mosses is the high state of preservation of animal substances buried in them for many years. In June, 1747, the body of a woman was found six feet deep in a peat moor in the Island of Axholm, Lincolnshire. Upon the feet were leather shoes or sandals, each cut out of a single piece of ox-hide folded about the foot and heel and piked with iron—such as are described by Chaucer as being worn in his time. This certainly afforded evidence of the corpse having been buried there for ages; yet the nails, hair, and skin are described as having shown hardly any marks of decay. In a turbary on the estate of the Earl of Moira, in Ireland, a human body was dug up, a foot deep in gravel, covered with eleven feet of peat; the body was completely clothed and the garments seemed all of hair. Before the use of wool in that country, the clothing of the inhabitants was made of hair, so that it would appear that this body had been buried at an early period, yet it was fresh and unimpaired. Dr. Rennie, in his essays, makes reference to several other instances of this kind, all tending to confirm the presence of gallic acid, which issued from the decaying wood. "Among other analogous facts," he writes, "we may mention that in digging a pit for a well near Dulverton, in Somersetshire, many pigs were found in various postures, still entire. Their shape was well preserved; the skin which retained the hair, a dry membraneous appearance. Their whole substance was converted into a white, friable, laminated, inodorous, and tasteless substance, but which, when

IN THE BATH—PREPARING FOR THE CLEANSING PROCESS. THE ATTENDANT IS ABOUT TO POUR WATER ON THE BATHER.

From Photos taken at Marienb

AN ARM BATH.

exposed to heat, emitted an odour precisely similar to broiled bacon."

Users of peat are not slow to admit its undeniable value as a disinfectant and deodorizer. In the United States, we are told, a famous "Chemical Deodorized Powder," which for fifteen years was extensively advertised and enjoyed an enormous sale, bringing in a rich harvest to the enterprising quack, was simply pulverized peat-charcoal put up for convenient use in neat, attractive packages. The advertisement ran thus: "Nature is ever true to herself. This preparation is the greatest absorbent of carbonic acid gas in Nature, and also of all those noxious and poisonous miasma which we generate in thickly populated districts from the decomposition of animal and vegetable substances. It is a great antiseptic, and will prevent the cholera and fever from entering your premises, as it absorbs all the noxious malaria which are so prevalent during the warm season. It is indispensable in the sick room and the sleeping room; a small quantity in an open vessel will keep the air pure and agreeable. It supersedes every other neutralizing substance, as it is entirely harmless and without odour of any kind. It is highly recommended by eminent chemists and medical men. It is really the abater of every nuisance." This statement was perfectly correct, for peat charcoal does possess the properties claimed.

THE PEAT BATH.

We are aware that various preparations of acid peat-tar have a marvellous effect in allaying the irritation caused by eczema, mosquito and gnat bites, in healing various skin diseases, and we are informed that they possess considerable efficacy in the treatment of the scalp: but most of our readers will possibly be surprised to learn that the medical faculty claims for this homely and somewhat unattractive substance curative properties in cases of chronic rheumatism, neurotic and muscular pains, gout, chronic stiffness of the joints, sciatica, the early stages of paralysis and locomotor ataxy, and in nervous disorders, also that it has a "champagne" stimulating effect on the circulation generally. Most of us who have done the "cure" at the much-frequented French, German, and Austrian spas must have noticed, if we have not actually experienced, the various mud-baths where this peculiar form of treatment forms a special feature that they are frequently attended with the best results.

The warmed substance in which the patients are immersed is not "moor earth" or soil, as it is called, but peat specially prepared. The peat-baths of the much-resorted-to Highland spa, Strathpeffer, within thirteen hours of London, are as efficacious as those of Bohemia or elsewhere. It is only at Franzenbad, Bohemia, that the peat is naturally saturated with waters from perennial warm mineral springs. At most of the spas the peat mull is carefully freed from all fibrous substance, and then, in a fine state of division, kneaded with mineral water, charged with carbonic acid, and heated by artificial means. At Dax, in the south of France, sea-weed and marine deposits are added with good effect, especially in the reduction of obesity, glandular swellings, and in promoting the resolution and absorption of the products of inflammation. The secret of success appears to lie in the maintenance for a lengthy period of an even given temperature. At Carlsbad, where 47,000 visitors congregate annually to "make the cure," the action of the peat is intensified by being worked up into the necessary consistency with the mineral water of the famous Sprudel spring, which has a temperature of 163·6 Fahr., and with this fortifying the action of the bath becomes so drastic that it is known as "the skin-eater."

We do not propose to enter minutely into any analytical disquisition on the comparative properties of the waters of the various home and continental spas, but we venture to submit that the ingredients found at Harrogate—where the bath equipments and buildings are the most perfect in the world—Buxton, Woodhall Spa, Leamington, Strathpeffer,

INTERIOR OF A BATH-ROOM AT KARLSBAD, WITH THE CLEANSING BATH ON THE LEFT, THE MUD BATH ON THE RIGHT.

and other localities, are of well-established efficacy in a wide range of diseases, and that those interested in those establishments will find to their advantage to utilize these curative waters in connection with the peat-bath. Our brine-baths at Droitwich, Nantwich, and Saltburn-by-the-Sea should adopt the salt mud-bath system now in vogue at Strömstad, Sweden, and as beds of rock-salt are now being systematically worked in the Carrickfergus district of Antrim there is no reason why Ireland should not have its brine-peat-baths. The once fashionable Lucan Spa may yet recover its *prestige.*

The nerve and pain-racked sufferer is advised to try the electro-peat-bath, which will be found not only palliative and curative, but restorative and invigorating. The potentialities of this electrical treatment, in conjunction with peat saturated with certain mineral waters at high temperatures, cannot, we submit, be overrated. The passage of a continuous current of electricity through the mass of peat not only generates heat but disintegrates and pulverizes the material. Electrodes are inserted at each end or side of the bath, to which are attached electric wires, and thus a well-regulated current is kept up during the patient's immersion. We would further suggest the heating of the bath, where an electric current is not to be recommended, on the principle of the light baths now installed by the King at Windsor Castle and at Buckingham Palace, the benefits derived from which are, we are informed, greatly appreciated by His Majesty. These are fitted internally with a series of electric bulbs capable of generating a temperature, inside the bath, of 170° Fahr.

An interesting description of the Continental mud-baths from the pen of Miss Mary Fermor appeared in the November, 1900, issue of *Pearson's Magazine,* and to the publishers of this communication we are indebted for the illustrations. These peat-baths are not inviting to look upon, but "handsome is that handsome does," and appearances are oft deceptive. This lady describes the sensation in language such as should tempt the invalid to yield his or her self to soft persuasion of these time-honoured healing agents. She writes:

"I went into the bath-room, the windows of which opened out on to a long corridor pervaded with a faint, boggy odour. I gave my instructions boldly in spite of my qualms about tasting forbidden fruit. The bath did not look at all tempting as it was rolled in by the man who had prepared the mixture, but I put my foot willingly into the bath and could not return. The other foot followed, and as I sank into the slimy compound and was comfortably settled I gave forth an involuntary cry of pleasure, the sensation was so delicious. Once the disagreeable feeling of having to get in was overcome, I felt a delight which continually increased at the enjoyable sensation of warmth, as my body became more and more impregnated with the moor.

"All my nerves tingled. I forgot to look at the sand-glass, and, instead of the twenty minutes prescribed—for my friends—I remained fully half-an-hour before ringing for the attendant to douse me with luke-warm water preparatory to stepping into the clean warm bath placed next to the moor one. I dressed quickly. I was all of a glow: a new life seemed born in me as I rapidly walked home—to rest. Every time I took a moor bath I enjoyed it more, and I went to Marienbad a third and a fourth time. The sensation in all three sister spas is to me pretty much the same, for whichever I patronise I have the same feeling of exaltation after the bath, and it is never followed by the prostration which I hear occurs in the majority of cases, and which renders absolute rest a necessity, for this rest brings one back to a normal condition."

PUBLIC MUD BATHS AT ST. AMAND-LES-EAUX.

CHAPTER XII.

RECLAMATION OF BOGS AND MOORS.

When a coal pit is exhausted it leaves nothing but long lines of underground burrowings, a gaping shaft, and a broken surface, often useless for cultivation. Not so with the cut-away peat bog. Mr. G. H. Kinahan, Vice-President of the Royal Geological Society of Ireland, points to how the Dutch in Friesland, Groningen, Derenth, and in numerous other localities, have shown the world what can be done with worked-out bog; and in France, in the vicinity of Amiens, we see fruitful orchards and gardens with a yearly rental of £5 and upwards (one-fifth of each acre is water) valued at over £160 an acre, on what a few years ago were swamps. This statement is fully confirmed by the late Mr. H. N. Jenkins, Secretary to the *Royal Agricultural Society of England.* As an instance of the cultivation of turf moors in olden times, the province of Groningen may be particularized. For centuries the vast moors originally in existence round the town of that name have been opened up to tillage, all the manure and sewage having been carried thither by the canal. The British Consul at Rotterdam, reporting to the Foreign Office, wrote: "Although the special advantages attaching to the mixture of litter and sewage appear to be so little recognized as yet, nevertheless we think that through this industry the grey turf moors have a great future before them. In 1889 the value of one hectare (fully two acres) of this kind of moor was £100, whilst only ten years previously the grey turf, being considered valueless, was ruthlessly cut up and thrown away, the object being to get the substrata of black turf. In the Netherlands, on granting a license to work a moor, the Government stipulates that within a certain number of years the soil must be fit either for agriculture or forestry. In Sweden over 600,000 acres of bog have been brought into cultivation in the Southern and Central provinces; and during the last half century increased and growing attention has been paid to the profits attainable from the Scandinavian peat bogs, both as regards their cultivation and the fuel obtainable from them. The Corporation of Manchester is rapidly reclaiming Carrington Moss, and the day will come when every acre of Chat Moss, of which this is but the tail end, will be one vast market garden. A waste, barren wilderness is being converted into a charming expanse of valuable farm and garden, every acre of which is indicative of fertility. Here may be seen a potato patch of 100 acres or more, whose leaves, flowers, and thriving condition betoken a heavy yield of sound tubers; there is a plantation of a dozen acres of birch, larch, rhododendron, Scotch and spruce fir, and sundry other growths, all of which thrive wonderfully. A big slice of moss which brought about 500 tons of excellent potatoes last year is now growing a promising crop of oats, with clover to follow. Mangolds, swedes, carrots, and cabbages all are full of promise. The development of Carrington Moss, covering about 1000 acres, originally cost the Corporation £38,000, a trifle over £34 an acre, and was first made productive by the judicious application of the refuse of the great manufacturing town; and this area, together with 2600 acres of Chat Moss, subsequently acquired from Sir Humphrey de Trafford, notorious as the largest and most treacherous of the country's wastes, is fast becoming one of the most fertile plains in Great Britain. In a paper read by Mr. J. Tissington Tatlow, of Schleswig-Holstein, before the Industrial Conference held with the Cork International Exhibition of 1902, some very interesting particulars are given of what on the Continent is known as Moorkulter. These are here reproduced *in extenso* from the Blue-Book. "The first person who achieved success in the cultivation of bogs in Germany was Hermann Rimpau, whose story reads like a fairy tale. Rimpau was the originator and inventor of what is called 'Moordammkultur,' by means of which, if properly applied to the right class of bog, it can be made to pay better than the richest land used for the culture of beets grown for the sugar industry of Germany. In the year 1849 Hermann purchased from the Baron Cunrau what is known as the Cunrau Moor for the sum of £18,000, of which he was only able to pay down £1000 in cash, giving security for the balance. In a few years, so great was his success, he was able to pay off the debt, and eventually realized a large fortune for himself. But where Rimpau succeeded many of his imitators failed, because they applied his methods cut and dry to their bogs without pausing to consider whether they were suitable. Rimpau bog was flat, and consisted of deep, well-decomposed stuff, extending down to the sand upon which the bog rested, and heavily charged with nitrogen. He drained this bog by means of a main drain, with others running at right angles; and from the bottoms of the draining he threw up sand, which he laid out upon the ridges. If lime is wanting when proceeding with the Rimpauische system, it must be artificially supplied together with potash and phosphoric acid, and thus a soil is made up which, mingling with the underneath decomposed stuff, produces the crops which made Hermann Rimpau's fortune, and gained for him the title of a benefactor of the German Empire. Authorities differ as to the requisite depth of decomposed nitrogeneous stuff which a bog should contain for agricultural purposes under the Rimpauische system, but the consensus of opinion seems to be 30 centimetres, or about 2½ feet English; if anything less than that the Rimpau system does not work, and the sand and chemicals only shut out the air from the soil, thus turning it into sour, poisonous stuff, strongly charged with saltpetre, in which nothing will grow." Mr.

Tatlow instances another brilliant example of this warping system in the case of the farm of Bokelholm, in Schleswig-Holstein. About twenty years ago the Government purchased this tract, consisting of 2000 acres of swampy bog. In twenty years it has been converted into a magnificent property, producing all classes of crops, with butter, cheese, bread, and turf factories. All classes of stock are reared on it, and the concern is a source of a rich return to the province. Dr. Dvorkovitz (see Appendix) mentions similar efforts on the part of Lord Longford and his enterprising agent, Colonel Clark, in Ireland.

It has been established beyond doubt that in parts of Great Britain and Ireland sugar beet richer in saccharine than that produced in any of the beet-sugar producing countries can be grown, and that here it yields a heavier crop per acre. It took many years to convince our farmers that any virtue lay in the field turnip; and as the sugar industry necessitates a heavy outlay in machinery and the constant presence of the chemical expert, it will probably be some time before conservative farmers can be induced to see any profit in this white beet. Such an industry can be successfully worked only by co-operation between the capitalist and the grower. The six continental countries interested in the growth and manufacture of this sugar produce annually about a million tons. Upon the Continent there are experimental stations for peat and bog culture. From such establishments, aided by the advice of the practical agricultural chemist, much good would assuredly result. The condition of forestry in the West Highlands and in Ireland is deplorable. Half a century ago Denmark found itself in a similar condition of surface nakedness. A society, commencing on a very limited scale, was formed, having for its object the re-afforestation of the kingdom, and it has achieved remarkable results, and a source of great wealth is being evolved from land which for centuries lay unproductive. Thousands of acres of waste land are now covered with fine timber, mainly spruce. Every year new tracts of land are planted, and in the course of half a century Denmark will boast immense forests sufficient to supply the country with all the wood it requires, and probably with a surplus for export.

Referring again to the important operations carried on by the Manchester Corporation, and the material advantage which the city has derived, and is deriving, from this great work as resulting from the acquisition of portions of Chat Moss as its natural deposit of its refuse. Thanks to the courtesy of the Cleansing Committee and of the Estates Sub-Committee of the Corporation, we are in a position to set before our readers a summary of these operations, together with some particulars of the financial results. Further, we add some extracts from *The Manchester Evening Chronicle* describing a visit of the Corporation to these properties.

CHAT MOSS ESTATE.

Situation.—The Chat Moss Estate is situate in the townships of Parton-on-Irwell and Irlam, Lancashire, and is distant from Manchester about 7 miles by road and 6½ by the Manchester Ship Canal, to which it has a frontage of 1½ miles.

Purchase and Development of the Estate.—The estate comprises 2579 acres, 3 roods, and 24 perches of land, and was purchased from Sir Humphrey de Trafford for the sum of £136,701 18s. 1d., with an additional sum for stamp duty and legal and surveyor's expenses of £1819 1s. 7d., making the total cost £138,520 19s. 8d., being an average price of £53 per acre. The purchase was agreed upon in June, 1893, and completed on August 2nd, 1895.

In addition to the amount required for the purchase of the estates, sanction was to be obtained for the borrowing of a sum of £55,000 for the works necessary in the development of the estate, for the building and repair of farmsteads, reconstruction of roads and drains, the provision of a wharf on the Ship Canal, and the construction of a light railway for the conveyance of manure to the tenants.

The amount expended to the 31st March, 1902, was as follows:—

	£	s.	d.
Farms, cottages, outbuildings. Sheds and water supply, - - -	£29,196	4	0
Loco. sheds, workshops, and stores, -	1,696	5	8
Boundary and partition fencing, - -	1,180	6	7
Pipe and field draining, - - -	4,522	5	2
Ditching, - - - - - - -	791	1	2
Road work, - - - - - -	575	6	5
Rolling stock, - - - - - -	4,239	3	9
Light railway, - - - - - -	7,966	4	6
Cutting and tunnel under Liverpool Road,	2,680	4	6
Construction of Boyshope basin and wall,	6,446	5	3
Cutting through Ship Canal bank, -	352	2	2
Contingencies, - - - - - -	394	12	2
	£60,040	1	4

(Excess of expenditure over borrowing powers paid out of money received for sale of Bridgewater Street land.)

Repayment of Borrowed Capital.—The repayment of amount borrowed for the purchase extends over 50 years from 1893, and the amount for works is repayable in 30 years from the date of borrowing.

Sinking Fund and Interest.—The amounts paid during the twelve months ending March 31st, 1902, were :—Sinking fund, £2642; and interest, £5229; total, £7871.

Division of the Estate.—The estate is divided as follows:—

	Acres.	1000 Parts of an acre.
54 Tenants occupy { Farm land, -	2,270	043
54 Tenants occupy { Moss land, -	106	478
Cottages, - - - - -	2	772
Raw moss, - - - - -	22	172
Plantations, - - - - -	54	343
Sludge, spoil banks, and old river bed,	32	219
Wharf and railway cutting, - -	5	676
Corporation depot, - - - -	2	969
Roads and light railway, - - -	82	999
Chief rents, - - - - -	0	231
Total, - - -	2575	902

Rents.—The rents received from all sources upon the estate for the twelve months ending March, 1902, amounted to £5081 6s. 5d.

Manure and Refuse disposed of.—The Boyshope wharf was first used for the reception of manure, etc., on the 14th December, 1898, and up to the 31st March, 1902, 208,349 tons of material have been received there and despatched by the light railway (of which there are about 10 miles) to various parts of the estate.

CARRINGTON ESTATE.

Situation.—The Carrington Estate is situate about 10 miles from Manchester in the parishes of Carrington and Dunham, Cheshire.

Purchase and Development.—The estate was purchased by the Corporation in 1886 from the trustees of Lord Stamford at a cost of £39,165 16s. 4d., inclusive of stamp duty and legal and other expenses. Since the date of purchase an additional sum of £43,976 12s. 8d. has been expended on capital account in the drainage on the land, formation and equipment of light railway, farm and other buildings, road, etc., making the total cost to the 31st March, 1902, £83,142 9s., and the City Surveyor's valuation of the estate on the 31st March, 1901, was £118,354 5s. 9d.

Repayment of Borrowed Capital.—The repayment of the amount borrowed for the purchase of the estate extends over 50 years from 1886, and the amount for works is repayable in 30 years from the dates of borrowing, which range from 1886 to 1891.

Sinking Fund and Interest.—The payments during the twelve months ending March 31st, 1902, were: Sinking Fund, £2025, and Interest, £1911; total, £3936.

Cultivation and Division of Estate.—At the time of purchase the estate comprised 600 acres of wild moss, plantations, etc., 209 acres of cultivated moss, 282 acres of agricultural land, and 10 acres of roads, etc.; or a total of 1101 acres.

Since the purchase of the estate the whole of the wild moss and the partially cultivated moss has been drained, delved, manured, and brought into a thorough state of cultivation.

The Parks and Cemeteries Committee have 58½ acres of the land as a nursery upon which they grow shrubs for the Manchester parks. The golden elder, rhododendron, privet, and poplar grow in perfection. Nurserymen and market gardeners occupy a considerable area, and grow shrubs and vegetables on an extensive scale.

The estate is now divided as follows:—

	A.	R.	P.
18 tenants occupy - - - - -	1012	3	8
Cottages, siding, and wharf, - - -	7	0	27
Land at wharf received from Ship Canal Co., not yet in full use, - - -	4	2	32
Roads and plantations, - - - -	75	3	21
Sand-hole, - - - - - -	0	3	18
	1101	1	26

Rents.—The rents received from the estate for the twelve months ending 31st March, 1902, amounted to £1986 5s. 8d.

Disposal of Refuse.—The manure and refuse is sent to the estate by the Ship Canal from the Committee's wharf at Water Street, Manchester, to their lay-bye at Carrington, and also from their dépôt, Gorton Lane, Ardwick, Manchester, to their railway sidings on the south side of the estate.

The quantity of manure and refuse sent to the estate during the 14 years ending March 31st, 1902, was 661,236 tons.

The manure and refuse, after being unloaded at either the lay-bye or railway siding, is despatched by the light railway to various parts of the estate and disposed of as manure to tenants, and the rough refuse utilized in the formation and repair of roads.

There are nearly 12 miles of light railway, and considerably more than this length of good roads upon the estate.

What has been done in and about Manchester can be equally well, and at less cost, carried out in Dublin, in the vicinity of which, on either side of the Grand Canal, there is an abundance of fine peat resting on limestone.

Extract from *The Manchester Evening Chronicle*, "The Development of Chat Moss—A Great Municipal Undertaking."

Three considerations combine to show the citizen that it was enlightened and salutary policy which directed the acquirement of the Moss, and to prove the wisdom and the forethought with which the estate has been managed for his communal good. It has relieved the cleansing authorities of the necessity of casting the rough refuse on the town tips, and being a menace to public health; it has opened up a fertile area, augmenting the sources of a cheap vegetable supply; and the rapidly improving letting value of the land establishes that it is a sound commercial investment. Beyond this, if he cares to give a passing thought to the subject otherwise than as it affects his material self, he may see an economic fitness in a great industrial centre drawing so much of its wealth from the natural products of the soil, giving back to the earth a quality of fertility which Nature had withheld for many a long century.

