PART III.

ECONOMICS OF PEAT.

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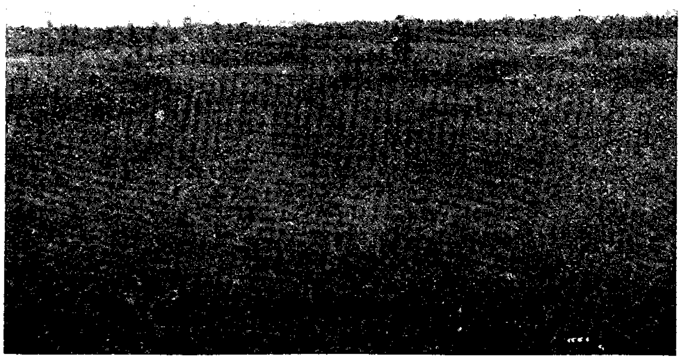

A PEAT BOG.

A SLANE OF THE OLDEN TIME, ABOUT 1760.

A MODERN SLANE.
(MADE BY O. AMES & SONS, NO. EASTON, MASS.)

PART III.

ECONOMICS OF PEAT.

MISCELLANEOUS USES OF PEAT.

Introductory: Peat is a substance of such common and abundant occurrence in the regions where it is found at all, and varies so much in texture and purity that it is not remarkable that it should be put to a variety of uses for which its composition, structure and other properties make it more or less perfectly fitted, especially in countries where other forms of raw materials are scarce and expensive, and where there is an abundance of various types of peat.

Uses in Agriculture: Long before it was considered as a source of manufactured material, however, it was used as a soil upon which to grow crops, and in a number of other ways by the farmers, and methods of improving "swamp," "marsh," "moor," "fen" and "muck" lands have been important problems in agriculture from early times. Some geologists, and others, make a technical distinction between muck and peat, applying the name peat only to nearly pure deposits of vegetable matter, while the name muck is given to those which have a considerable admixture of mineral matter in the form of mud or other finely divided rock débris, but among the farmers of Michigan and adjoining regions no such distinction is made and all classes of soil, from pure peat, to that with much mineral matter mixed with it, are called muck.

Importance of Muck Soils in Michigan Agriculture: Swamp lands, largely covered by peat and muck, are estimated according to Towar[1] to form one seventh of the entire area of Michigan, and since they are quite uniformly spread over the agricultural regions of the state, so that most farms of 100 acres or more have some part of their surface of this type of soil, it is apparent that they furnish a problem of some magnitude.

In the early days of farming in the state, these areas were considered worthless and were left in a wild and much neglected condition, as many still are, but as the higher and dryer lands have become less productive, and through improved conditions, drainage of swamps has become possible, the muck soils have attracted more and more of the attention of progressive farmers, and from being considered nearly worthless, and entirely

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[1] Towar, J. D., Loc. cit.

unproductive, they are now recognized as valuable and highly productive types of soil for many crops, and it is as farm land, perhaps, that peat will yield the largest returns. In spite of this fact, however, there are still great areas of such land in Michigan in a wild condition, which if they could be reclaimed, would add largely to the total wealth of the state, and to the individual resources of the owners.

Difficulties in Growing Crops in Muck Soils: It is apparent that there must be some reasons why swamp lands are neglected to such an extent, and these appear, when it is learned that in many cases there are serious difficulties encountered in securing paying crops from soils of this type, after they have been made ready for cultivation.

The causes of these difficulties naturally group themselves under the following heads:

(1) Those due to situation.
(2) Those due to the nature of the soil itself.
(3) Those due to impurities in the soil.
(4) Those due to unwise choice of crops.

Under (1) the following must be considered:

(a). The swamp is such because it lies in a situation where the ground water level rises nearly to, quite to, or above the surface of the ground, which causes the soil to be excessively wet.

(b). Swamps are usually located in depressions, and as cold air flows down hill just as water does, it accumulates over the swamps and causes unseasonable frosts during cool nights in the summer time.

(2) Peculiarities of the muck which give trouble are:

(a). The retention of vegetable structure, which gives it great power to take up and hold water, as is shown by the following table quoted by Carpenter[1] from Schubler, which gives the amount of water absorbed and retained without dripping by 100 pounds of the following soils:

	Pounds of water retained.	Per cent of evaporation in 4 hours.
Quartz sand	25	88.4
Lime sand	29	75.9
Clay soil	40	52.0
Heavy clay	61	34.9
Muck	181	25.5
Coarse peat	377 to 519	

The muck holds more then seven times as much as the sand and three times as much as the heavy clay.

(b). This water-holding property of muck makes it cold under ordinary moist conditions, since before the soil can be warmed the water which it holds must be warmed also.

(c). On the other hand, when dry, muck heats up very quickly, and radiates its acquired heat more rapidly than any other soil, making it very warm during the day and cold at night.

(d). When it has become thoroughly dried out, peat is often powdery, and very porous, and the dried particles become to a considerable degree, impervious to water, so that in dry times it does not readily be-

[1] Carpenter, R. C., Report Mich. Bd. of Agriculture, Lansing, 1886, p. 158.

come wet after it has once dried out. This property taken in connection with (c) makes it especially hard to deal with in times of drought.

(e). As has been pointed out in another place (page 214) peat may seem quite moist, and yet, because the water it contains is held in the remains of plant cells and tissues of which it is made, this is not available for absorption by the roots of growing plants.

(f). Because of its loose structure and lack of firmness and compactness when dry, it does not give good root hold to crops which grow tall.

(g). Because it is so wet during the fall and spring, when freezing and thawing are going on, crop plants wintered upon this type of soil are very liable to injury from frost "heaving."

(h). While very rich in plant foods, muck soils have some of the most important of these so combined with other substances that they are not readily available to the growing plants.

In this connection attention should be called to the work of the European bog and swamp culture societies and the excellent work which they have done and are doing in bringing large areas of unproductive moors and swamps into such condition that crops of some kinds can be raised on them. Since, however, European conditions of climate, of land holding, of labor, of crop production, and of markets are unlike ours, the methods used there can only be used in a general way here, but the thoroughness of the investigation of these societies, their wide scope and the excellent results make it seem that the work done by them should be followed in this country by that of similar organizations among land owners and farmers.

(3) The impurities injurious to crops which accumulate in peaty soils are of two classes, as follows:

(a). Organic acids.

(b). Mineral salts.

(a). It is a matter of common observation that muck soils are frequently so sour that they cannot be used for certain crops. This is due, in