The history and the mystery of these mosses, of which there is an area of 20,000 acres in Lancashire, provide a theme of curious speculation and informing research. But our object is not to discuss their nature; it is to examine their use. If the purchase of Carrington was a profitable investment for our Corporation, how much more so does their more recent and more important venture, Chat Moss, promise to be? Whilst a visit to Carrington last week revealed how much had been accomplished by the Corporation, under the thoughtful direction of Mr. Councillor Richards (the Chairman of the Cleansing Committee) and

Alderham Grantham (the Chairman of the Estates Sub-Committee), aided by the able organizing abilities of Mr. R. D. Callison, the superintendent, and the sound agricultural knowledge of Mr. M'Connell, the farm bailiff—a visit to Chat Moss since discovers how great a work they have yet to undertake. To most people figures—outside their own personal business regard—do not constitute an excessively interesting study, but if the reader will bear with us a short while, it shall be made clear by their instrumentality how much more speedily the financial advantage to the city of the purchase of Chat Moss is likely to make itself manifest than was to be expected in the case of Carrington.

The Two Mosses: A Comparison.—When Carrington was purchased from the trustees of Lord Stamford eleven years ago, it was in the main an uncultivated and practically undrained waste of 1101 acres, and cost £38,000. The Corporation have since expended upon it in light railways, roads, drainage, rolling stock, buildings, and other ways, £60,000. They have been sending to the estate some 50,000 tons of refuse per annum. Last year the net cost of maintaining the estate, paying the interest and repaying the instalment of principal upon the loans was £2482. The receipts from rents last year were £1458, exclusive of the rent charged against the Corporation's farming operation of £933. Chat Moss, which is between two and three miles nearer Manchester—the nearest point of the estate being within seven miles of the city—consists of 2595 acres, and was purchased from Sir Humphrey de Trafford at a cost, with legal expenses, of £139,350 8s. 8d. This is £19 an acre more than was given for Carrington; but it has been under cultivation for 90 years, and when the leases expired in February of this year, and the Corporation took possession, they were in a position to re-let at £2 an acre. In the previous month Mr. Callison had presented to his committee a detailed report of proposed tenancies and rents, and upon this report he estimated the rents would amount in the aggregate to £4772 3s. 2d. The amount the department contemplated spending in wharves, roads, railways, homesteads, rolling stock, etc., was £55,000, making a total outlay of £200,000, to use round figures. The payment of the interest and instalment of loans would be £5960; so that there was a balance against the rents of only £1187 16s. 10d. The estate will require about 20 tons of manure per acre, and the tenants will buy this from the Committee at 1s. 3d. per ton, which represents a good profit to the Corporation. At Carrington, hitherto, the tenants have had what manure they required and paid nothing for it, excepting in their rent.

These figures, and the superior advantages the estate possesses, seem thoroughly to justify the expectation of the Committee that, when they have had Chat Moss as long as they have had Carrington, it will be worth more than double the price of the purchase money. The Committee have only had it in their possession six months, and that is but a short time in which to achieve much of the great work they have to do in developing and improving the estate. But already the entire face of the Moss has undergone remarkable alteration. It will be readily understood into what a dilapidated condition the estate had fallen. Nearly the whole of it was under 90 years leases, and the leaseholders had so neglected the buildings that, with a few exceptions, they were unfit for occupation, and the roads were in a deplorable state, and required re-making, levelling, and ballasting; the ditches (some of which had been in existence for nearly 100 years) needed thoroughly cleaning and reforming, and the fences were in an equally bad way. On every side tumble-down and old wooden shanties are coming down, and their places being taken by well-constructed and commodious brick homesteads.

The *Evening Chronicle* a week or so since investigated a complaint made that the Committee were dealing hardly with some of the tenants. That investigation, while revealing that the tenant in question was not in a position to receive as great an advantage from occupancy under the Committee as the terms of his lease had provided, showed a praiseworthy concern upon the part of the Corporation Department, to avoid driving any one off the estate who wished to remain there. This attitude they have universally adopted. They have refrained from turning away any tenant who wished to re-establish himself upon the Moss; but it was imperative that they should consolidate a number of the smaller farms, and in doing this they have succeeded in giving excellent new homesteads to a number of holdings, and in spite of that outlay, and notwithstanding the improvements which they will make to the estate to the direct benefit of each individual tenant, have been in a position to substantially reduce rents.

When the estate was let out 90 years ago on lease the rents were merely nominal, but subsequently the leases and interests were repeatedly sold, and, as a result, some of the small holdings were very heavily rented. In comparing the rents which were paid with the rents which the Corporation have fixed, we should say, without being able to exactly calculate it, that the Corporation is charging in the aggregate a less rental than was charged before, and is at the same time spending £21,500 on new homesteads and accessory buildings, and providing a very material saving to the tenant by bringing his manure to his farm at a third the cost to which he was put before, when he had to cart it by road from Manchester. This saving in the cost of manure alone represents a long way towards the payment of the rental. An incidental benefit which the estate derives from Corporation ownership is that it will secure a pure water supply. Twelve months before they came into actual possession, a mile of pipes to supply town water was put down. All the circumstances considered, the Committee are well entitled to claim they are both liberal and indulgent landlords, and under their management the estate, which has hitherto been highly productive, may be looked to yield to the tenants far heavier and more profitable crops. The land will be better drained, manure in sufficient quantities will be more accessible, the facilities for conveyance of produce to market greatly increased. The land is admirably adapted and easily worked under some of the most valuable vegetable crops. Celery does excellently, and in letting highly cultivated land of this description to the tenants at forty shillings or so per acre the Committee have displayed a liberal-minded spirit. The largest farm on the estate consists of 460 acres, and this brings in a rental of £2 per acre. The Committee are rebuilding or repairing 42 houses and outbuildings, at a cost of £21,500; they will spend £8000 on ten miles of light railway, £4000 in making and repairing the roads, £4000 in ditching and draining, £2700 in fencing, £2250 in locomotives and waggons, and £3650 in the construction of a dock at Bovsnope, in connecting the lay-bye with the Ship Canal, and providing engine-sheds, workshops, and other buildings at the wharf. The estate has a frontage of a mile and a quarter to the Ship Canal. The basin is being made out of the old river bed, and the wharf wall, which is 100 yards long, has already been built. In a month it is hoped the steam travelling crane, similar to that at Carrington, will be fixed and ready for work. The rails conveying the manure trucks from the basin to the estate, owing to obstacles placed in the way by the Parish Council, instead of crossing over the Liverpool Road, as originally intended by a bridge, will pass under by a tunnel. The Chat Moss and Carrington estates together have an area of 3700 acres, and will take all the rough refuse which the Committee have to dispose of in order to keep them under sound cultivation. This method of utilizing refuse is unquestionably the cheapest and the best in existence.

Thanks to the exertions of the National Potato Society, and the Exhibition which it recently organized at the Crystal Palace, considerable attention has been drawn in this country to the desirability of improving the yield and the immunity to disease of our most popular vegetable. The exertions of potato-growers are directed to two main objects—increasing the weight of edible tubers which a given acreage can produce, and making them proof against the onsets of the potato disease, which practically means the rotting caused by the fungus *Phytophthora infestans.* In a sense the two things are connected, because a potato which produces a heavy crop is usually also a hardy potato. An interesting piece of news was laid before the last meeting of the French Academy of Science. One of the great enemies of the ordinary potato is a wet summer, which lowers the vitality of the potato and enfeebles its resistance to the germs of disease, which are always waiting for an opportunity of seizing upon its plants. M. Labergerie, a well-known agriculturist of the Department of Vienne, in Central France, has been working for some time, by judicious selection, to produce a damp-proof potato. With the aid of a wild Uruguayan variety as the parent stock, he has succeeded in raising a potato which flourishes best in wet soil, where its yield is about six times that of the ordinary variety.

The normal yield of potato-growing land in these islands is between five and six tons to the acre; roughly speaking, we raise about three million tons annually on an area of 500,000 to 600,000 acres. Mr. Labergerie's new potato is said to produce about 36 tons to the acre in a damp soil, though in dry ground the yield is below the average. Analysis shows that its proportion of carbo-hydrates—in other words, its food value—is about normal. The great trouble of potato-growers in this country and Ireland is the excessive moisture which debilitates the crop, and if further experiments bear out M. Labergerie's statements his new potato should, for years to come, prove of incalculable benefit to the Sister Isle, where the bulk of the population is almost wholly dependent on this tuber for its daily food, and should invest damp, peaty soils with a greatly enhanced value. We commend the Labergerie potato to the Department of Agriculture for Ireland, and to the Congested Districts Boards of Scotland and Ireland.

A new class of market gardeners has sprung up in the fertile valley of the Avon, long noted for the excellence of its fruits and vegetables—a class which is determined to secure the market in London for early produce—such as lettuce, asparagus, and other crops—now held by the foreigner.

On the Continent these crops are largely grown under glass, with the result that they can be placed on the market when no English vegetables are to be had.

To study these methods a large party of gardeners will leave Evesham for Paris in January; and in order that the small growers may be in a position to make the journey a number of gentlemen of the neighbourhood have subscribed to a fund to defray a portion of the expenses.

An interesting experiment in co-operative organisation has been made by a number of fruit and vegetable growers in the Evesham district during the present year. A central depot, says *Country Life*, has been formed, to which the produce is sent, and the manager of this depot is in direct communication, by telegraph and telephone, with dealers in the great centres of population. Sales can thus be arranged for the Worcestershire produce at rates which, owing to the exclusion of several different middlemen's profits, will frequently bring a paying return to the growers where formerly the profit was not sufficient to cover the cost of picking and carriage. A weekly price-list is also sent out to shopkeepers all over the country, while efforts are also being made to develop a business with private consumers, boxes of fruit being sent to any address at rates which include carriage and delivery.

CHAPTER XIII.

HOW TO WORK A PEAT BOG.

THE systematic working of a peat-bog is best understood in the Netherlands, and lately some hundreds of Hollanders have been imported to work the moors at Thorne and Hatfield-Chase, near Doncaster, also on that part of Chat Moss acquired from the Astley Estates Company by the Corporation of Manchester. The Dutch peat-cutter has a deservedly high reputation for skill in this moist and not very interesting occupation, he having acquired proficiency from his forefathers in a land where, from earliest times, peat as fuel has been an article of prime necessity.

The treatment of wet, quaking bogs, lying on level ground, the subsoil of which is an impervious clay, must, of necessity, differ from that known as mountain bogs or such as are formed on undulating land, resting, in some instances, on granite. If these latter are not worked in a careful manner they may slide, doing enormous damage. Not long ago an avalanche of peat submerged a large area of land in the County of Kerry, Ireland.[1] One Sunday night "The Bog of the Mule," as it is interpreted in the Saxon language, suddenly got under weigh. It lay about fourteen miles from Killarney, on the Kenmore estate, at a height of about twelve hundred feet above the sea,—occupying a kind of table-land from which the ground slopes gently downwards to the south. It was about two hundred acres in extent, and had a maximum depth of about thirty feet. Accidents of the kind are by no means unprecedented; indeed, in some parts of

[1] Another and very serious bog-slide has just taken place in Roscommon.

RAISED GANTRIES FOR DRYING PEAT TURVES.

Ireland and Scotland they are far from uncommon. The wet bogs of these countries are especially liable to such mishaps; and even Chat Moss, in our own country, is accused by Leland of doing something of the kind about the year 1546. One at Enaghmore in Ireland did considerable mischief in January, 1853; and another at Dunmore in October, 1873, covered both houses and fields. In Sligo, in 1831, a bog burst after a sudden thaw of snow and swept on over the meadows like a torrent. Solway Moss also, in 1772, after heavy rains, is said to have swelled up almost like a bladder and then burst, the mud destroying several cottages and covering four hundred acres of land.

Injudiciously planned and constructed canals and drains, and a badly conceived system of working, may cast the Moss free from its moorings and induce it to slide, when the owners may find themselves landed in heavy damages for injury done to neighbouring proprietors. There is a great diversity in bogs and their contents owing mainly to the varying depressions in their beds, and the rain and snow fall. In boring for water in America, on Otter Creek flats, eighty feet of peat were pierced, and at seventy-two feet the drill struck a sound log of wood, the trunk of a former growth. On the summit of the Mansfield Mountains, New England, at an elevation of 4348 feet above sea level, beds of peat have been found with the sphagnous moss that produces them. Submerged deposits are existent on the sea-shore.

There is one difference between the ordinary Irish bog and those on the East coast, and inland to within a few miles of Doncaster, bordering the North Sea, which at once attracts the traveller's notice. The latter occupy the lowest ground, and their surface, allowing for chance vegetable, is a dead level. The former are by no means always thus situated, and the surface takes the form of an extremely flat dome—that is to say, it slopes very gently upwards towards the centre. Moreover, this surface often seems stronger and more tenacious than is sometimes the case in an undrained fen a considerable variety of plants are growing among and above the actual mosses, such as bog-myrtle, heaths, and heather, besides rushes and sedges, cotton and other grasses. In fact, the bog often seems to be enclosed in a rather tenacious envelope of skin, formed by the matted roots of these plants, together, sometimes, with the king and other ferns, and even sundry shrubs which love damp places. To the rupture of this envelope calamities such as that which has just occurred in the Killarney district are largely due. Heavy rain such as there was at the ill-fated spot referred to rapidly sink into the loose mass, which is gradually swollen by the water just as happens with a sponge, the outer envelope holding the whole together for a time. Meanwhile the coherency of the peat in the sodden mass is diminished; it continues to increase in volume, to become more fluid, and to press against the only thing which prevents it from spreading like a mass of "hasty pudding"—namely, the skin of growing vegetation. At last this retaining envelope bursts, and the semi-liquid peat flows in the direction of least resistance—that is down such slope as there may be. But since the surface of the bog, as already explained, may be higher than the ground at its margin, some movement may take place even in perfectly flat ground. It is evident that in the case of the bog of the Mule circumstances were very favourable to a flow of the mass when once rupture has taken place, even the black mud of some swollen Alpine torrents could hardly be a more merciless or deadly foe.

Before cutting, after surface uncovering, be commenced, whether for moss-litter or fuel, the bog must be well drained. If this be neglected the labour and cost of winning of the peat and its subsequent drying is very seriously increased. With every sod an amount of water far exceeding its own weight is raised to the surface, and this water must subsequently be got rid of. In moist climates and during wet summers artificial drying must of necessity be had recourse to. The surface must first be attacked by a series of shallow, narrow, sloping drains leading into larger ones, or canals, the process being gradual and progressive. The herring-bone system for these drains is in most instances the best and safest.

In these drainage operations we must bear in mind that it is necessary to leave the lower parts of the bog in a moist condition, so the artificial main drains must not be carried right down to the pan; indeed, in some deep bogs this cutting down to the substratum of clay, sand, gravel, or rock is impossible. In cutting the surface for litter the diggers seldom go lower than four feet, as at that depth the fibrous peat begins to merge into the darker coloured variety—that which has undergone decay. Those drains in wet bogs cannot be cut down to their projected depth at one operation, but must be deepened at intervals as the mass becomes drier and more consolidated. If this is not observed the sides of the drains are liable to cave in, rifts and flaws appearing in the peat, rendering the subsequent working more difficult. Ditches are run at about a distance of eleven yards from each other, all emptying themselves into a larger ditch communicating with a canal, through which the manufactured produce is conveyed to the nearest station or canal. These main ditches or canals are usually two hundred yards apart, and parallel to each other, so that no portion of the moor being worked is at a greater distance than one hundred yards from these main arteries. The configuration of Holland lends itself to this method of transport. There these leading canals communicate with the large canals and rivers, and so carriage is cheap by means of barges. Some of these barges are constructed to carry 200 tons, and reach Rotterdam and Antwerp in four or five days from the moors bordering on the "Zuid Willems Canal." "The importance of situation," reports our Consul, "is emphasized by the fact that whereas 50 per cent. of the selling price of the Northern moss litter represents freight, that from the South (the peat district bordering on North Brabant and Limburg) figures for only 20 per cent. of the price of the Southern product." This canal system is adaptable to many of the low-lying bogs of Ireland. In that country of all others, where the exorbitant cost of carriage weighs so ruinously on all industries, the question of locality and consequent cost of haulage should be very carefully considered by all intending to embark in the peat industry. Some years ago these "hasty pudding" formations were worked by flat-bottomed barges termed "scows," carrying a power-driven centrifugal pump that delivered the pulpy substance on to a drying bed formed on the surface of the bog. A somewhat similar process has lately been brought out by Mr. F. Schulke, of Hamburg, the salient feature of which is that after cleaning the peat to be operated upon from roots, gravel, or other foreign matters, it is liquefied by water and pumped several miles to the works through a pipe line; it is then leached and converted by heat and pressure into briquettes, at a cost of 8s. a ton, or into artificial coal, having a thermal value of 6250 calories, at a cost of 10s. per ton. It is understood that a large plant to work on a commercial scale is now being installed on the North Coast of Germany, but as to the practical value of the enterprise no exact information is at present obtainable.

The steam dredgers invented by Herr O. Fruling, of Brunswick, which, so far as regards Great Britain and its dependencies, is now the property of the British Dredging Company (Limited), promise to simplify the working of "quaking" and submerged bogs, and to facilitate, at a cost not exceeding 3d. per ton of spoil, the working of these deposits on a scale hitherto not dreamt of. The principle of this Fruhling system may be briefly described as a combination of mechanism in which mechanical attrition is successfully applied to heavier and more clay-like soils than it has hitherto been considered possible to deal with by suction. Dredging by suction is not new, and may be seen in operation in many of our harbours. It was brought into requisition for cutting the Suez Canal with economy and advantage. But the original type, Bazine's, of a centrifugal pump acting upon a suction pipe whose nozzle was placed close to the submerged sand, did not give satisfactory results when the bottom acted upon was more of a mud or clay deposit. This difficulty Herr Fruhling has overcome, and, as proved by the operations of the pioneer dredger, the "Nicolaus," in the Kiel Canal, efficient dredging can be carried on at any depth from 9 feet up to 47 feet at the rate of 1750 tons per hour. The Chief Engineer of the German Government shows the work done on the system of the Kiel Canal Company:—

"*Kiel,* 12*th March,* 1903.—*This is to certify that the dredger 'Nicolaus' in the Emperor William Canal, from the* 15*th October,* 1901, *to the* 1*st March,* 1903, *has dredged in* 700 *working hours* 1,350,000 *tons of sand, mud, and salt, and has transported and discharged this material for a distance of* 1·5 *miles in* 1450 *hours. The average cost of the above work (including transport) was three-fifths of a penny per ton.*"

The steam hopper in this instance was 155 feet long by 28 feet beam, but a vessel of such dimensions would not be necessary for working a bog and conveying the spoil to the bank. A remodelling of the lighter on a considerably reduced scale would be necessary, retaining the powerful centrifugal and Blake pumps and the 15¾ inch suction pipe. There is a contrivance by which the material in the holds or wells can be lifted by the suction pump and delivered on the banks or into the lighters. The dredger itself also is fitted with an elevator. An important feature is that the volume of water lifted with the dredged material can be regulated at will and limited to the minimum quantity; moreover, it is possible to work to a uniformly level bottom.

The special dredging apparatus consists of a dredging head-piece about 11½ feet wide. The forward or front part is in the form of a scoop or bucket having a cutting edge of several sharp prongs or points, which excavates the ground mechanically. The other or hindermost portion forms a chamber, well, or receiver, closed all round, into which the excavated material is pushed, and into which the necessary volume of water can also be admitted in adjustable proportions. The vessel being propelled by two powerful winches, the ground is cut or scooped out level to any required depth, the dredger head and its conduit, suspended from a crane fixed aloft on deck, being lowered or raised at will; the spoil is delivered by the powerful centrifugal pump making 200 revolutions a minute into barges and deposited on the bank. When excavating ground of such medium stiffness as would be found in a submerged peat bog, the dredger can be made to travel forward at a speed to enable the dredging head to cut just sufficient material. The dredging of the bottom is done in long strips 11 feet wide. This dredged material is atomized in a well or mixing chamber situate in the after part of the vessel, so that any lumps brought up by the prongs or points may be split up. The loosening is effected by means of water under pressure forced by a Blake pump. This piping system is very perfect, and can be made also to assist the cutting apparatus at will in loosening the ground when working in stiff, tenacious material. The crane can be used for lifting submerged trunks and roots of trees, such as are frequently found in peat bogs. The description of peat found in floating bogs is usually of excellent quality, and in North Germany is called baggertorf, or mud-peat.

In graving peat from the bog the surface layer of "ling," composed of earth and growing plants, such as heather, heaths, the cotton plant, etc., and their roots, is removed to the depth of six to nine inches. The "slane" is then brought into play. This digging implement is a peculiarly shaped spade fifteen inches long by four and a half wide, with a flange or wing on one side bent upwards at right angles to the blade. In Germany slanes with flanges on both sides of the cutter are employed. With this tool the peat is cut perpendicularly into long rectangular bricks or turves and laid on the bank in one operation. On the Continent four men work in each gang, one man cutting vertically from the top, the second following and dividing the turves as he goes along with a round-ended cutter of the "whale-spade" pattern. He is followed by a third with a four-pronged fork, the handle of which is bent upwards to an angle of 45 degrees, who lifts and removes the turves, the fourth hand laying them out in rows on the moor. One cubic metre of turf yields 400 of these sods. Women, after the turves have lain some time on the surface and, weather permitting, are partially dried, "up end" them, each turf leaning against the other so that they may be exposed to the action of sun and air. During a dry summer the turves will dry down to a water content of about 30 per cent., as stated above, by which time they will have shrunk to about a quarter of their original dimensions. Under the best conditions, viz. bright sun, a high, dry temperature, and a strong wind, a wall of peat turves, each turf from 1½ to 2 inches thick, will evaporate from the original 80 per cent. of moisture down to 45 per cent. in about 2½ hours. It is worthy of note that while a layer of excavated peat lying on the surface of a bog is evaporated down to 45 per cent. in this short time, a similar layer spread on a raised dry surface, with the current of air circulating below it, the moisture will be evaporated down to 35 per cent., thus proving that while the upper portion of the layer lying on the bog is losing moisture the lower portion in contact with the bog is, by capillary action, drawing moisture from the damp bog below. This circumstance points to the necessity of drying peat on elevated platforms as adopted by the Scottish Peat Industries at Racks. A good dry wind such as we have in March has more influence than the sun. Having got rid of much of the moisture after several days' weathering—peat turves as a rule retain 35 per cent. of hygroscopic moisture—and have acquired some consistency, they are piled or cobbled up into loosely built pyramids so disposed as to admit a free circulation of air. These pyramids are generally 6 feet long by 3 feet broad and 6 feet high, representing 3 cubic metres of peat or 1200 turves. Having remained some weeks in the pyramid they are then stacked for use. These turves as originally cut—much depends on the condition and drainage of the bog—weigh from 12 to 25 pounds each. It is said that an Irishman used to handle the slane, and working with a will—such men are few and far between—cut out 25 or more peats a minute. When working by the "job" he will cut 22, and when "by the day" the output dwindles down to 15 of only 15 pounds each. The result is 225 wet turves per minute, and consequently 62½ tons in a working day of 10 hours. The writer has not met the man capable of keeping slogging at such break-back work for such a length of time. Mr. B. H. Paul, who published a paper on the "Utilisation of Peat" in the *Journal of the Society of Arts*, asserts that two men working together, one cutting and the other casting the peat, will in good weather get through what is equivalent to 10 tons of dried peat; so that if they were able to work every day during May they would cut and cast from 200 to 300 tons of peat in the month, and that to win 10,000 tons, cut and spread, the services of 100 men would be required.

The mountain peats of Scotland and Ireland being more uniform in texture and character, better naturally drained, and, therefore, more consolidated than the wet quaking bogs, are more easily worked. This mountain peat weighs from 53 to 78 pounds the cubic foot, and, when dry and compressed, has a density greater than water and takes a high polish. These mountain deposits are seldom of great depth, averaging 2 to 12 feet. The method of graving peat in the Highlands differs from that in vogue on lowland bogs. After removing the surface sod and heather, the peat cutter digs out turves a foot square and three or four inches thick, using a peculiar shaped tool for the purpose. These large flat slices are then spread out on the ground to cure and dry, the process from the nature of the material being more speedily accomplished than is the case with other peat. These are then set up on edge, and are dry and fit for the stack in from six weeks to two months. The surface of the turves acquires a kind of skin, something like a dark coloured gold-beater's skin, which is nearly if not quite water-proof. In the Hebrides and Western Islands of Scotland, where there is a large extent of excellent peat, and where rain is very frequent, even in the summer months, artificial drying must be had recourse to; but as the bye-products of these peats are more than usually valuable this extra expense need not be seriously considered, as with an efficient system, bottom peat is, of all materials, the best able to bear this expense, for it provides its own fuel on the spot at prime cost price.

Several attempts have been made in the past to substitute machinery for hand labour in cutting bogs. In North Prussia Brosowky's Peat-Cutting Machine was in much request, and thirteen thousand of these implements were at work in Mecklenburg and Pomerania within three years of its introduction. It had the advantage of being able to raise peat from below the surface of the water, thus, in some cases, rendering drainage unnecessary. It consisted of a rectangular casing made like the four sides of a box, but with oblique lower edges, which, by its own weight, and by means of a crank and a rack-work operated by hand, was forced down to various depths. Having penetrated to the desired depth a spade-like blade, acting horizontally, was driven under the cutter by means of levers thus releasing a solid parallelopipedon of peat. By reversing the crank-motion this mass, a block of ten feet or more in length and twenty four by twenty eight inches in other dimensions, was lifted out from the bog. Each of these blocks made one hundred and forty-four sods, enabling four hands to lay out twelve thousand turves, or 3100 cubic feet daily. This machine could only cut at the edge or on the perpendicular face of an excavation. The Mecklenburg moors are now traversed by canals cut by this mechanical graver.

In Canada, where labour is scarce and costly, and where there is no demand for Moss-Litter, after the surface of the bog has been drained and levelled, a mechanical excavator—the Dobson—is used. This implement, actuated by electricity, travels slowly up and down both sides of the area under removal, the excavator or slicer working against the side or perpendicular face of the ditch. It consists of a platform 7 feet wide by 10 feet long, mounted on four wood-faced wheels, the front pair being the drivers and measuring 33 inches in diameter and 18 inches face, and the rear wheels being

22 inches in diameter and 18 inches face. The great width of the tyre is designed to meet the softness and the yielding nature of the bog surface. A barrel-shaped wheel would be an improvement. A 10 H.P. electric motor operates, by belting and gear wheels, all the machinery, at the same time propelling the carriage forward at the desired speed. Overhanging the cutting on the bog, on the right-hand side of the machine, is the excavating and elevating mechanism, which is an endless chain, armed along its lower surface with alternating cutting teeth and sharp-edged plates, somewhat on the principle of the dredger. This armed chain, which can be raised or lowered according to the depth of the cut to be made, the maximum depth being 4 feet, travels in a vertical plane down the outside and up the inside of the elevator box, serving the double purpose of scraping off a thin slice of peat and elevating it to a conveyer running across the front of the carriage. At the opposite side of the distributor a partially hooded paddle wheel, revolving at a high speed, catches the stream of wet-peat fragments, showering them broadcast over the surface of the bog to a distance of 30 to 50 feet. Each such distribution leaves a deposit about half an inch thick, consisting of finely divided fragments, in excellent condition, to be dried by sun and wind. A steering gear is provided. The machine travels at the rate of 3 to 3·5 feet per minute, excavating about 4500 cubic feet in a day of 10 hours. Heavy insulated transmission wires trail on the bog behind the carriage, conveying the electric current to the motor.

The most primitive method of working a moor for Litter is that practised in North-west Germany, where, on the higher-lying moors, after the ling and heather has been burnt off, the surface is ploughed up and harrowed in the autumn. In the following spring, when the surface, from the action of the March winds, is sufficiently dry to be workable, it is again harrowed and thrown into heaps. This process of harrowing is repeated as often as the weather permits. The method is simple and inexpensive, but has brought much discredit on imported litter, for this bedding, though useful on the farm where live stock is ripening for the shambles, it is too full of mull and earthy matter to be marketable. A somewhat similar process is in vogue on the Canadian mosses, where the object is fuel and not litter.

The writer has invented two "knifing" or cutting implements, either of which, as a labour-saving machine, in his opinion, may be found useful. Both are impelled either by an auto-motor or by electricity, or by a small portable engine fitted with winding drum and steel rope, as in steam ploughs and cultivating tackle. At a late trial at Biggleswade the Ivel agricultural motor, with a three-furrow plough, turned over 5 acres 4 poles in 8 hours 24 minutes at a consumption of 11½ gallons of petrol, which works out at 2 gallons 1 quart per acre. In one of these turf-cutters the framework of mild steel is mounted on hollow barrel-shaped wheels, the ends being closed to permit of their travelling over the surface of the bog. The knives are so arranged that they cut several parallel strips of turf, each of the required width and thickness, both vertically and horizontally, in such a manner that each layer lies in its own original bed, but completely severed one from the other, and from the bog. The number of these continuous strips or ribbons, running the whole length of the surface operated upon, is regulated by the width of the machine and the motive power employed; but as a rule a foot in width, and three to four inches in depth, will be found sufficient. Thus a six-foot implement will cut six strips and from three to four layers at one operation. The knives can be arranged to cut any desired width and depth. By shifting the anchors and pulleys, an operation of a few minutes, and by substituting a different pattern of knife, the implement, then crossing the surface so treated, cuts these long strips into turves of any length, when they can be lifted out rapidly by the fork; or, if preferred, these turves can be severed by hand. This operation, by severing the fibres of the peat, even if the turf be left for a time *in situ*, greatly facilitates drainage.

The other implement is an application of the ordinary hand-cutting spade used in skinning and lifting turves on pastures for laying down for lawns and grass plots. It has one or more sharp-edged winged shovels fixed to the frame at an obtuse angle, the gradual slope or incline being from the front towards the rear of the implement. On either side of the cutting edge of each shovel are two sharp-edged steel revolving discs, which, as they advance, sever the sides of the turf. By this means a continuous strip of turf is released, which, seized by an endless band fitted with a series of revolving spiked rollers travelling over the upper face of the shovel, carries the turf upwards and backwards along and up the inclined plane till, on reaching the back edge of the channel, it falls over and on to the surface of the moor, breaking as it falls. If uniformity of length be desired, a revolving blade, as in the case of the chaff-cutter and brick machine, is so placed that the strip of turf is automatically severed into lengths as it leaves the channel. The shovel or shovels, with their revolving disc cutters, can be regulated to cut to various depths as desired. By this means turves up to six inches of thickness can be raised. The cutters are interchangeable, and can be removed to be sharpened. A man, riding as is usual with steam cultivators, steers the implement. The frame is carried on barrel-shaped wheels of peculiar construction.

In the United States, where there is an abundance of peat, the clam-claw dredger has been used with effect. An improvement on this is the Hone-Tyne-Grab, and, where extensive operations are contemplated, will be found most efficient and labour saving. It is manufactured by the Thames Iron Works and Shipbuilding Company. This grab has been used for dealing with vestry, town, and market rubbish. The powerful blades can be made with cutting edges capable of severing fibrous peat and of tearing it from its bed. A grab of 4 feet by 3 feet and a half, when closed, weighing 16 hundred-weights, can excavate 18 cubic feet per hour. Its cost is £93. To this the cost of the crane must be added. As some of the water in the peat is got rid of in the process of grabbing and lifting by the powerful pressure on the material, a 3 to 5-ton locomotive crane should suffice. The former is equal to a lift of 3 tons at a 16 feet radius, and travels upon rails of 4 feet 8½ inches gauge. The cranes are fitted with steam-lifting, lowering, and propelling jib-adjustment and gear. They can be turned in any direction whilst raising or lowering the load, without stopping or reversing the engine, and all hand levers are placed in a position to be easily manipulated, while the driver has a clear view of his work. The makers claim that these grabs reduce labour about 35 per cent. Such a weighty mechanical digger or sapper can only be used on consolidated bogs. It will be found most useful in forming and deepening canals and drains, in raising submerged peat, and in warping operations. In a peat factory, whether for fuel or litter, the crane will always be found handy.

In the Netherlands, after digging the canals and drains, the following plan of working the bogs is sometimes adopted:

The upper crust of ground is first broken up, and, when in the spring it has somewhat dried up, the whole surface is burnt through the following process. A few bits of dry turf are placed on an iron basket at the end of a long pole, and then lighted. This basket is held on high, and, through the action of the wind, some bits of smouldering turf are blown over the ground and set fire to it. As soon as the basket is nearly empty, it is refilled and the same process repeated. With a fairly good blaze the whole field is soon a smouldering mass, occasioning that irritating smoke which, in the

Macpherson's heather-burner will be found useful for this purpose. It is simple, effective and cheap.

spring, pretty nearly covers the whole of the country, and is known as "turf fire." The smouldering mass extinguishes itself, as the ground is covered with only a small crust, beneath which the soil is very wet, but a small layer of ashes is left behind which serves as manure for the crop of buckwheat about to be sown. The sowing and harvesting of the crop do not differ from the processes adapted as regards cultivation on sandy soil, excepting that in the carrying due attention must be given to the softness of the ground; and with this view the carts are provided with broad-tyre wheels, and the horses have broad bits of woods attached to their feet. This process of cultivation can be carried on for six succeeding years, the ground being annually burned, after which period, the humus being exhausted from which the manure was obtained, it would not pay to raise any further crop. It is then that preparations are made for the digging up of what is called the "grey turf," the leading element of the peat-moss industry.

In order to work a wet, floating or submerged bog, it is obvious that dredging or pumping by the centrifugal chain disc pump, or raising by means of the dredger or grab, must be resorted to. Here the peat is found in a more or less coherent condition, or in the form of paste or mud. The following method was in vogue some years ago on the Continent; but probably the grab just described, especially when fibrous peat is met with, worked from a flat-bottomed lighter or scow, from a pontoon or raft, would prove vastly superior to the make-shift here referred to by Professor Johnson. In such a case the peat is dredged from the bottom of the bog by means of an iron scoop, like a pail with sharp edges fastened to a long handle. The bottom is made of coarse sacking, so that the water may run off. Sometimes a stout ring of iron, with a bag attached, is employed in the same way. The fine peat is emptied from the dredge upon the ground, where it remains until the water has been absorbed or has evaporated so far as to leave the mass somewhat firm and elastic. In the meantime a drying bed is prepared by smoothing, and, if needful, stamping a sufficient space of ground, and enclosing it in boards fourteen inches wide set on edge. In this bed the partially dried peat is thrown, and, as it cracks on the surface by drying, it is compressed by blows with a heavy mallet or flail, or by treading it with flat boards attached to the feet, something like snowshoes. By this treatment the mass is reduced to a continuous sheet of less than one-half its first thickness, and becomes so firm that a man's step makes little impression on it. The boards are now removed, and it is cut into blocks by means of a very sharp, thin spade. Every other block being lifted out and placed crossways on those remaining, air is admitted to the whole and drying goes on rapidly. Here the construction of the pulp bed is faulty, for no provision is made for drainage. Surely the modern pug-mill would do all the kneading necessary at a fraction of the cost and in much less time.

Mr. James Hodges of Montreal conceived the idea of a complete floating manufactory constructed to excavate, pulp, dry, and manufacture. His *modus operandi* was to select an extensive undrained bog, from eight to twelve feet deep—or, if deeper, the better—and to trace out, at some distance from its margin, a contour level line of, say, several miles in extent. Along this line a space or strip of some nineteen feet in width was cleared, and the live moss or turf entirely removed. By the side of this uncovering a space of ninety feet in width was cleared and drained to receive the pulped peat. At one end of the nineteen feet canal a barge or scow, 81 feet long 16 feet beam and 6 feet deep, was constructed and launched into a hole or bay in the bog dug to receive her. This barge contained all the machinery necessary for the complete manufacture of the peat. At one end of the scow were placed a pair of large screw augurs eleven feet in diameter, which, provided with suitable shafting and gearing, were caused to revolve by an engine placed in the stern of the vessel. These augurs or screw elevators bored out the peat in precisely the same manner that a common augur bores out wood. In this way a canal nineteen feet wide, and from four to six feet deep, was cut as the scow progressed, the water draining from the adjacent pulp bed filling the canal as fast (?) as it is excavated. The speed at which the scow advances is about fifteen feet an hour. A competent engineer should determine and lay out the canal level as well as arrange its water-supply, for upon this greatly depends the successful working of the whole.

The peat when bored out or excavated by the screws is delivered into the well of the barge and conveyed from thence by means of an elevator to a hopper, into which it is tumbled. It then passes through machinery, which, removing all sticks and roots and thoroughly destroying the fibre, reduces the peat to a homogeneous mass of soft, pulp-like, well-tempered mortar. This pulp is then passed into a long spout or distributer, which, extending at right angles over the side of the scow, spreads out the pulp upon the levelled strip of moss bordering the canal in a thin slab nine inches thick and ninety feet wide. After the slab of pulp has been deposited for a couple of days, or in the hot weather a shorter period, it begins to consolidate and shows symptoms of cracking. Immediately any cracks make their appearance the surface is marked out by drawing a framework, carrying curved knives placed six inches apart, across it. A few days' more exposure hardens the pulp so that, by the aid of boards, a man can walk on and mark it longitudinally with cuts eighteen inches apart. In about a fortnight the shrinkage of the pulp slab causes the cuts made in it to gape open and the whole presents the appearance of an immense floor covered with bricks eighteen inches long and six inches wide. As soon as the bricks are sufficiently hard to bear handling they are separated and "footed," that is stood up on end, five in a stook with one across the top, in which position they remain until dry enough to be removed to the store or market.

In the preparation of the pulp-bed great care should be taken, and the surface obtained must be as level as possible. The roots of all trees are carefully removed. The long grass, shrubs, and rank mosses are cut down with a short scythe and are used to fill up any irregularities on the surface. Drains from nine to twelve inches deep are cut leading into the canal and are filled up with brush-wood or any open material and covered by a fibrous inverted turf. The soft pulp, when poured upon this drying bed in a semi-fluid condition, advances, lava-like, covering the whole surface. The pulp should not be deposited nearer than five feet off the canal and upon this space or bank may be shot any surplus moss or turf from the uncovering of the canal track. A double thickness of turves is all that is necessary to complete the sides and divisions of the pulp-bed.

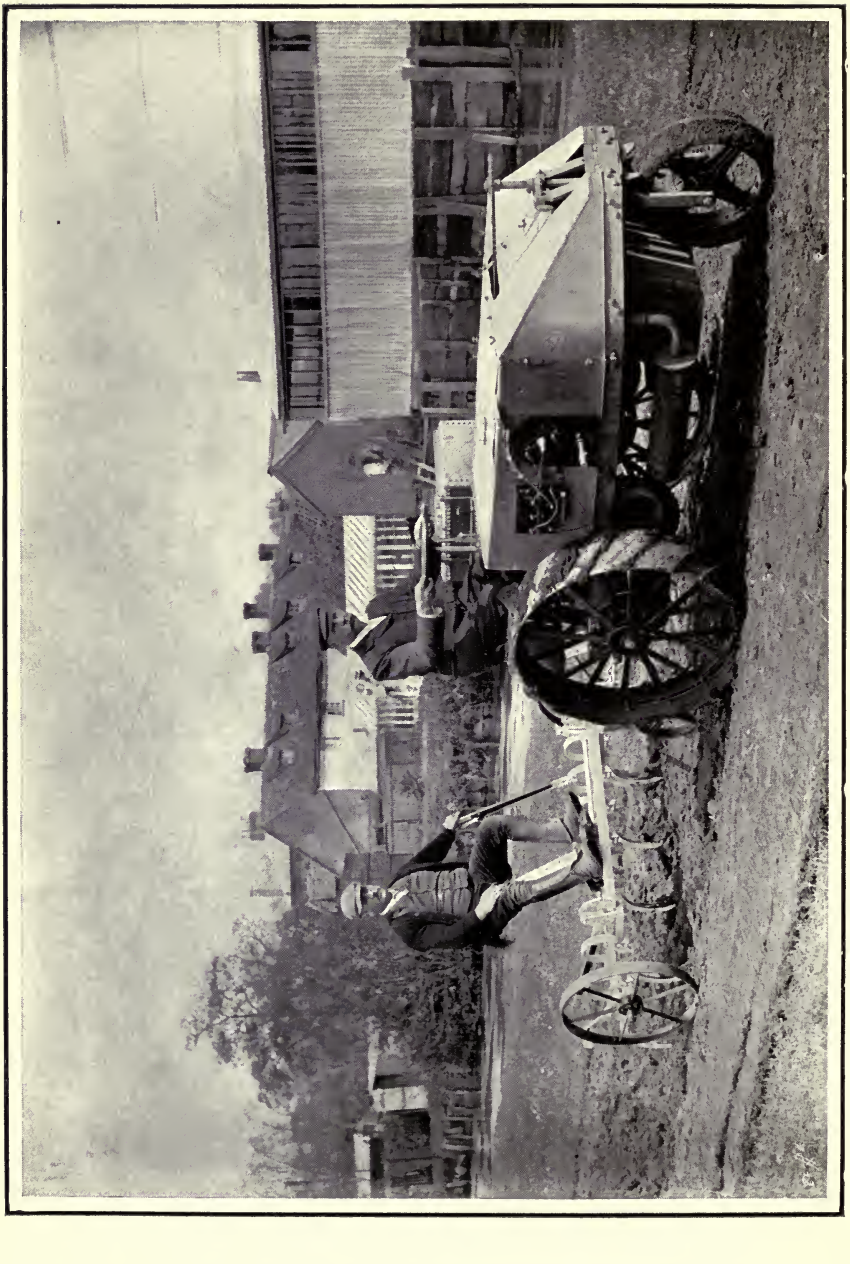
The canal track and pulp-bed having been prepared, and the scow with its machinery in position, nothing more is required than to set it in motion. As each revolution excavates from one and a half to three inches, the augurs must he kept up to the face of the peat by hand on a cable anchored on a head, so as to preserve a continuous feed. As the screws revolve they cut off continuous slices of the peat, which, by the assistance of a couple of men, are delivered, through the rear of the casing the screw works in, into a well in the bow of the scow. These men also remove any large masses of foreign material coming to the surface, such as pieces of wood, roots of trees, etc. Some bogs are full of roots. After the peat has reached the well it is carried to the hopper by means of an endless elevator, from which it passes through a stick and fibre-catcher, on to the pulping and distributing trough or spout. If the pulp be too stiff or dry a pump is turned on until it is reduced to the proper liquid consistency. The levelling of the pulp should be attended to. A few days' experience will enable any intelligent man to accomplish this ; and upon its being well done depends, in some measure, the quality of the skin of the peat, so essential, not only in shedding the rain and preventing cracking from the sun, but also for giving permanent toughness to the bricks. The marking of the pulp beds in transverse cuts at six-inch intervals is proceeded with as soon as the pulp begins to set, or becomes so tough that when the incisions are made in it by the knives the blocks do not reunite. The operation is performed by two men, one at each end of the pulp bed, who, by means of a rope, pull a frame-work of wood carrying curved knives too and fro across the bed. A little practice causes the work to be performed with great accuracy. The longitudinal cuts, eighteen inches apart, are made as soon as the pulp is firm enough to bear the weight of a man upon a plank laid on the surface, the implement used being a disc-cutter, something like the circular saw, which severs the pulp right down to the bed. The "footing" is done by gangs of men and boys, one man and three boys working together—the man to separate the bricks, the boys to upend them in groups of five as already explained. In footing and turning, two boys can handle four thousand in a day.

The crew of the scow all told numbers six hands, including the "skipper," who keeps the knives of the scow excavator clean and sees that all is going right, two men to the excavators, one engine-man, one man leading and levelling the pulp, and one man to attend to the stick-catcher and pulp-flow spout.

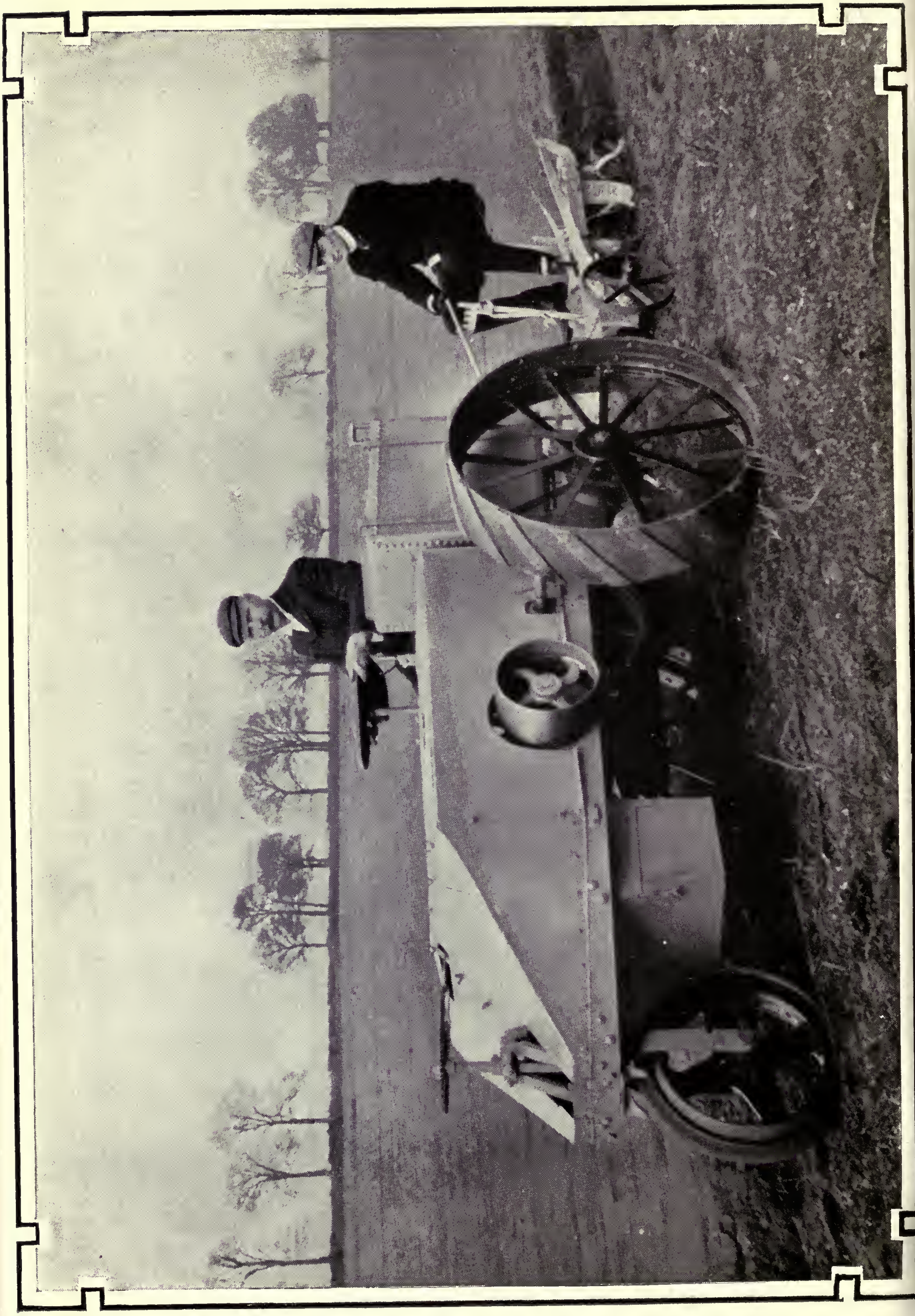
In working mountain deposits the main difficulty lies in the conveyance of the manufactured article to the nearest railway, canal or tramway. The aerial ropeway system solves this difficulty better than any other method, and will be found the most convenient and economical means of transporting litter, fuel, or the bye-products of peat even, over somewhat long distances. Roe & Bedlington's systems, manufactured by the Ropeways Syndicate, 30 St. Mary Axe, London, E.C., possesses many advantages. Aerial ropeways have no regard for irregularities of ground, as they span rivers and valleys, cross railways and roads, and go over hills and ravines in a manner impossible by any other existing method of transport. Nor are their advantages confined to hilly districts, as they compare favourably with light railways on easy ground, and also with traction engines, without their great disadvantage of damage to roads, and the attendant constant squabbles with local authorities with regard to repairs; while, naturally, the costs of haulage by this means are far below those of the primitive method of carting. They are also valuable as auxiliaries or feeders to establish means of communication, as well as in localities where the daily output to be transported would not warrant railways or trams. Another important feature is the fact that where the gradient in favour of the load is sufficient they become self-acting; the descending loaded buckets not only giving sufficient power to haul up the empties, but leaving a surplus energy available for other purposes. As an instance of the ease with which these suspended lines work, an installation 2830 metres long, conveying 40 tons with a mean grade of 1 in 22, or 4½ per cent., is self-acting with a small amount of spare power. By this system 2 to 70 tons per hour can be transported, the weight of each individual load being from 2½ to 10 cwt., though, by special arrangements, heavier loads can be carried, and the suspended carriers or receptacles may be designed for any material. Various modifications of the system can be arranged to meet special requirements with regard to loading and unloading, and the unloading station can be designed for dumping into railway trucks or canal boats, or into shoots for feeding mills. Some of the spans between the trestles or supports are as much as 2000 feet clear. The loads automatically take on and leave the cable at the stations without any separate coupling operations. With regard to that important item, haulage costs, these depend upon the capacity of the line, heavy installations being more favourable in this respect than the lighter ropeways. An example of this system is to be seen at work at Bellinhassig station on the Cork, Bandon and South Coast Railway, the cable of which is four miles long, with a capacity of 10 tons per hour, and this works at just over 1d. per ton per mile. The Gowrie and Blockhouse Collieries (Limited), at their mines, Port Morien, Cape Breton, despatched 100 buckets per hour from the pithead to the shipping pier. At the Dalbeattie Granite Works, N.B., 200 tons of crushed granite pass over one of these ropeways every day, a distance of half a mile.

For centuries, both at home and abroad, the windmill has played a leading part in the drainage of morasses and bogs, and now that those wind engines are being treated scientifically there is every probability of the theory being converted into fact, and of their being employed over a larger field of usefulness. So far they have been constructed empirically, but the late important trials of wind-pumping engines instituted by the Royal Agricultural Society in its Show Yard have directed the attention of the engineer to these little understood sources of motor-power. Though one Canadian firm of builders had an exhibit, America was unrepresented at this trial, and this is to be regretted, for in the United States the wind-engine is in far more general use than in this country. American builders have arrived at a standard type, though we cannot say for certain that this type, the outcome of gradual evolution, is the best or incapable of improvement. Many questions regarding the shape and number of the sails, whether they are best tapered or twisted, their relative position one to the other, the angle at which they should be set, their width, the method of self-governing, steady running, change of pressure, speed, ease of arrangement and maintenance, size as relative to power, stability of tower, and other important points present themselves, and will, let us hope, be clearly answered. Though never so efficient as a well-planned system of drainage, the self-governed wind-engine, running night and day, will be found to be an economical and effective adjunct for keeping the water in a bog down to the desired level, and in many ways may be turned

We have lately seen a working model of an air-motor on an entirely new principle promising to revolutionize this economical method of obtaining power.



"IVEL" MOTOR PLOUGH.



to good account in a peat factory. "Let man invent, scheme and drive, but let wind, the forerunner of Nature, do the toil."

The elevators and spiral conveyers manufactured by the Conveyor and Elevator Company of Accrington will be found very efficient in carrying peat in any form as graved from the bog to the hopper of the briquette or moss-litter mill. The steel-chain push-plate conveyers are best adapted for the rapid and continuous delivery of turves and briquettes to the stack, or of peat-bricks to the clamp or kiln.

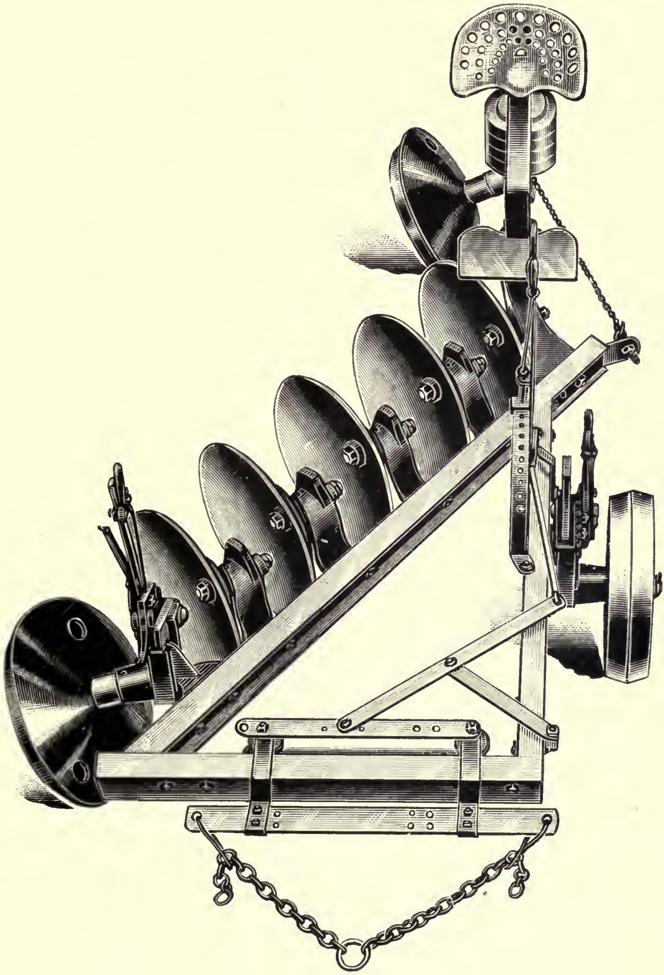
One of the phenomena of latter-day industrial development, and an outcome of the remarkable growth of the motor innovation, a remarkable departure seriously challenging the empire of the horse in the field of agriculture, and destined to revolutionize our system of tillage, is found in the *Ivel Agricultural Motor*. This novel invention and application of the portable petrol motor, though it has been designed mainly for farm work to haul ploughs, cultivators, reapers, and all the field implements, as well as to actuate the machinery of the rick-yard and the barn, we propose to harness to the various labour-saving devices of the peat moor and the peat factory, and also to utilize it as a force for the traction of the broad-wheeled waggons over the surface of the moss and on the road. We are second to none in our love of the horse, in our appreciation of his usefulness, and in our admiration of his picturesque symmetry and beauty; we regret his decadence, but we are reluctantly compelled to put sentiment on one side and to accept the inevitable. Agriculture cannot be conducted on sentimental lines. Successful farming in our fickle and often "juicy" climate means the carrying out of field operations in the shortest possible space of time, and this is doubly true when a sponge-like material such as peat, stubborn in its retention of moisture, has to be dealt with. Save on the best drained and most consolidated bogs horses, even when their feet are armed with pattens or broad boots, are useless, or at least over-taxed.

To plough an acre of land the horse has to traverse fourteen miles, and with such a surface to plod over the work, always slow—the man at the tail of the implement, to save his own legs, sees carefully to that—is slower still. On heavy land with most teams half an acre to three-quarters of an acre in a day is about all that the modern ploughman gets over. It is true that the motor requires occasional repairs, and that there is not so much difference in the upkeep as the *Car* and other journals devoted to this industry would have us believe; it is a fact also that the agricultural tractor has sometimes, like the horse, to go into hospital; but no "spares" are required, there are no epidemics of influenza or pink-eye; and when the cost and amount of work got through are compared, to say nothing of the quality and reliability, the machine is, from a commercial point of view, much to be preferred. The initial expenditure is a serious item, but then the equipment of a farm with suitable horse-power must always be provided for. If the motor falls lame it can be restored to absolute soundness, it does not suffer from musty oats or mow-burnt hay, it is not pricked in the shoeing, it does not suffer from gripes or inflammatory attacks; it is, if kept in proper repair, always ready for continuous work in all weathers, and need never be idle; when idle it needs no corn and no attendance. The tractor here depicted at rest and at work is supplied with a 14 H.P., governed, double-cylinder motor of a special construction. The machine complete weighs 28 cwt., this weight being distributed over three wide tyred wheels. Although this weight makes little impression on ordinary land, the wheels, the steering one in front in particular, should be wider in the rim and boxed in when the surface to be worked over is of such a yielding nature as peat; the grips also with advantage might be deeper. Detachable rubber pads are supplied to the wheels, and these, or an extension of them, might prove useful on soft land. Extra road wheels might be provided.

This illustration is not one of an ideal trial trip, for the invention has been put to numerous severe continuous tests in the presence of practical farmers, and has done excellent work in the field at harvest time. This tireless instrument, the "shadow before" of the type of the future all-round cultivator and handy general-purpose machine, has done excellent work at a speed beyond compare. It works with perfect accuracy. A pair of horses, costing say £80, will average an acre a day in the plough, whereas this 14 H.P. motor costs £300, and will do the work of at least eight of the best Shires, Clydes, or Suffolks that ever trod a furrow or wore a collar. This price in the face of possible and probable opposition, must come down. This agricultural motor ploughed 11 acres 1 rood and 13 poles of wet land in 17 hours 28 minutes, using 25½ gallons of petrol, the cost including lubricant, men's time, etc., being 5s. per acre. It finished cutting 19 acres of wheat in 10 hours at a cost of 1s. 9d. per acre, and cut three acres of grass in 1 hour 33 minutes at the same cost. It is impossible to get corn cut with a binder under 5s. an acre. Unfortunately, in the absence of detailed statistics, it is impossible to contrast the cost of upkeep of agricultural motors with that of the horse team. Some interesting and useful information from a general purpose point of view has been supplied by Mr. F. Johnson of Clapham, who, since he abandoned horse traction for the motor, has kept an accurate and detailed account of every item of expenditure in the upkeep and running of his cars. The results of 23 months' almost daily work of his 7 H.P. car show that with a record of 15,306 miles the total cost per mile, including petrol, repairs, lubrication and wages, works out at 4·93 pence. The average monthly mileage was 665½, and the average total cost per month £13 5s. 6d. Against this the estimated cost of the same work with horses is put down at £29 per month, or 10·47 pence per mile.[1]

[1] The Metropolitan and other omnibus companies are now rapidly turning their attention to the double-decker motor omnibuses. The omnibus mare and the cab horse will soon be extinct as the dodo.

The harrow, as already mentioned, is largely employed in both North Germany and Canada to break up the surface beat bogs to the depth of two or three inches, the broken-up stuff being left to dry and then gathered, generally by hand rakes, into windrows preparatory to being conveyed to the factory or stacked for future use. The disc plough has of late years also been an implement much used on mosses, and with good effect. A great improvement on the ordinary pattern is found in that new and distinct application of this revolving cultivator, the Spalding-Robbins Disc Plough, which is held in high esteem in the United States and in our Colonies, and which, ere long, is destined to supplant the old types in this "the base of all industry—ploughing," the most extensive industry of the earth, costing more time, labour, and money than any other avocation. Where the ground to be operated on is, as in the case of peat, of a distinctly fibrous nature the downward, advancing, circular, sliding sweep of the heavily-weighted revolving steel disc, so set that by the friction it is self-sharpening, is the most perfect system for severing this peculiar vegetable substance. It has been found to work admirably in Alfalfa (Lucerne), Salt grass, and in such obstructions as Buckthorn and Greasewood roots. Practically unbreakable, it has all the advantages of the "stump-jump plough," for what roots it cannot cut through it rides or rolls over. It works to a depth of 9 inches, cutting and turning a perfect furrow, throwing up the soil in such a manner that it can dry or freeze in a short time. By cross-ploughing the fibrous peat becomes thoroughly cut up and disintegrated. The implement can be worked by any ordinary farm hand, it turns a perfect square corner without touching a lever, and requires one-third less traction than the ordinary horse plough. A Californian estate owner certifies that he ploughed 1800 acres of soft peat land, averaging fourteen to fifteen acres daily, and that the discs lost only an eighth of an inch in wear. Another large farming concern, The Holt Manufacturing



THE S.-R. 5 DISC PLOUGH.

Company, using traction engines, ploughed 4000 acres with this implement in one season, some of the land being so hard that no ordinary horse plough could touch it, averaging 20 to 40 acres a day. In stripping and uncovering the surface of a moss, a necessity before tramways can be laid down and operations commenced, the disc plough is specially useful, for it cuts up the stems and roots of the ling, the coarse water plants, and the top growth generally. On the Welland bog in Canada the cost of this operation by ordinary means was 30s. an acre. In California the Spalding-Robbins plough breaks up alfalfa sod at a cost of 3s. an acre. Our firm impression is that when the merits of the disc come to be known by our farmers, at home and in the Colonies, the mould board and share plough will disappear.

APPENDIX I.

THE DISTILLATION OF PEAT.

BY P. DVORKOVITZ, D.SC., PRESIDENT OF THE PETROLEUM INSTITUTE.

Reprinted from the Journal of the Society of Chemical Industry, 30 June, 1894.

IT is with very great reluctance that I venture to approach the subject of peat treatment in face of the strong prejudice which exists against any method for its profitable utilization; moreover, geologists and botanists having after careful research ignored its usefulness, it remains for the chemist to determine whether it can be turned to profitable account; hence with this object in view I have recently visited Ireland and, supported by considerate Government influence, have inspected the principal peat districts, procured reliable samples, and I propose to place before you as precisely as I can the result of my experiments.

Although peat has been known so long ago as B.C., it is only lately that it has excited a certain interest, it having been brought before your notice in very able addresses by two of your presidents: in 1889 by Mr. Ludwig Mond, and in 1892 by Professor Emerson Reynolds; and I think that as our Society has for its main object the furtherance and development of chemical industry in the United Kingdom, a few remarks on the development of the distillation of peat may interest you.

Before showing how peat could be treated, I will explain what it really is. Generally, opinions as to the origin of peat are diverse. First, that peat is mainly received by the decay of forests; and this view is supported by Mr. H. O'Hara in his paper read before the Royal Dublin Society in 1864. He says that abundant proofs exist that peat bogs in Ireland are mainly formed from forests, and that formerly Ireland was one vast forest. In times of warfare broad tracts were cleared to facilitate military operations, and extensive woods were consumed by fire. Immense quantities of timber were likewise consumed by the forges and iron furnaces, which at various times were in a state of great activity. The remains of these ancient bloomaries which are found in the counties of Antrim, Leitrim, Roscommon, Sligo, Tyrone, Killarney, Carlow, Tipperary, Limerick, Kerry, and Cork prove that smelting of iron was very generally known in Ireland previous to the exhaustion of wood.

The destruction of the forests caused a considerable change in the climate, and a still greater change in the soil; indeed, the most remarkable fact has been the conversion of nearly one-seventh of Ireland into a swamp. This results from the greater exposure of the surface of the land to the moist winds of the Atlantic, which are highly favourable to the growth of a species of moss known as Sphagnum Palustre. This moss thrives only in exposed situations, and so favourable is the condition of Ireland to its propagation that if the existing arable and pasture lands which have a south-westerly exposure were abandoned to nature most of them would be covered by peat moss to a depth of several inches* in the course of a century.

Captain Portlock, in his account of the survey of Londonderry, is of opinion that sphagnum is acted upon by the superabundant moisture of the climate in inducing the formation, and this opinion is supported by Mr. Aher, who shows that trees are found generally six or seven feet above the bogs, standing as they grew, conclusively proving the foundation of peat to have been prior to the growth of the trees, a fact which, in relation to firs, may be verified in every bog in the parish of Donegal, where turf exists from threeto five feet underlying the layer of such trees.

* Query—feet. Author.

Further, Messrs. Nimeno and Griffiths in their bog report are of opinion that the strong resemblance to ancient water-courses of the valleys and basins which now contain the bog, and the accumulation of marl and shells at the bottom of the moss naturally suggest the idea of shallow lakes. Such lakes may have originated in natural inequalities of the ground, or been formed by the choking up of channels of transit by heaps of clay and gravel, or they may have been reduced to a condition of shallowness by the gradual wearing away of the obstacles which had blocked up and retained their water at a higher level. In all such cases the origin and formation of bogs would be as follows: A shallow pool induces and favours the vegetation of aquatic plants, which gradually creep in from the borders towards the deeper centre, mud accumulates around their roots and stocks in a spongy semi-fluid mass specially conducive to the growth of moss, which latter, particularly *sphagnum*, begins to luxuriate, thus absorbing a large quantity of water and tending to shoot out new plants above, while the old ones are decaying, pressing the lower ones into a solid substance, and gradually replacing the water by a mass of vegetable matter. In this manner a marsh might be filled up, while the centre moisture portion, continuing to excite a more rapid growth of the moss, would gradually rise above the edges until the whole surface had attained an elevation sufficient to discharge the surface water by existing channels. Springs existing under the bog would raise the surface so high as to cause it to flow over the retaining obstacle and flood the adjacent country.

The last theory as to the formation of bog from *sphagnum* only, I think, is the most interesting, and this is corroborated by the experiments made by Mr. Joseph Boehm in the year 1875 about the fermentation of marsh and aquatic plants. He investigated the character of a large number of different plants, and has come to the following conclusion: *Firstly*, that a large number of marsh plants—for example, Berula Augustifolia, Nasturum Officinale, etc.—if under water for any considerable time undergo a process of fermentation. *Secondly*, that aquatic plants and a large number of the marsh plants develop marsh gas. *Thirdly*, that the development of marsh gas from the decaying plants must be taken as a consequent result. This fermentation arises from yet unknown bacilli, which are very sensitive to high temperatures. *Fourthly*, the destruction of the cellulose of the plants by fermentation could be explained by the formation from one part of cellulose of three parts of carbonic acid and three parts of marsh gas:

$$C_6H_{12}O_6 = 3CO_2 + 3CH_4$$

By this experiment the amount of carbonic acid has been less than it should be under the formula, and this is accounted for by the presence of ammonia with which a portion of the carbonic acid is combined, and *lastly*, and most important, that by a prolonged continuation of such fermentation a certain amount of turf is formed. Mr. Fremy in 1879, in Comptes Rendus XXI., has expressed the opinion that plants have been first transformed into peat, and afterwards into coal, and that this process of transformation is the result of fermentation. I think that only upon this theory of the formation of peat from plants belonging to the family of sphagnum could be explained such facts as are known about the renovating of peat bogs. Already about 150 years ago, the Earl of Cromarty demonstrated that moss could be renovated if the bogs were cut down to the bottom and the moss peat from above filled in again, when in the course of years the bog will grow up again. Mr. De Luc who has had a very great experience at the beginning of this century in the surveying of peat bogs all over Europe has expressed his full belief in the possibility of growing up peat bogs in a comparatively short space of time.

Mr. Waggemann, in 1828, made experiments in the artificial production of peat from the plants of sphagnum, which he placed in brick tanks three feet high, filled with water, and carefully covered, leaving them to undergo fermentation, which resulted in dark brown peat the following spring.

As it is shown by the Table I., the area of the bogs which are spread over Ireland amounts to 2,830,000 acres. Of this quantity 1,816,642 acres lie in the mountains and hilly districts near the coast, and the remaining acres, viz., 1,013,358 extend across the great limestone plain, and contain almost an inexhaustible supply of peat.

In the Table I. I have shown that the chief bogs are sufficiently high above the level of the nearest rivers and lakes, and therefore they could easily be drained.

One fourth of the entire superficial extent of Ireland between a line drawn from Wicklow Head to Galway, and another line drawn from Horoth Head to Sligo, comprised within it about six sevenths of the bogs of Ireland, exclusive of mountain bogs and bogs less than 500 acres. This division of Ireland from east to west is traversed by the river Shannon from north to south, and were the bogs to be divided into 20 parts, 17 of them would be found between those lines, 12 parts west of the Shannon, 5 east of the Shannon, and of the remaining three parts, two are south, and one north of the division.

If we take the average depth of the bogs of 20 feet, which, according to the Table III., contains in the average 6·94 lbs. per cubic feet, we will find that each acre contains 2,700 tons or about 7,440,000,000 tons of very dry peat is on the bogs of Ireland.

Professor Reynolds is of opinion that the stores of peat are only an asset which may become valuable when the coal beds have been exhausted after 170 years. But certainly it is in the interest of the owners of the bogs, and all the Irish people to anticipate the consequent benefit, before the expiration of such period. It is also a matter of very great importance to the prosperity of that country to utilize so serious an amount of waste land.

We find that the British Government turned its attention to this question at the commencement of this century, a special commission of surveyors having been appointed, and about £50,000 spent in surveying and preparing plans of the Irish peat bogs. I do not know for what reasons, but the further investigation was abandoned, and

TABLE I.—Extent of the Bogs of Ireland.

Districts.	Counties.	English Acres.	Depth.		Elevation above Sea at Low Water.		Rivers and Lakes into which the Bogs could be Drained.	Height of the Rivers and Lakes above Sea at Low Water.
			Greatest.	Average.	Greatest Height.	Lowest Height.		
Eastern part of Bog of Allen,	Kildare,	36,730	41	22-25	312	228	Teogill and other streams falling into the Barrow,	At Monastereven, 208 ft. 4 in.
Western part of Bog of Allen called District of the Barrow,	King's and Queen's,	41,075	41	22-25	329	203	,, ,,	At Ashy, 188 ft. 1 in.
The Boyne,	Meath and Westmeath,	42,370	40	22-25	350	232	Streams discharging into Boyne,	At Edenderry, 241 ft. 7 in.
Brusna,	King's,	44,594	45	22-25	324	125	,, ,, Brusna,	At Ferbank, 153 ft. 7 in.
The Shannon,	Westmeath, Longford,	34,500	44	30	288	128	Blackwater, Brusna, and Shannon,	At Harbour, 114 ft. 4 in.
The Inny and Lough Ree,	Longford and Westmeath,	34,569	47	30-35	268	191	Camlin and Inny,	—
Lough Gara,	Roscommon, Sligo and Mayo,	83,689	45	20-30	415	204	Streams discharging into Lough Gara,	Lough Gara, 178 ft.
Between Roscrea and Killynaule,	Tipperary, Kilkenny, and Queen's,	36,025	33	16-20	418	340	Streams discharging into Nore and Suir,	—
Westward of Maryborough,	Queen's,	14,724	35	18-20	340	288	Streams discharging into Barrow,	—
Western extremity of Co. Clare,	Clare,	22,340	35	15-20	130	64	Dunbeg, etc.,	—
Banks of the Barrow,	Kildare and King's,	7,459	36	20	257	227	Barrow,	—
Lough Corrib,	Galway and Mayo,	83,724	45	15-20	366	46	Streams discharging into Lough Corrib,	Lough Corrib, 16 ft.
Three Districts,	Mayo and Sligo,	161,962	54	8-16	488	54	Lough Mask, Lough Conn, and Clew Bay,	Lough Mask, 48 ft.; Lough Conn, 30 ft.
Surrounding Loch Neagh and extending to the River Bann,	Antrim, Down, Tyrone, Armagh, and Londonderry,	64,855	—	—	200	93	Blackwater, Bann, and Lough Neagh,	Lough Neagh, 40 ft.
Iveragh,	Kerry,	43,567	25	5-12	250	75	Cashen, etc.,	—
Kenmare River,	,,	14,605	20	20	300	200	Blackwater, etc.,	—
Lawmand, Lower Maine,	,,	17,990	20	6	160	25	Lakes of Killarney,	Lakes of Killarney, 40 ft.
Upper Maine,	,,	8,566	22	10-15	200	38	Gheeston and Laure,	—
Slieve Laughar,	Kerry and Cork,	32,902	32	6-12	700	250	Blackwater and Coolrea,	—
River Cashen,	Kerry, Northern part,	31,517	32	12-20	110	35	Cashen,	—
Lough Ree,	Longford, Leitrim, and Roscommon,	26,630	43	20-30	229	144	Shannon,	At Harbour, 114 ft. 4 in.
Southern extremity of River Suck,	Galway and Roscommon,	76,818	30	20-25	284	126	Lough Corrib, Mask, Gara, Suck,	Lough Corrib, 16 ft.; Lough Mask, 48 ft.
Northern extremity of River Suck,	,, ,,	52,390	20	15	300	150	Suck,	At Ballinasloe, 116 ft.
		1,013,358						
Mountain bogs and bogs less than 500 acres not included in the reports,	Kerry, Sligo, Galway, Wicklow, etc.,	1,816,612						
	Total,	2,830,000						

no practical result obtained from the very valuable reports and maps now quiescent in the Government archives.

I show here five sections of beat bogs taken by the Commissioners appointed by the English Government; the first representing a section of turf bank exhibiting marl on bog. As is seen from the drawing, in the centre of the bog there is a layer of marl, the bottom being limestone gravel. The next represents marl on the surface of the bog with the root of a fir tree well preserved. The third represents a section of two growths of trees on bog. The fourth a section of a renovated pit, showing from the other side the method of cutting drains. Regarding renovating pits, sometimes old pits and turf hill are found filled with a new growth of moss, the surface appearing to have been sunk in the centre on being deprived of its water. This new growth consists of some of the varieties of the hipnum and sphagnum, and seems perfectly distinct from the original formation with which it is in contact, and in some cases is not even the same variety of plant. No part of this new formation has yet undergone the process of decomposition, or even far advanced towards a state of decay. There are other pits in which the process of renovation appears to be going on, where the tender fibres of the conferva are spreading like a green film on the surface of the stagnant water. This, by interweaving with other aquatic plants may form a receptacle for the deposition of the light seeds or mosses which are blown about in abundance at the shedding season.

Figure 5 is a section of turf bank representing three distinct growth of trees. This bog is 12 feet high, and the lowest part represents the roots of trees based on limestone gravel. Above these roots is about 4 feet of compact black peat or strong turf. This constitutes the best and most durable fuel, is very hard, and has a high specific gravity. Above this black peat you will see roots of fir trees again well preserved. Beyond these we have another 4 feet deep blackish peat or turf, and, further, roots of young fir trees, on the surface of which exists a layer of moss grasses. The fir roots and trunks possess a high degree of inflammability from the resin they contain, and when dried are used by the peasants in place of candles.

The question presents itself is peat advantageously convertible for industrial purposes? If we turn our attention to the development and use of peat in Europe, we discover that it is used in very great quantities in different industries. Already in 1856 in Germany the Aldenburg Iron Company was established and has consumed not less than 20,000 tons of peat per year, and notwithstanding coal existed in the immediate neighbourhood, and very profitable results followed. Not far from the works of this company, in 1873, another company was established for steel manufacture by means of peat charcoal. Further, we find that in 1890, 27 glass works in Germany used peat fuel, one ton of glass consuming eight tons of peat. A Mr. Peach at Berlin said that one ton of ready-made bottles (1600 ordinary wine bottles) required only 2½ tons of peat dried in the air; or if we take 1000 sods of peat as equal to 3½ tons, we find that one ton of bottles required 700 sods. A glass-melting stove, with eight pots, having a charge of 400 kilos. each, consumed 4½ tons of peat per day. In Bavaria about 60,000 tons of peat are used annually as fuel for railway locomotives.

In the report prepared by the Russian Government for the Exhibition of 1893 at Chicago, certain figures are given about the utilization of peat for different manufacturing purposes; and we find for 1890 the following industries have used peat as fuel, viz., the cotton manufacturers have consumed 537,000 tons; sugar manufacturers, alcohol manufacturers, confectioners, flour mills, and macaroni manufacturers, 70,000 tons; chemical manufacturers, 5000 tons; candle, tallow, and leather manufacturers, 4000 tons; wood-workers, 1000 tons; metal manufacturers, 60,000 tons; glass manufacturers, 80,000 tons; paper manufacturers, 12,000 tons; miscellaneous manufacturers, 2000 tons; aggregating approximately, 772,000 tons. In addition, the Oural mines used 60,000 tons and the railway companies 15,000 tons, with prospectively an increased demand, proving conclusively the value of peat as fuel.

The use of peat for moss litter has greatly increased both in England and on the Continent during the last few years, and forms a most important branch of the industry. It is also largely used in Russia and on the Continent for earth closets and other sanitary purposes, for which, from its antiseptic properties, it is especially suited. These properties are also utilized for the preservation of fish, meat, and eggs in transit, and its non-conducting properties have rendered it useful for the preservation of ice. Lately attention has been paid to the utilization of the fibres of the top peat for making paper-pulp, felt soles, and in substitution for shoddy in the manufacture of horse-clothing and other cheap cloths.

Professor Reynolds in his paper showed that peat in its ordinary condition is a very bulky fuel, occupying more than five times the space of an equal weight of coal; that it contains from 15 to 25 per cent. of water and seldom less than 10 per cent. of ash, and that at least 2½ lb. of Irish peat is required to perform the same work as 1 lb. of Staffordshire coal in an ordinary fireplace or furnace. All these disadvantages could be easily removed by more careful treatment of the peat itself. Reduction of the bulk and the removal of the water could be done by partial carbonization.

Carbonization of peat is a very old question, and generally speaking can be described under the following heads:

First, carbonization in heaps.

Second, in closed ovens of brick and iron in which the peat is lighted, and after it has sufficiently formed a good flame the oven is closed, air excluded, and the carbonization goes on.

Third, the carbonization in closed retorts heated from the outside.

Fourth, carbonization by superheated steam.

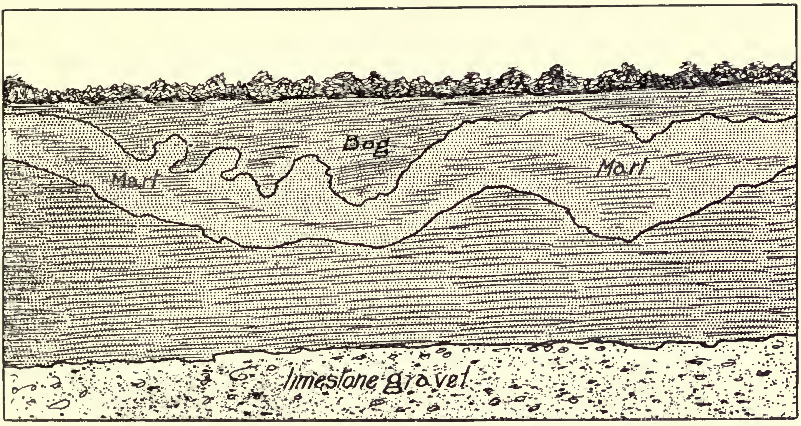

Bog
Marl
Marl
limestone gravel

Fig. 1.

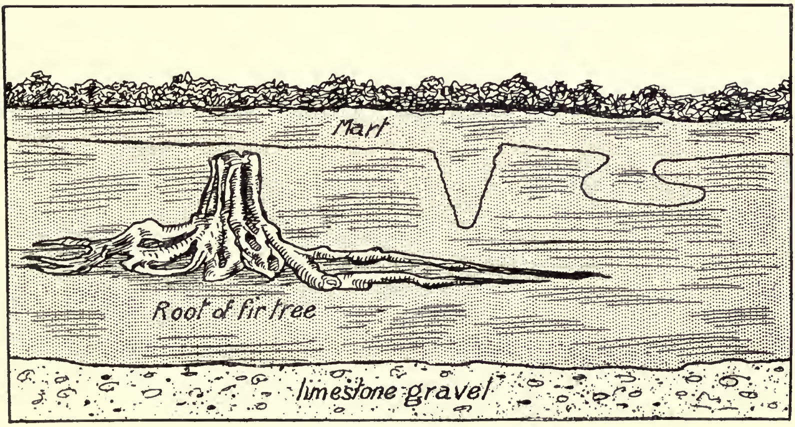

Marl
Root of fir tree
limestone gravel

Fig. 2.

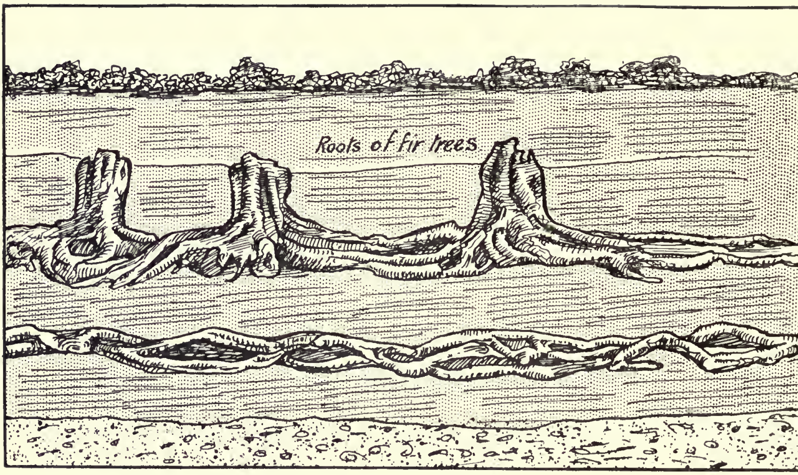


Fig. 3.

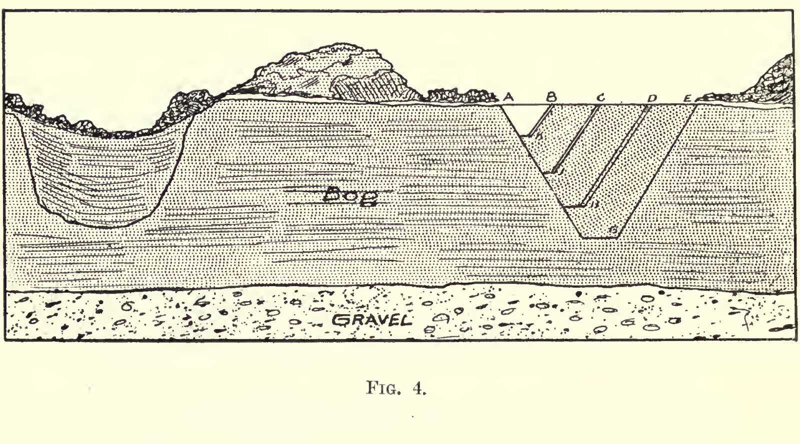


Fig. 4.

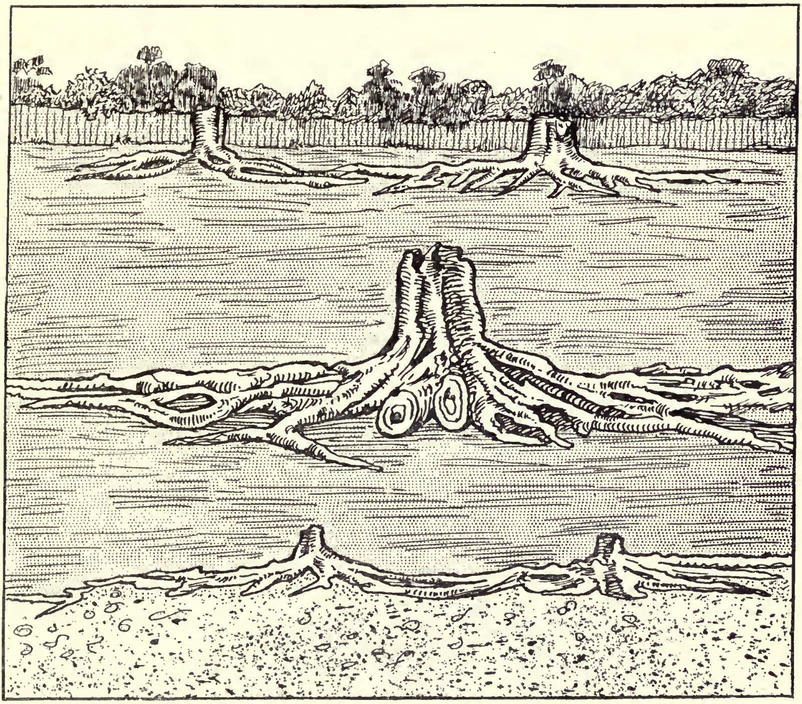


Fig. 5.

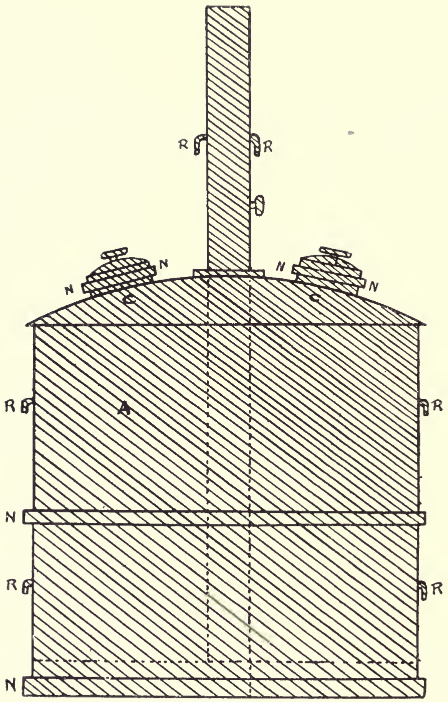


FIG. 6.—PEAT OVEN BY MOREAU AND SONS. EXHIBITED AT THE PARIS EXHIBITION OF 1855.

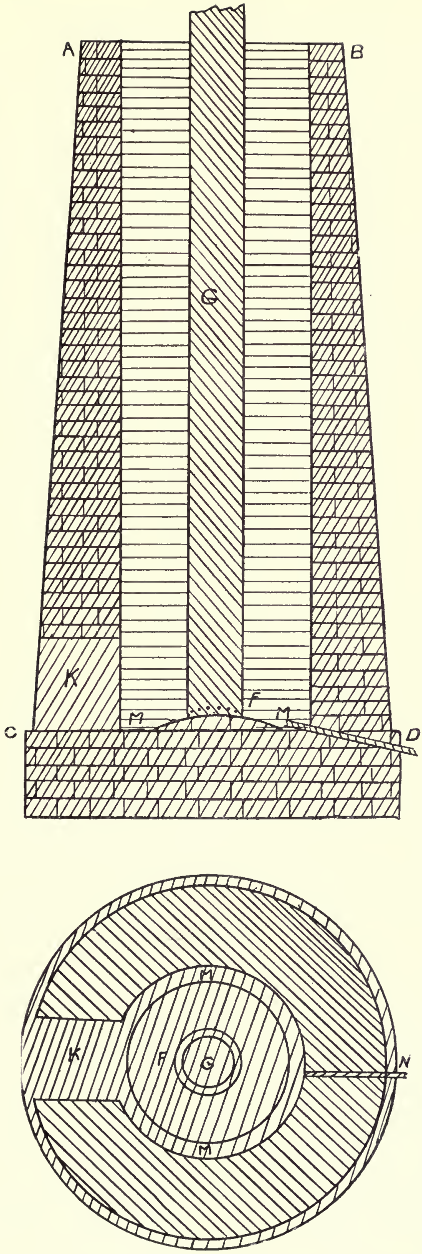


FIG. 7.—IMPROVED PEAT OVEN BY HAHNEMANN.

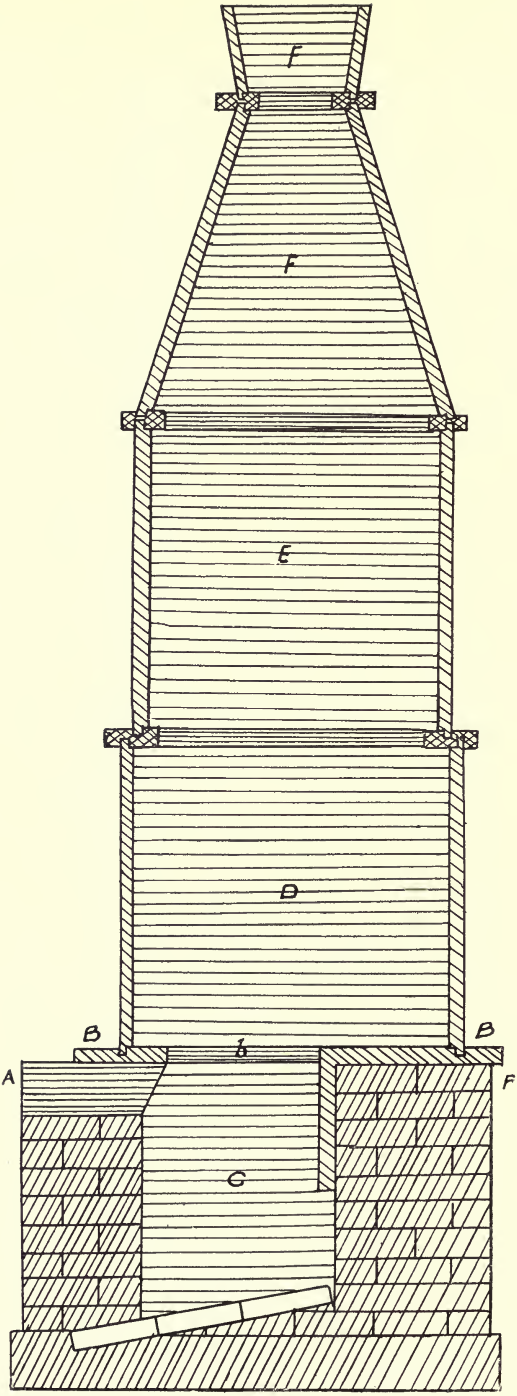


FIG. 8.—FIRST PEAT OVEN CONSTRUCTED BY LANGE, 1745.

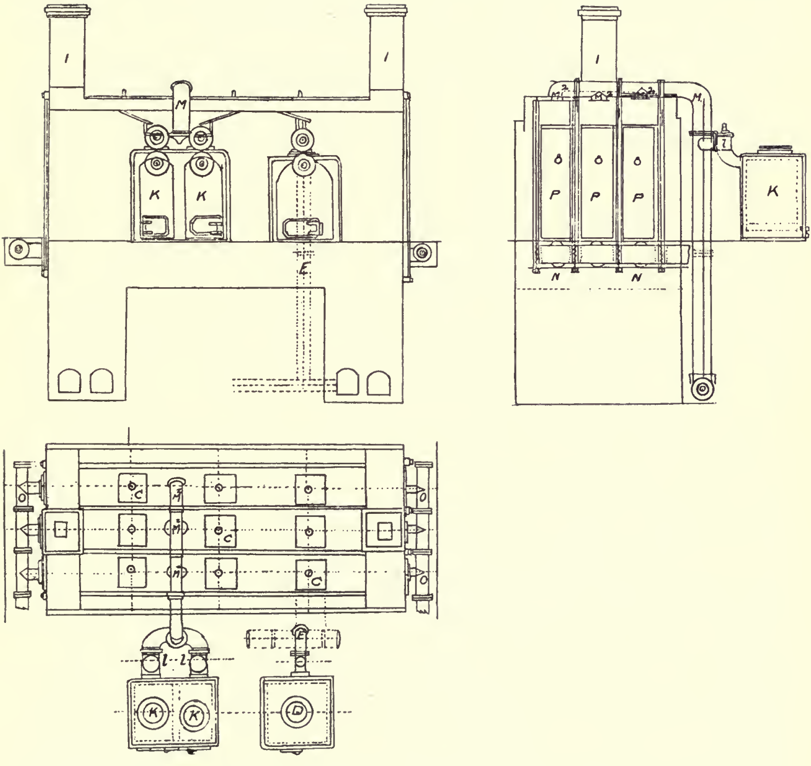


FIG. 9.—PEAT OVEN FOR RECOVERING BYE-PRODUCTS (DVORKOVITZ'S PATENT).

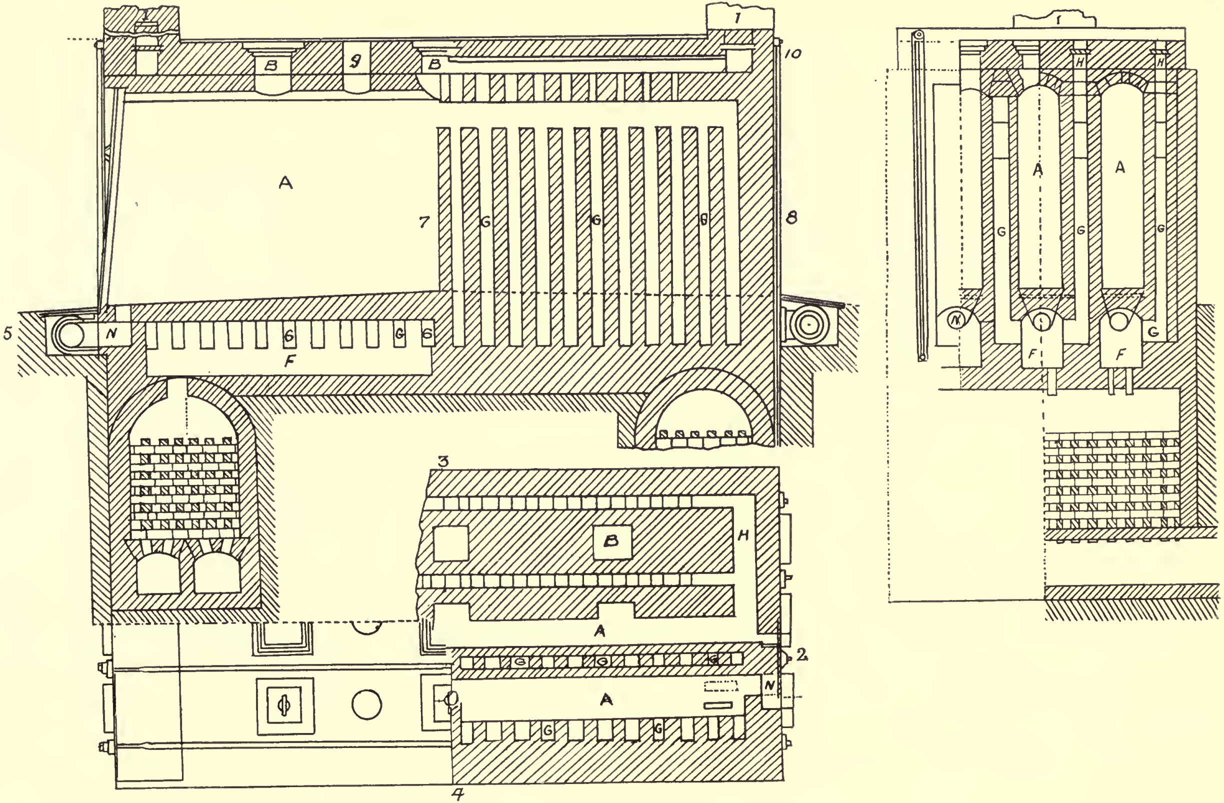


FIG. 10.—SECTION OF PEAT OVEN FOR RECOVERING BYE-PRODUCTS (DVORKOVITZ'S PATENT).

Fifth, carbonization by burnt and consumed gases.

First, carbonization by heaps. As early as 1712 Mr. Carlowitz in his *Sylviacultura Economica* proposed to carbonize peat in heaps, but no important steps appear to have been taken until 1836, when Mr. Schmidt introduced it into the Bavarian State iron manufactories. This method was to pile up heaps of 2500 cubic feet capacity; the quantity of peat carbonized was stated to be 13½ tons, and the amount of peat charcoal obtained 3 tons 8 cwt., or 25·2 per cent. The carbonization of such heaps and the cooling down required about 12 to 14 days.

Second, in closed ovens. The oldest and best known oven has been constructed by Mr. Lange in 1745. As it is seen from the drawing, this oven consists of a square foundation (*a a*) on which an iron plate (*b b*) is placed, in which (*b*) a square hole of 15 inches is made; (*c*) is the grate, which is closed by a door. On the plate is based an iron cylinder (*d*), above (*d*) a second one (*e*), and above (*e*) a conical stone (*f*) is placed with an opening (*g*) 16 inches diameter.

In 1767 an oven of new construction was built on a round foundation of 17 feet diameter, and from 2 to 4 feet high, on which has been placed a round brick cupola of 16 feet exterior diameter, and 4 feet thickness. In the centre of this cupola a cylinder of 6 inches diameter has been built up filled with sand and ashes. At a height of 13 feet, the oven finishes with an opening of 4 feet diameter. Both ovens, however, proved a failure. The peat lying above crushed down the charcoal formed below it, and to avoid this Mr. Hahnemann proposed the following construction as seen by the drawing. A round cupola of 16 feet high and 7 feet diameter, with a thickness of the walls of 2 feet at the bottom and 10 inches at the top, on the foundation the grate (*f*) is placed, and connected with an opening (*k*) for taking out the charcoal. At the commencement of the charring, the opening (*k*) is closed, and the cupola is filled up with peat and fired from the top. When the peat has commenced to burn sufficiently, then the top of the opening of the cupola (*a b*) is closed, and thereby the gases produced are bound to pass down through the mass of the peat and through the opening (*f*) and pipe (*g*) through the retorts. The products of this distillation are condensed in the condenser. When the fire in the cupola has come down nearer to the opening (*f*) all the openings are closed and the stove is left to cool down.

On the same principle is based the stove of Moreau, Père and Fils, a model of which has been exhibited in the Paris Industry Exhibition in the year 1855. This apparatus consists of a cylinder of sheet iron eight feet in diameter and the same height, such stove carbonizing in 24 hours three tons, and producing 40 per cent. of charcoal. In 1851 a special process was invented by Mr. Reece, in which process the British Government took very great interest, and appointed a special commission to investigate with a view to establishing profitable peat industries in Ireland, and the Irish Peat Co. was then formed. A site was chosen in the North of Ireland, called Kilberry, about four miles from the town of Athy in connection with the Carlo branch of the Great Southern and Western Railway, while on the other side runs the navigable river Barrow and the canal to Dublin and Waterford. 500 acres of very excellent bog land were taken on a lease for 100 years at a rent of 5s. per acre. Mr. Scanlon, chemist, was sent by the Company to make experiments. He commenced working the furnaces at low temperature, and distilling the products by steam. From the information supplied by the Company it seems that from 100 tons of peat were received—

1 ton of sulphate of ammonia -	£12	0	0
$\frac{3}{4}$ ton of acetate of lime - -	9	10	0
50 gallons of naphtha - -	12	10	0
300 lbs. of paraffin - - -	15	0	0
300 gallons of volatile oils -	15	0	0
	£64	0	0

these being current value at the time. Cost of production of peat, acids, labour, etc., £32.

The last practical attempts, so far as I know, were made in the year 1880. A company was formed in the name of the West of England Compressed Peat Co., which constructed 12 ovens for making peat charcoal at Rattlebrook on the slope of one of the highest hills of Dartmoor, nearly 2,000 feet high. The process which was adopted by this company was the invention of Mr. Kidd. The principle of his invention was the introduction of a jet of superheated steam, but nothing came of the scheme. The Duke of Sutherland was the first to take up Kidd's process, and in 1874 an experimental plant was erected on his estate in Sutherlandshire. The peat here is of very dense quality like the Dartmoor peat, and contains a large amount of hydro-carbons.

From this short description of the processes introduced for the utilization of peat in one way or the other, it will be seen that most of the inventors have only had one end in view, whereas to gain a real practical success we must work in the same sensible manner as we do with all other products. Most of the inventors have striven to produce only peat-charcoal, not taking notice of by-products which could be and should be received in course of charring, or they have concentrated their attention on the by-products without regard to the charcoal.

In my investigation I have first tried to avoid all the conditions under which any of the constituent parts of the peat would be destroyed. I have applied in this the same principle as I have adopted in the destructive gasification of oil and of coal. This means using a very low temperature, and gasifying in the presence of an inert gas which could not have any chemical influence on the substances received, but which would have the mechanical effect of extracting all the by-products and leaving only pure charcoal in the retorts.

The apparatus with which I propose to treat the peat consists, as you will see from the drawing, of two or more chambers or retorts, in which the peat is placed. The chambers or retorts are heated externally by generator gas from a furnace (*d*). The inside of the retorts or chambers is heated by water gas produced in a furnace (*k*) and passing to the upper parts of such retorts. This water gas, which is admitted into the retorts at a temperature above the initial heat of the interior of the retorts, mingles with the matter under treatment, and rapidly separates the volatile constituents, which are conveyed from the passage (*m*) through the pipe (*o*) and then into the condensers in which the liquid by-products are condensed.

TABLE II.

ANALYSIS OF PEAT.

From Barrow-in-Furness.

No.	Peat.	Charcoal.		Liquor.		Gas.
	Grms.	Grms.	Per cent.	Grms.	Per cent.	Per cent.
1	115·0	40·5	35·2	52·0	45·2	19·6
2	127·0	45·0	35·4	50·0	39·3	25·3
3	120·0	45·0	37·5	47·0	39·2	23·3
4	105·0	35·5	33·8	43·0	41·0	25·2
5	115·0	43·0	37·4	48·0	41·7	20·9
6	141·0	50·0	35·5	50·0	35·3	29·0
7	120·0	50·0	41·7	48·0	40·0	18·3
8	122·0	46·5	38·1	53·5	43·9	18·0
9	106·0	39·0	36·8	43·5	41·0	22·2
10	134·5	50·0	37·2	57·0	42·4	20·4
11	130·0	45·0	34·6	56·0	43·1	22·3
12	116·0	44·0	35·9	49·0	42·2	19·9
13	129·0	49·0	38·0	49·0	38·0	24·0
—	1,580·5	Max.	41·7	Max.	45·2	29·0
—	—	Min.	33·8	Min.	35·5	18·0
—	—	Avgs.	36·9	Avgs.	40·9	22·2

The charcoal contains 4·23 per cent. of ash. The liquor contains an average of 5·89 per cent. of tar, and 35·7 per cent. of water solution. The specific gravity of the liquor is 1·0135. 100 cc. of the solution contains 0·2344 grms. of ammonia and 2·16 grms. of acetic acid.

From the Table II., which is a result of 13 analyses made by my assistant Dr. Fuerst (to whom I now take the opportunity of expressing my thanks) I have received such

TABLE III.

Analysis of Peat.

A.—*Peat from the Estate of the Earl of Longford, Killucan, Ireland.*

No.	Weight of Wet Peat in Lbs. per Cub. Ft.	Volume of One Cub. Ft. after Drying.	Percentage of Water.	Weight of Dried Peat in Lbs. per Cub. Ft.
		Cub. Ft.		
1	48·45	0·756	90·5	4·60
2	54·91	0·4146	88·26	6·44
3	55·81	0·4146	86·9	7·31
4	60·89	0·4634	85·03	9·11
5	61·10	0·4146	86·80	8·06
6	55·45	0·5608	86·96	7·23
7	57·04	0·4146	87·4	7·19
8	59·77	0·4146	87·7	7·35
9	60·34	0·439	86·85	7·93
10	59·17	0·683	87·2	7·75

B.—*Peat from the Estate of Mr. Atkins, Dunmanway, Ireland.*

No.	Weight of Wet Peat in Lbs. per Cub. Ft.	Volume of One Cub. Ft. after Drying.	Percentage of Water.	Weight of Dried Peat in Lbs. per Cub. Ft.
		Cub. Ft.		
1	54·94	0·4876	84·93	8·28
2	54·36	0·4146	89·94	5·47
3	54·54	0·377	84·96	8·20
4	56·94	0·3281	88·51	6·54
5	57·12	0·377	89·59	5·94
6	61·45	0·2683	88·47	7·08
7	60·76	0·2193	87·73	7·45

C.—*Distillation of Peat A. and B. Calculated on Dry Peat.*

Peat.	Nos.	Charcoal.	Paraffin Oil.	Acetic Acid (Anhydrid).	Ammonia.	Gas.	Water.
Peat A.	1 (top).	35·20	5·00	1·20	0·85	27·00	30·75
	5 (middle).	47·40	7·50	0·80	0·63	24·60	19·07
	10 (bottom).	44·00	6·75	0·75	0·67	19·50	28·33
Peat B.	1 and 2 (top).	50·25	4·73	0·67	0·57	27·20	16·58
	6 and 7 (bottom).	46·70	5·64	0·72	0·51	25·35	21·48

results as applied in practical form will give the possibility of developing a large chemical industry in Ireland. The peat used for this analysis was sent down to me from Barrow-in-Furness, and was sufficiently dry. But to obtain a fairer sample and a practical knowledge of the peat bogs themselves I made a special journey to Ireland in April last, and after careful investigations took samples representing both lowland and mountain bogs. The first range of samples which I took (lowland) were from the estate of the Earl of Longford. This estate is situated at Killucan, with the Royal Canal on one side and the railway on the other, and contains about 11,683 acres, which mostly consist of peat bogs. On this estate are about 340 tenants, who cut the peat for fuel, and afterwards reclaim the land. I also take here the opportunity of thanking the manager of this estate, Colonel Clark, for his kindness in showing me such a well conducted estate. He has been for 19 years fighting hard with the object of reclaiming the peat land for agricultural purposes with splendid results, of which he has reason to be proud. From the view shown to you you will see that a large number of trees have been planted by him on the peat bogs. It is true that the work demanded a large expenditure of energy, especially during the first years, but the results are so satisfactory that I am sure the gallant Colonel will never regret the pains taken, nor the owners the expense. The trees on the sides of the bogs are doing very well, but those planted in the centre do not thrive so well, on account of the excess of moisture. The other samples, which represent the mountain peat, were taken from the estate of Mr. Atkins, at Dunmanway, County Cork. This peat is much blacker than the peat from the North. The difference between the top and the bottom peat is not so great, and the top peat has not the elasticity which we have seen in the case of Killucan. In such cases this peat should be used for distillation purposes only, but when we have the top parts light coloured, I think it would be more practical to treat them separately and prepare from them very valuable moss litter, leaving the lower layers for distillation.

From the results shown in the Table III. you will see that I have taken care to have a fair sample of the peat bog as it is. I have taken a section from the top to the bottom, so that my analyses represents the real nature of the peat. The higher strata has a lighter colour, which is chiefly due to the fact that it is not sufficiently decomposed. The main constituent of this top part is the real moss, which is very elastic and like a sponge, having the quality of holding a large amount of water, the most of which you could press out by hand, after which the moss regains its original form and volume. When dried in the air, or artificially, it does not form hard lumps, but always remains soft and elastic. The analysis shows that whereas the volume of the lower layers has been reduced more than one half after drying, the volume of the top has reduced very little. The lower peat is generally very much decomposed, and after drying, has not the property of reabsorption, whereas the top section will absorb the same amount of water which they previously contained. These results are in accordance with those obtained by Professor Fleischer, the director of the German official peat investigation station at Bremen.

As it is seen from the analysis, the difference between the low land peat and mountain bogs is chiefly in the producing of more charcoal. The quantity of other products is less than in lowland bogs, and I think that is mainly due to the physical condition of the top part of the bog. Whereas the top part at Killucan is very porous and elastic, and therefore the absorption of ammonia from the air is great, the top part at Dunmanway's bogs do not differ from the bottom part. But in the average the difference is very little.

The distillation of peat for by-products is not a new idea. It was proposed long ago, but, unfortunately, for the reasons already explained, the industry has not flourished. The production of mineral oil and paraffin from peat was established in 1889 in Brazil at Marahu. In the Journal of the Society of Chemical industry there is an account of this establishment, which was producing not less than 80 tons per month of solid paraffin for candle-making. What is very important for the practical establishment of such industry is the treatment of peat before distillation.

The analysis shows that the peat as originally won contains from 85 per cent. to 93 per cent. of water, which when pressed out is found to contain in solution salt, and therefore it is very important to squeeze out as much as possible, as thereby the amount of ashes in the charcoal will be reduced. We have certainly in the market a great many different systems of compressing machines, and I am quite sure that the English engineers will soon find out the best means for compressing out this large amount of water at a cheap price. Apart from this, special attention must be paid to the drainage of peat bogs themselves. If the peat bogs are not properly drained, as very often is the case, the amount of work necessary for cutting and drying is increased tremendously. At the same time you must always bear in mind that in draining off the water it is necessary to leave a sufficient amount to keep the lower parts in a sufficiently spongy state. This, however, is not a place to explain all the necessary conditions under which peat bogs must be worked, nor have I gained sufficient practical knowledge to warrant my advising upon the best methods of cutting and drying. My researches have been directed to the treatment of the industry from a chemical point of view, and I certainly think there is something to be done, and I am also sure that painstaking work will show fresh means of treatment, and larger openings for products obtained.

APPENDIX II.

UTILIZATION OF THE PEAT BOGS OF IRELAND FOR THE GENERATION AND DISTRIBUTION OF ELECTRICAL ENERGY.

By Lieut.-General Sir R. H. Sankey, K.C.B., R.E. (Retired),
Late Chairman, Irish Board of Works.

The heading sufficiently indicates the scope of this paper, limiting it strictly to the employment of peat as a fuel for the purpose specified.

1.—Calorific Value of Peat.

Professor Johnson, in his pamphlet on *The Irish Peat Question* (1899), shows that, while freshly dug peat may contain as much as 90, the air-dried turf will still have from 15 to 30 per cent. of water; and, further on, expresses the opinion that "ordinary air-dried turf has about half the heating power of good coal."

Hausding, in his *Industrielle Torfgewinnung* (1887), states that air-dried machine-made turf, with at most 10 per cent. of ash, has two-thirds the heating power of superior coal, whilst ordinary turves are equivalent to only one-third.

The general inference from all this is that, as a rough assumption, the calorific value of ten tons of ordinary bog stuff, as freshly dug, should at least equal that of one ton of fairly good coal, and this equation, if accepted, will be useful in dealing with the next point, viz.:—

2.—The Total Calorific Value of the Bogs of Ireland.

First, as to the gross quantity of stuff available, we have in Ireland, on the authority of Sir Robert Kane, an area of about 2·8 millions of acres, varying in depth from 16 to 30 feet.

Professor Johnson observes, in reference to the depth of bogs, that "while the average thickness of turf in Europe is 9 to 20 feet, Ireland has beds as much as 40 feet thick, the average being 25 feet." Without accurate surveys and soundings no reliable calculation can be made on this point; I therefore prefer, in our present state of information, to take 15 feet as a conservative estimate of average depth.

Taking the specific gravity of turf as that of water (actual, 1·025), we find each acre has 18,231 tons of peat stuff, or, applying our useful equation above, the equivalent of 1823 tons of average coal in calorific value. This, multiplied into 2·8 millions, gives a grand total for Ireland equivalent to 5104 million tons of coal.

Is it, therefore, too sanguine to assume that one-half of this quantity might be fairly counted on (or, say, 2500 millions) as available ultimately for steam-raising purposes?

3.—Horse Power Available.

We have it on the high authority of Sir Frederick Bramwell, as the result of careful investigations made by him, that old pattern steam engines all round may be taken to have consumed 18 lbs. of coal per indicated horse-power per hour, and allowing on an average 3000 hours' work per annum, the total annual consumption would thus have been about 24 tons.

But with more modern engines (*e.g.* Willans and Robinson's Central Valve, Parsons' Turbines, and other high-class engines) the thermal efficiency is vastly better than this, and I think we may confidently take 2 tons of coal, or even less, as the quantity required annually for an indicated horse-power. On this basis we should thus have for an annual output of

100,000 horse-power a life in the bogs of about				1250 years;
200,000	"	"	"	625 "
300,000	"	"	"	412 "

4.—Time Required to Exhaust the Supply.

This necessarily entirely depends on the unknown factor of horse-power likely to be developed annually, but for the moment the above figures may furnish a rough indication. If even approximately correct, the outlook, it must be admitted, is not depressing.

England's outlook with the present output of coal is not so good as this, but even here a further question arises as to the reproductive or recuperative powers in bogs. As observed by Professor Johnson, their growth in thickness "is naturally dependent on the nature of the flora, and, in some cases, the bogs increase in thickness each year five or six inches; in others, not at all. This process of growth must not be overlooked, especially in districts where peat fuel is scarce, and it is necessary to make provision for a renewal of the peat beds." Further on, "that a continual production of peat may be confidently anticipated," and, again, that it may be "considered sufficient to prepare a plan for from 50 to 100 years, according to the extent of the bog."

I find that other authorities are not so favourable as to the possibilities of reproduction, and therefore without labouring the subject further, I note it in this connection as one worthy of discussion and special study, as in case reproduction be at all feasible it must be manifest that the life of the bogs as a fuel preserve would, under adequate arrangements, be capable, like that of well-managed forests, of indefinite extension. The bogs, as I maintain, are the true gold-mines of Ireland, and, if reproducible, infinitely more valuable than any inexhaustible supply of the precious metal.

5.—Cost of Production.

On this, which is probably the most important point, the evidence at present available is inconclusive, as so much depends on the locality selected for the generating centre, the price of land, labour, etc.

As regards the acquirement of bog land, while possessing but little knowledge of the subject, I may be permitted to quote a letter, in which the writer observes: "A friend to whom I wrote, told me that he had a bog of 8000 acres on the Dublin-Cork Railway, which he would be very pleased to let me have if I started the working of a process in Ireland," adding "The Congested District Board for Scotland are, I understand, prepared to view the matter favourably in order to promote industries," and I think it may confidently be assumed that in such a cause the Congested District Board of Ireland will, on occasion arising, not be found wanting in their support.

If, as stated by Mr. Ralph Richardson in his pamphlet on *Peat as a Substitute for Coal*, peat fuel prepared by the Schlickeysen process, costs in Prussia 6s. 6d., in Bohemia 6s. 9d., and in France only 6s., it surely would not be an over sanguine estimate to assume that peat fuel, equal to coal, could be produced for 7s. a ton on the spot in selected positions in Ireland. We should thus have the equivalent of good English coal to convert, *in situ*, into power, at less than half the present price. My conviction is, that with properly designed works and organization generally, the cost could be reduced; but, even as it is, this, as will presently be seen, would prove an inestimable boon to the country.

6.—What has already been achieved in the British Isles, as regards the Generation of Electrcal Energy in Bulk.

In this connection, it is needless to advert to what has already, as a matter of common knowledge, been accomplished, regarding the electrical lighting of cities and towns, electrifying of tramways, etc., etc., these being hardly such as to be classed as schemes for the generation of electrical power in bulk, and "on tap" for general purposes, all over a district, such as that which I venture to suggest as the distinctive province of peat fuel, used *in situ*, though, of course, such matters are incidentally included.

No less than thirteen power schemes have already obtained Parliamentary authorization in the British Isles within the last three or four years, and it is not too much to assume that before another decade has passed there will be hardly an existing industry anywhere which will not be within reach of electrical energy, and able to apply it. The Newcastle-upon-Tyne Electric Supply Company, Ltd., one of the first in the field, and which also, I believe, has parented the very successful installation at Cork, has been at work over two years, and has already achieved most striking results. In connection with this, evidence was lately given before a Parliamentary Committee by the great firm of Armstrong & Co., that, as regards one of their building yards on the Tyne, involving the use of 500 H.P. steam engines, 40 per cent. would be saved by the substitution of electrical power taken from this company.

With coal at 6s. to 7s. per ton, which is about the price nearly everywhere available close to the pits, energy conveyed at high tension (5,000 to 15,000 volts) and transformed at subsidiary stations to direct current of sufficiently low potentiality, can be supplied in bulk (500,000 units) at prices ranging from 1⅛d. to 1½d. per Board of Trade unit. As the energy thus supplied comes more into general use, as it is certain to do, and the "load factor" accordingly rises, the price at which it can be offered to the public will no doubt come down, but even as it is, power of this kind "on tap" is so cheap, and easily applied, that nobody having any work to do, from curling a lady's hair, to driving all the machinery in Belfast, can possibly resist its attractions. Yes! even tramway and railway boards, all employers of labour, high or low, great or small, must in time bow the knee to the Electric King!

7.—Distance to which available from the Generating Centre.

This is a matter entirely dependent on section of the copper wires, and the perfection of insulation of the cables, now preferably placed underground for conveyance of high potential currents; but already it is considered by good authorities that the losses of transmission at present should not exceed one per cent. per mile (some even claim only one-fifth of this loss), and that this, trifling as it is, can be further improved on in future.

Speaking very generally, however, generating centres are taken to command an area of about sixteen miles radius, with very little loss of energy; but forty or fifty miles might easily prove economically feasible under favourable conditions. In this connection, it may not be out of place to mention that with quite a late installation, utilizing the falls of the river Cauvery, in Mysore (S. India), for working the well-known Colar Gold Fields, the energy has to be transmitted at least ninety miles, and not long since, when on a tour in America, the great Lord Kelvin is reported to have expressed an opinion that eventually it might possibly be found feasible to transmit the power generated at Niagara, 400 miles, to New York.

Why should not Mayo, and other distant areas in Ireland, thus one day, from their interminable and now useless wastes of bog land, send out vivifying streams of power to the farthest extremity of Ireland? The day cannot surely be far distant when, with scientific advance, this, and much more, will be achieved, and Ireland be placed in a position to compete in all forms of industry with England and Scotland, and any part of the world, for that matter.

8.—Water Power incapable of competing with Peat Fuel for Generation of Electrical Energy.

The River Shannon Power Scheme, to which everyone must wish success, now that it has obtained Parliamentary sanction, may at first sight appear to refute the idea that the water power of Ireland, which has, as is well known, a strong hold on the popular imagination, would be incapable if properly applied to do all, and more than all, that I claim for the peat supplies available from the bogs.

It would be quite outside the scope of this short paper to deal in detail with this matter; but I think a very slight consideration of the enormous area drained by the Shannon

(4,500 square miles) as compared with the very small results, only 10,000 horse-power, as aimed at by the approved scheme, will, *per se*, suffice to create a doubt as to the sufficiency of the power stored up in the other Irish rivers, and available for use.

Setting aside the great cost and difficulties inseparable from the buying out and acquirement of all vested interests, etc., it must be borne in mind that in dealing with a water-power scheme the head works must, unlike those depending on steam power (which may from very small beginnings be added to from time to time as business comes in), be designed *ab initio* for utilizing in each case the whole volume of the stream or river. The total expense must, in fact, be incurred at the outset on these, the most costly portions of the works. Again, unless where any great storage capacity be present, as, say, in the case of Lough Neagh, provision must be made for auxiliary steam power, in order to make suitable provision against the possible effects of recurring droughts and shortage of water.

With undeveloped industries, my conviction is that (1) there are only some very rare cases in Ireland in which, for the above reasons, water can with advantage be made use of for the economical generation of electricity, and (2) the aggregate results as measured in horse-power resulting from such schemes would be quite a *bagatelle* as compared with what can be derived from the utilization of the bogs in the way I propose. This, however, by no means excludes the idea that some local schemes might prove remunerative, and these certainly should not be neglected, or their development discouraged.

Similarly, as regards other sources of power production, the existing coalfields of Ireland, the tides, winds, etc.; which, however, in no wise, to my mind, come in competition with cheap peat fuel.

9.—Conclusion.

We are now fairly embarked on the electrical era, in which every civilized nation, finding at hand a power applicable to every form of human activity, is already exercising its ingenuity to the utmost in turning to account all the forces at its disposal for fighting the industrial battle, and securing the spoils. Woe to the nation that lags behind! Already it is to be feared that even England and Scotland have been caught napping. "Mr. Pigeon the Pie-man," and all the forces of Bumbledom in City Councils, and, worst of all, in Parliament, have till quite lately succeeded in clogging the wheels of industry, and especially in impeding the free adaptation of electricity in the British Isles. But, thank God! at last "Pie-man" and all other municipal ignoramuses have substantially been defeated. Parliament has at length began to rub its sleepy eyes, and though as yet not wholly awake, it has conceded much. Powers are now being granted, through the Companies above adverted to, for generating and selling electrical energy in bulk. Everywhere motor cars, previously compelled to crawl, can now at last legally move at a moderate pace along our high roads. With liberal views on the part of the Board of Trade, the obstruction of municipalities is giving way more and more. The day is breaking, even in ultra-conservative England, and surely it is time that Ireland should take part in this great awakening, now that, as I firmly believe, she finds within her grasp a store of power in her peat bogs unequalled in the world.

But, gentlemen, I am only too conscious that the adequate treatment of this great subject is beyond my powers, and that it should, properly speaking, have fallen into the hands of one of the many learned and able scientific gentlemen whom I see around me, and whom I can only now, in all seriousness, ask to criticise what I have said in a perfectly frank manner, being only too well aware of the many points which must have escaped me in hastily compiling this paper.

On concluding the reading of his paper, Sir Richard Sankey stated that he had on the previous morning perused the first Report, made in 1810 (on the reclamation of the Bogs in Ireland), by his predecessor in the Board of Works, Sir Richard Griffiths, when a young man, and found that the attached plans, sections, etc., gave such details as would enable an engineer now to frame a reliable scheme for utilizing the bogs for the generation of electrical energy.

He found—to select a single example by way of illustration—that, in dealing with that portion of the Bog of Allen comprising the Lullymore, Timahoe, Monds, and Clane Bogs, the maps showed their total area to amount to 36,430 acres (English), with depths, respectively, of 20, 25, 30, and 30 feet.

The cost of draining these for reclamation did not exceed 2s. per acre.

We have thus an average depth of bog stuff in this locality nearly double that (15 feet) assumed in his paper as probably available for electrical generation, and further, that the cost of unwatering would be absurdly small.

The next point, Sir Richard Sankey went on to say, which he wished to enforce, being the widely extending limits for the transmission of electrical energy, and with this object he read out the following observations from the pen of Mr. Alton D. Adams, as published in the current month's number of the well-known scientific journal, the *Engineering Magazine*, viz.:

"For several years groups of transformers have been worked regularly at 40,000 volts, notably those concerned in the transmission of power from Prove to the Mercur Mills, Utah, over a distance of thirty-five miles. More recently transformers operating most of the time at 40,000 volts, but on one or two occasions at 60,000 volts, for which they are ultimately intended, have been used in the transmission from the Colgate power-house in Yuba county, California, to San Francisco, a distance of 218 miles. Since the early months of the present year, transformers have been operating at 50,000 volts at Cañon Ferry and Butte, Montana, for the purpose of an electrical transmission between these points, a distance of seventy miles.

"In none of these instances, where transformers are working at 40,000 to 60,000 volts, is there any indication that the maximum limit of practicable voltage has been reached. On the contrary, transformers have repeatedly been worked experimentally up to and above 100,000 volts."

In this connection the following extract from a letter from Mr. E. K. Carmichael, who, jointly with Mr. Sahlström, holds patents for the process bearing their names, will, Sir Richard Sankey hopes, be found apposite:

"I think the fuel ought to be used as powder, which would be practically smokeless, with perfect combustion. Some years ago Professor Sahlström invented a process for manufacturing carbonized peat and sawdust fuel in London, which was the parent of our new process.

"The carbonized fuel was pulverized, and used in this state by being blown into the furnace by an air jet.

. . . .

"There has now come into use powdered coal as fuel in the process of the Central Cyclone Co., for which they claim from 20 per cent. to 25 per cent. higher efficiency than can be obtained by the present method of stoking.

"I think this is a detail of some importance in carrying out your proposal that the fuel can so conveniently be used as powder, the state to which it has almost to be reduced in carbonizing for the proper extraction and separation of the bye-products, as it will not require to be in the form of briquettes, which otherwise is necessary, as powdered fuel cannot easily be carried.

"Again, where peat is used on a large scale, it should be carbonized; not so much, in this case, to improve the fuel, as it will not require to be carried far, in order that the bye-products may not be wasted, they being all so useful and valuable.

"Tar is, of course, the most valuable of these bye-products, and in some notes of Professor Sahlström's I find that from an average sample of sun-dried good Scotch peat, on which he experimented, he extracted 9·085 per cent. of tar, of which 18·678 per cent. was petroleum benzine, 20·165 per cent. lubricating oil, 3·318 per cent. solid paraffin, and 20·459 per cent. was creosote and carbolic acid, the remainder being pitch and waste. The pitch is what we propose to use for briquetting, so that none of the more valuable products of the tar might be wasted."

Sir Richard Sankey expressed his belief that some process, owing to the use made of the waste gases in carbonizing the bog stuff ((1) securing all the valuable bye-products, and (2) making, without having to incur the expense of forming, the fuel into briquettes), the stuff can be turned *in situ* by a very simple process into fuel in the form of powder, which will ensure automatic stoking, and with this the most economical way of raising steam for the object in view.

APPENDIX III.

STATE AID TO INDUSTRY (INCLUDING "GEWERBE" MUSEUMS AND COTTAGE INDUSTRIES).

By Dr. William Exner, K.k. Sections-Chef, Technologisches Gewerbe Museum, Vienna.

I am highly honoured by the invitation of the Department of Agriculture and Technical Instruction for Ireland, and I am very happy to have the opportunity of putting before you some information as to my experience in Austria. The large empire of Austro-Hungary shows a great variety of economic conditions, and there are provinces which have a great resemblance to Ireland in the physiognomy of the surface of the soil, as well as in the combination of agriculture and industry. Therefore, I may hope that what I shall report and the hints I shall permit myself to give you may be not without value.

I have been informed that you would like to become acquainted with my opinions concerning the promotion of handicraft trades and cottage industries; therefore, I shall not, in this address, occupy myself with agriculture or the great industries (fabrics), but shall endeavour to explain what we have done, and what results we have obtained, in relation to the small rural and urban industries and trades during the last two or three decades, in Austria, especially in localities where the conditions are similar to those in Ireland.

On several occasions the rural industries have been the object of public attention. The so-called "national or traditional" cottage industries—an appellation sanctioned officially by the International Statistical Congress of Budapest in 1876—are to be distinguished from the mechanical factory industries, which have neither national nor traditional root, and which are not closely connected with any agricultural industry. It is, indeed, difficult to draw the line between these two classes of industries, and in many cases it is impossible to distinguish between rural industries and trade industries. It is not, however, necessary to determine these special circumstances, and it would not be desirable to enter, here, into scientific considerations bearing on the matter.

Agricultural, forestry, and industrial exhibitions might always insert into their programme a special representation for this particular form of production, the so-called rural, domestic or cottage industry. Whenever such an opportunity is offered these industries arouse universal interest, and most sincere sympathy is given to the most deserving class who carry on these industries. The experiment of making use of exhibitions to bring before the public those industries, which occupy the country people outside of their main agricultural occupations, was attempted and worked out several times, in Ireland as well as in Austria, always, for a considerable period at least, with the same striking success.

These exhibitions offer to the intelligent visitor, who is desirous of profiting thereby, a collective picture of the rural and domestic industries then practised in the country, a picture that is sure to be full of colour and variety. Such a picture helps to draw the attention of the town inhabitants to various little-known circumstances; and monographic studies, which are written and edited in connection with the exhibitions, are of even greater value. Such a work was entrusted to my charge, and I had to prepare an official handbook dealing with the Austrian domestic industries, which were represented in a special department of the Vienna Exhibition of 1891. This book, *The Domestic Industry in Austria,* is a compilation of descriptions of the most remarkable rural industries existing in the provinces and countries of Austria; and the descriptions contributed by various authors have been written with great care and profound knowledge.

Just the same thing was done by the Irish Department of Agriculture and Technical Instruction when it took part in the Glasgow International Exhibition, 1901, by organizing an Irish Pavilion. Mr. William P. Coyne and his colleagues published an admirable book, which gives a review of Ireland's chief economic resources. Everyone who desires to get ample information on the art and cottage industries of Ireland will find it in that handbook. A splendid new edition of *Ireland: Industrial and Agricultural,* was issued this year, which was, indeed, a very useful book of reference for me.

Mr. T. W. Rolleston says in this book the principal cottage industries of Ireland are hand weaving and spinning, lace-making, hand-knitting, and embroidery. Of the extent to which these cottage industries are practised no accurate statistics are available. In many cases they are carried on in spare hours as subsidiary occupations to farming and household work. There can be no doubt, however, that they are widely diffused over the country, and add largely to the comfort of many hundreds of families, especially in the poorer districts of the West of Ireland. They are nowhere so much practised, or found in such variety, as in County Donegal, which offers a kind of microcosm of the cottage industries of Ireland.

It may surprise many, as it surprised me, to learn that the hand loom and the spinning wheel are still capable of holding their own against steam machinery in any quarter of the United Kingdom: but such is the case in some districts. Hand-spun and hand-woven cloths, dyed with the lichens and plants, which the Irish peasant has understood how to use from time immemorial, is not only a peculiarly comfortable material to wear, but has, also, a certain artistic character of its own, possessing a distinct market value, which is so well recognized in the trade. The result is that attempts, more or less unsuccessful, are constantly made to imitate by machinery the effect of genuine home spinning; and power-loom cloths are sometimes even impregnated with peat smoke, in order to heighten the illusion that they have been produced in a peasant's cottage. I speak, here, of woollen goods chiefly, for in linen goods the power loom has practically supplanted the hand loom, save as regards the very finest cambrics, while the linen-spinning wheel has entirely disappeared from Ireland, though in France it is still in use for the production of yarns whose delicacy no existing agency of a purely mechanical kind can approach. But hand weaving and spinning in wool still hold their ground in Donegal, Connemara, Kerry, and a few other districts, where there is mountain grazing for a hardy breed of sheep, and where there is much superfluous labour during the winter months, as well as a hereditary aptitude for dealing with wool. It is principally in County Donegal that we find home-spun cloth produced, not merely for local use, but for sale outside the district—the local dealers having agents in the principal cities of Great Britain and Ireland.

The technical details of the industry are not only interesting in themselves, but are worthy of observation as exhibiting the germs of the whole textile industry, which, under the influence of steam power and the Jacquard loom, has attained such mighty proportions. The remarks which I have made on the Irish woollen cottage industry are true, with a few modifications only, of the Austrian woollen hand-loom weaving industry.

The Irish linen industry has a higher importance, compared with the rest of Austrian cottage industries treated of in this article, for the manufacture of linen is undoubtedly, after agriculture, the most important industry in Ireland, although it is practically confined to the north-eastern corner of the country. The growth of the trade is shown by the fact that Belfast, the headquarters of this industry, has grown from a small town of 8000 inhabitants, in 1757, into a great city, with an estimated population of 350,000.

It is well known that Louis Crommelin, one of the Huguenot refugees, who was induced by William III. to emigrate to Ireland, is considered the real founder of this industry. He was appointed overseer of the "Royal linen manufacture of Ireland." The distribution of Parliamentary grants, which varied from £10,000 to £33,000 a year, must not be forgotten. The extent of the linen manufacture in Ireland is indicated for the years 1899, 1900, 1901, by the fact that the number of spindles employed was 835,100, and the number of looms 31,484. Most of the flax used now is imported, though formerly a very large quantity was produced in Ireland. The Department of Agriculture and Technical Instruction for Ireland is conducting experiments as to the kind of soil and the manures best suited for the flax plant. The history of Irish linen industry is a good example of how to create, to develop, to protect, and to maintain an industry.

The French and Hungarian silk production would not have reached their present importance without the aid of the Government, and the Austrian silk production in the southern districts of Tyrol will very soon disappear, because the indispensable aid has not been granted. There are cases in which protection and help are needed, and ought to be given.

The highest interest is directed and reserved to those branches of the textile industry, in which the artistic taste is prominent, as it is the case in lace-making and embroidery.

The growth of lace-making can, in Ireland, be distinctly traced from its origin in embroidered linen, at the beginning of the sixteenth century. At the Cork Exhibition in 1883 special notice was given to the excellence of the work, as far as the use of the needle was concerned; but it was found to be combined with poverty of design and very bad drawing.

Mr. James Brenan and Mr. Alan Cole made, in 1884, the first effort to improve the character of the design, and the quality of drawing. A great and ruling principle was laid down, namely, that it is absolutely impossible for any student, no matter how clever he may be, to make successful designs, without fully comprehending the limitations of the material in which the design is to be carried out.

The efforts to develop the lace industry from 1883 have been very successful—all known schemes of protecting this industry have been employed—and the revival of Irish lace-making is of such a nature as to lead to permanent results if the intelligent supervision be maintained.

I agree with Mr. James Brenan in thinking that the existing lace centres in Ireland are quite adequate to supply the present demand for hand-made lace; but the hand-made article need never expect to keep its place in the market unless it can prove its superiority to the machine-made work.

With twenty-three co-operative societies of lace workers, sixteen successful schools under the Congested Districts Board, and large numbers of unorganized workers, furnishing an abundant supply, and the Lace Depôt and other agencies opening the way to the market, the prospects of the lace industry in Ireland are decidedly hopeful. The following figures show the growth of the sales in recent years:—1895, £4,230; 1897, £6,904; 1899, £11,130; 1900, £23,149.

Hand knitting, in spite of the growing severity of the competition of the knitting-machine, is still widely spread over the country, and is the means of bringing in earnings great in bulk if small from the point of view of the individual worker. There are important centres of this industry in County Donegal. The Arran industry, in County Mayo, turns out beautiful specimens of hand knitting, and in other places, also, it is practised with a success which is, in no small degree, due to the market provided by the depôts, and sales of the Irish Industries Association.

Hand embroidery in the more artistic developments, fortunately, is still incapable of satisfactory imitation by machinery, and must rank in Ireland as a very considerable, and by no means decaying industry. The so-called Swiss embroidery has, no doubt, largely killed some of the cheaper and poorer forms of white embroidery (or "sprigging"), but the better forms have shared in the benefit of the reviving taste for genuine hand work in industrial art; and more exquisite work in colour, than that which is produced in obedience to a large and steady demand, by the Royal School of Art Needlework, in Dublin, or the Garryhill, Turbotstown, Dalkey, or Kenmare industries, would be difficult to produce from any period of European art history.

The white embroidery and drawn-work, produced for the large Belfast firms, is also of most admirable quality in design and execution.

In the whole department of Irish art-work, it may safely be said that nothing approaching it for excellence is to be found anywhere else in the United Kingdom, and not very much even in France or Belgium.

In Austria the administrator of public instruction (Ministry of Cult and Instruction) organized a great number of schools and ateliers for the promotion of the various branches of the textile industry. The Austrian weaving schools are intended to give instruction to young men who wish to be engaged in textile establishments. The hand loom is more and more displaced by the power loom, and the cottage weaving industry is absorbed by the great power loom manufactories. Our schools help and facilitate the transformation of the old hand loom practice into the modern system of fabrication. It would be useless to resist such an irresistible development. Of over thirty weaving schools only four are limited to instruction in hand-loom weaving. But our weaving schools render service to the poor weaving districts, where the cottage industry is still existing.

The Central Lace-making School at Vienna is intended to cultivate needle-point, pillow, and crochet lace, and to instruct teachers in lace-making. The Atelier for lace-making at the Imperial Austrian Industrial Art Museum is charged with providing the provincial schools with new, tasteful, modern designs and sketches, and occupies itself with lace marketing.

Under the direction and inspection of these institutions there are eleven lace schools of the State, and nine private schools with annual State grants. The budget for the lace schools for 1902 is as follows:—

UNIVERSITY OF CALIFORNIA

	Crowns.
For the Central School, - - -	17,000
For the State Schools, - - -	28,980
Subventions, - - - - -	7,000
Total, - - - -	53,000

For the last few years a young lady has been engaged to teach Irish crochet lace-making at the Central school. Copies are made of old Irish originals. The number of women and girls engaged in lace-making in Austria is estimated at 4000; the number of scholars of the classes for 1901-2 is 751.

For embroidery we must distinguish between common embroidery, compulsorily taught in all public schools (Volksschulen) and artistic embroidery, which is the object of a high school in Vienna, with three years' day classes, and an atelier of seven sections for embroidery in State-trade schools, and of a number of private schools aided by the State.

Compared to the textile industries, no other cottage industries are, in Ireland, of any considerable importance, but in Austria the wood industries are very remarkable. Basket-work of an ornamental as well as useful character is carried on at various places in Ireland. Much ingenuity and taste are displayed in adopting wicker-work to various purposes; but these industries have suffered, hitherto, from the lack of native-grown osiers of the right quality; a need which steps are being taken to supply.

We, in Austria, had not long ago imported a very considerable quantity of basket-work from Germany, Bavaria, Coburg, and France, and as the conditions for the manufacturing of baskets were favourable in our countries, we tried to develop the existing domestic basket-making, and to create new centres for this simple industry. We engaged a clever Bavarian basket-maker, charged him to buy tools, models, and good articles, and organized with him a workshop at the Technological Museum at Vienna, in the year 1879. We made selection from among the inhabitants of certain young men of rural districts, where genuine basket-working was carried on, granted allowances to these persons, and gave them, during six months or a year, instruction in the craft and trade of dyeing, drawing, and designing of baskets, bookkeeping, etc. In this way we gained instructors for ateliers and schools for basket-work in the provinces. These schools, or teaching workshops, have been erected by the Government, boards, societies, and private individuals. The State gave subventions, and supervised the private undertakings—in one word, we made this proceeding an affair of the State.

We did not neglect osier culture, because wild-growing osiers can never provide a sufficiently good raw material for finer basket work. A very eminent authority on osier culture—the late Professor Breitenlohner, of the High School of Agriculture at Vienna—has been invited to give lessons in the culture of osiers, and a model plantation of osiers has been organized, in order to forward sets or slips of cultivated osiers to managers of agricultural properties.

The scholars of the Vienna Imperial Central School of Basket-work and of the Culture of Osiers (now independent of the Technological Museum), on their return to their villages, became the pioneers for propagating the industry and culture. The result was astonishing. After a few years we could do without any imports of basket work; on the contrary, our exportation became very considerable, and is still growing. In some districts of Bohemia, Moravia, and Galicia, thousands are engaged in the basket cottage industry, and have received great benefit; and wealth is rising out of the soil, where only a short time ago poverty was dominant. At present the Ministry of Cult and Instruction assi ns for the development of the basket industry alone 88,697 crowns, which are allocated as follows:—

	Crowns.
Central workshop for practical instruction, - - - - -	35,460
Professional schools of the State for basket work, - - - -	22,627
Subventions for 31 private schools and workshops, - - - -	30,610

It may be remarked that in Austria, besides the product of the osier plantations, Esparto, Piasava, rush, reed-grass, aspwood, splinters, and palm leaves are also used for basket-work. The present extension of the Austro-Hungarian basket industry is shewn by the following figures:—The number of basket-makers is at present 11,000. Of these, 1000 are occupied all the year long in basket-work shops, in manufactures for children-carriages, and for glass. The other 10,000 workmen, women and children, are rural industrials, who are, however, not occupied the whole year, some of them half a year, others only three months. The value of their products is nearly 5,000,000 crowns. Of this sum, the workmen are earning half. The value of the exports in the year 1901 was 1,200,000 crowns. To this sum are to be added 100,000 crowns for fruit-commerce baskets. England and the United States use enormous quantities of baskets of a special shape.

The domestic industries which depend on wood-working are capable of great extension. In the charming valley of Gröden (Tyrol) about 2000 persons—men, women, and children—occupy themselves in their spare hours with wood-carving and wood turnery. They manufacture with great ability crucifixes and toys. They make these objects with a few chisels only, and work all day long to earn a few pence. In another valley, the Viechtau, near Gmunden, in the province of Upper Austria, formerly a considerable cottage industry existed; but now there are only a few peasant houses where house implements and utensils are manufactured. The chief material, maple wood, becomes more scarce, and, therefore, more expensive; so it is probable that this industry will disappear. In the south of Krain, in the province of Austria, where beech forests furnish a cheap and highly-qualified material for the rural people, the latter occupy themselves on a considerable scale with manufacturing shovels, sieve hoops, and cooper's work. Rural wood industries, like the above-mentioned industry in Krain, are carried on in the eastern part of Moravia and the south-western mountain district of Bohemia (Böhmerwald). A large quantity of first-rate pine-wood has been preserved. An important speciality is the forming of resounding-boards of highly-qualified pine-wood. Very interesting examples of domestic industries are the chair-makers at Mariano, a village in the neighbourhood of Trieste, our most important Adriatic port. About 600 men and women are engaged in the manufacture of chairs. We have founded, with the aid of the professional school, a co-operative society, and a workshop with wood-working machinery; and so the production rose from 32,832 chairs in the year 1880 to 88,440 chairs, of the value of 143,660 crowns, in the year 1899. The material is exclusively beech-wood, brought from the neighbouring forests. A chair-maker earned, in 1880, 60 heller a day, while he now earns three times as much—2 crowns; and the consumption of meat is now nine times larger than before.

The cottage industries producing joiner-work at Vola (Sweden) and in the valley of Chiavari (Italy) have, in some degree, a certain resemblance to the above-described cottage industry at Mariano. No similar circumstances are to be found in Ireland. But it must be mentioned that cabinet-making exists, as you know, in one locality—Killarney. Here, however, a school of arts and crafts, founded by the Viscountess Castleross, has lately been producing work of the greatest promise.

At Cortina d'Ampezzo—very famous on account of the picturesque Dolomite mountains, highly appreciated by tourists—a trades school for wood-work (cabinet-making, carving, and turnery) has, through its students, created a cottage industry of importance. That is, especially, a certain manufacturing of Tar-Kashi ware (metal intarsia in wood—an Indian article), which has had great success. The number of workmen, with a tolerably good income, has risen to nearly 200 in the small town and its neighbouring cottages. They are also occupied in cabinet-making, joinery, and smith's work. Cortina will be very soon a centre for industrial arts, which signifies a great economic development.

A small town in the Böhmerwald is the seat of a wood-button turnery. The citizens—half peasants, half craftsmen—make, in a very primitive manner, buttons for tapestry work, for exportation, the material being alder-wood. The influence of the Imperial professional school at Tachau—the name of the town—has not been considerable.

In the northern corner of Bohemia there exists a very curious industry, which gives occupation to more than 3000 persons (men, women, children). The product of this industry is called "spartery," and consists in weaving thin and small splinters or chips from Russian white asp-wood on a loom. This product is employed to manufacture summer hats and other fancy articles, The centre of this industry has been for more than a century at Alt-Ehrenberg.

The rural industries of the nations which occupy the east of Galicia (Polonian province of Austria) and of the Bukowina, if not of much importance from the economic point of view, are still very interesting for artisans—the Hazuls and the Tsiganes (gipsies). The ornaments and the style are original, and, at the same time, traditional, showing the character of a special culture. The form and ornamentation of these products are as primitive as the methods of their workmen. The number of the domestic industrial working men and women in the Bukowina is estimated at 20,000, and the value of the wood consumed by them 3,000,000 crowns. The professional schools at Zakopane and Kolomea produce a very successful influence on the rural wood industry of the East.

There are in Austria very remarkable examples of cottage industries, by which iron and steel are worked up to locks, knives, various cutting tools, and household implements. In Galicia there exists a locksmith's trade-colony (Swiatniki). The knife-making industry is spread over the district of Steyr, in Upper Austria; tools are worked in Fulpnes (Tyrol). In all these places the Ministry of Public Instruction has organized professional schools, trades' day classes, with theoretical instruction and manual training in modern-equipped workshop. The "Special Service," of which I shall speak later on, has also in these places organized co-operative societies, which are under the supervision of the school authorities. Very good results may be expected; for instancc, at Swiatniki, in the year 1901, 60,000 parts of locks were manufactured. Steyr and Fulpmes are beginning to fight successfully against the dangerous competition of Solingen, in Germany.

While in Austria, as we have seen, there are old national cottage industries for iron and steel work, there is in Ireland one example of metal-work produced, and this is a recently-founded industry, the *repoussé* metal-work of Fivemiletown. Cottage industries have flourished in Fivemiletown for several years, under the direction of Mrs. Montgomery, of Blessingborne, who has organized embroidery and sewing classes for girls. Mrs. Montgomery wished to extend the scope of the work, and to find occupation to which the young men, as well as the young women, of Fivemiletown could devote their spare hours. She went to London in 1891, and placed herself under the tuition of a lady teacher in *repoussé* metal-work, who had been recommended to her by the Home Arts and Industries Association, and by the spring of 1892 she was able to start an art metal-work class at Fivemiletown itself. She was at first the only teacher, but was soon ably seconded by Mr. Wilson, the manager of the Fivemiletown branch of the Northern Bank. The Fivemiletown *repoussé* work earned the most favourable notice and the warmest praise of many exhibitions: one of the judges gave expression to the opinion that he had seldom seen modern work approach so high a standard of excellence.

The Belleek pottery ware, which has been made so popular by its characteristic lustre and tint, is the one pottery industry of any considerable extent in Ireland; but in Austria there are many considerable centres—one in nearly every province. Very remarkable are the peasants' Majolicas in several districts of Galicia, and of Lüstenau, in Vorarlberg.

The movement for the general introduction of Drawing into public schools, and the work that has been done to promote art education, with the purpose of developing and improving the art industries of a nation, appeared alike suddenly in Europe and in the United States. In England it was, apparently, the definite result of the first world's fair —the Exhibition of 1851. In Austria it had its origin in Vienna; in the United States, in Boston, where it was a direct outcome of the English movement. Other States—Germany, Belgium, the Scandinavian countries—followed soon. France alone did not need new institutions, for there the superiority of taste and artistic ability has never been wanting. But France did not forget that scientific and technical instruction is no less important than artistic ability, and, therefore, the Conservatoire des Arts et Metiers (which is a technological institute) had been organized in Paris before the end of the eighteenth century. About, or nearly, a hundred years later than in France other progressive nations began to realize that for a complete work, as well as for an industry, which will survive and not decay, artistic faculties are not sufficient; on the contrary, the first condition for a permanent success on the market is the technical and practical performance of the workman. We in Austria were famous for our products from the æsthetic point of view; but we missed in our workshops the knowledge and employment of scientific technical progress, the accuracy of handicraft, the durability and exactitude of the products, thescrupulous choice of the raw material—the genuine technical element.

Consequently, I thought of getting help from a technological institution, or museum, which consists of a number of lower and higher trades-schools, industrial schools, testing stations, technological collections, scientific laboratories and workshops for the training of handicraft, etc. I have already shown how we developed the basket industry, and how we had to perfect wood-carving and turnery in cottage industries for the manufacturing of household implements, toys, Christ-bodies, etc. Our success was not so great as in the basket industry, but our efforts were sufficiently rewarded.

But it would be wrong to think that the Vienna Technological Museum has nothing else to attend to but Cottage industries. It is hard to distinguish in a great many cases where cottage industry ends and urban trade begins, and the same difficulty occurs sometimes to determine a line of demarcation between handicraft or trade and industry. I have not been pedantic in this matter; I have been trying to help wherever national labour would need my co-operation.

It would not be convenient to relate here the history of the development of the Technological Museum. I only want to mention that at first, in 1879, one section was inaugurated—the section for wood-work, basket-making, carving, turnery, cabinetmaking and joinery, carpentering, etc. All means for the promotion of labour have been employed; a collection of different varieties of wood, tools, machines for wood-working, selected products of the various industries which consist in wood-working, have been brought together. We opened evening classes and professional schools, published monographs about technological matters concerning wood industries, and made a series of experiments on various questions, etc.

According to the same scheme, we organized—encouraged by the success of the first—a second section for applied chemistry, especially for those branches which lacked institutions to sustain them—as dyeing, printing, bleaching, etc.

The third section has been devoted to metal-work trades and the construction of machines, and electric engineering. The collections have been enlarged, and the evening classes —at the beginning mere drawing courses and series of technological lessons—are now very complete.

Testing institutions for the paper industry, for brewing operations, for the quality (strength) of building and construction of materials, for chemistry, for electric engineering, all in connection with our lower and superior professional schools, became from day to day more appreciated and popular, and the Parliamentary Grant, increasing till the year 1885, when it reached the sum of 800,000 crowns, is now a very modest contribution to our yearly expenditure of 380,000 crowns.

The staff of the Institute consisted, at the opening of the first section, of two volunteers (that is, myself and my assistant), a clerk, and a servant. At present more than 100 persons are engaged—professors, assistants, teachers, clerks, etc., etc. We have now nearly 1200 students, and the buildings devoted to the constitution by the Lower Austrian Industrial Society (Nieder-oesterreichischer Gewerbe-Verein) cost a sum of 1,200,000 crowns (£56,000), not including the value of the outfitting, machinery, etc.

You must not forget that exclusively technical instruction is our task—experimental science, drawing, mathematics, and technology, as the head branches of the so-called theoretical instruction, combined with workshop practice, and experimental study in the laboratories; and you may find in our schools apprentices for various trades, as well as students who come from universities and high technical colleges, to find in our laboratories a supplementary scientific training.

A very important enlargement of the Technological Museum took place in the year 1892, in consequence of a motion of my political friends in Parliament: a new (the fifth) section was joined to the former four; that is the Service for the promotion of Trades.

But while these four former sections (for wood and metal-work, for electric engineering, and for applied chemistry) were, and are, intended for the rising industrial generation, the new "Service" is destined to bring direct and, as far as possible, immediate help to those grown-up men as are already carrying on their profession as masters, foremen, or journeymen. A very important administrative difference is that it divides the jurisdictions of the Boards of Education and of Trade. You can easily fancy that such an opportunity for red-tape difficulties was not altogether thrown away.

Nevertheless, this fifth section of the Museum—namely, the Service for the promotion of Trades—has within these ten years grown to be a very large Board itself, with about seventy officers, under my direction, and it now carries out the following duties:

1. It keeps an *intelligence office*, which is very much applied to by all sorts of tradesmen when they are about to buy machines, to introduce new methods of work or new articles, when they wish to form co-operative societies, and in all such questions. The office has experts for the various branches of industry, and agents in the provinces.

2. Classes for Masters exist now, for shoemakers, tailors, carpenters, builders, joiners, locksmiths, and tool-makers, and for galvanisers. In course of preparation are classes for plumbers, (canal-boat) barge-builders, electricians, etc.

A feature common to all these classes is that only the best and only carefully selected men are admitted, who may be expected to transfer the newly-acquired knowledge to their fellow-tradesmen in the guilds and in co-operative societies, or to their apprentices. The classes, then, must not last too long—from four to twelve weeks at the most—with a very intensive instruction from morning till evening, and to all the students an allowance is made in the form of stipends, varying from 100 to 240 crowns, for the loss of their usual wages or gains during the attendance of the class.

The object of the teaching in the classes is to make the student thoroughly acquainted with the modern technical methods of his trade, with book-keeping and with calculation; all this according to the exigencies of a trade of medium size, or of a co-operative society. The student becomes interested in the modern methods of work, and is, in a model workshop, instructed in the use of labour-saving machines. Although the classes began but a few years ago, more than 250 have been held in Vienna and in the provinces, with more than 5000 students.

3. The Promotion of Co-operative Societies was also taken up by the Service. This is the most important and also the most difficult and the most costly task of the Service. Co-operation is promoted in every way by the

Service, but chiefly by giving loans, or by lending machines to industrial societies of workmen or tradesmen. The machines must be paid for by instalments; presents are strictly prohibited. Other conditions for granting machines are the following: No tradesman may be the borrower of a machine, only associations; the machines themselves are lent, not the money to buy them; the machines are chosen, bought, and tested by the Service, and remain the property of the State until the last of the yearly instalments, usually ten in number, have been paid; the expense of building the workshop must be provided for by the society, because building loans are not given. The Service always keeps in contact with the societies, watches over their technical management and bookkeeping, and helps them as much as possible when they are under difficulties.

The Service might, of course, simplify matters, and cut down its expenditure by limiting its task to handing over the machines or the loans; but I think there are benefits which oblige the giver rather more than the receiver, and the Service, therefore, incurs the responsibility of seeing that the machines become really profitable to the users, and that co-operation will be an unmixed blessing to the members of the society.

A few statistics will give you an idea of the extent to which this branch of the Service has grown. Since 1893 to more than 200 societies or associations of various kinds, machines have been given of the value of more than 600,000 crowns (£25,000), and loans averaging 4000 crowns (£166) each to fifty societies.

And what has been the success of all these exertions, you may be eager to ask? Naturally, we have had failures, but, on the whole, we may be satisfied with the results of our work: the co-operative movement has been quickened, to many able tradesmen new and fairer chances of economic prosperity have been given, and finally, we prove that, contrary to what the Manchester School tried to make us believe, handicraft must by no means disappear, but may, under certain conditions, flourish and thrive alongside of manufacturing industry.

I have finished. I gave you, what I thought convenient on this opportunity, as far as I understood the task entrusted to me. I will not neglect, however, to offer you the opportunity of making further use of my experiences now, and at any time you might require them; for I consider that industrial progress ought not to be the exclusive privilege of one nation or one state, but an acquirement for the whole of the labouring classes fighting for their every-day existence.

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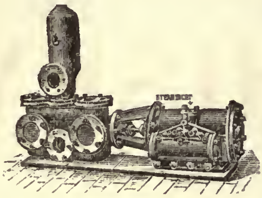

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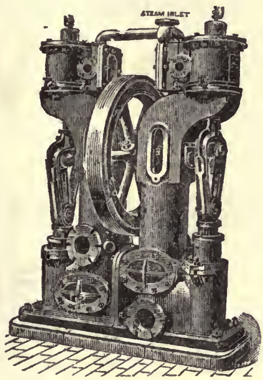

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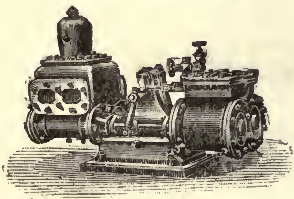

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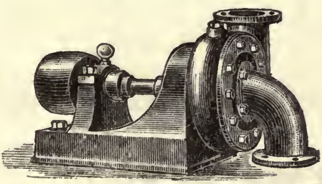

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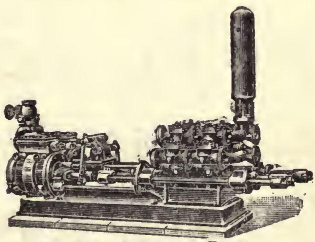

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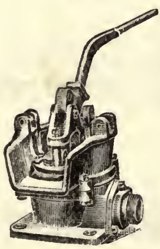

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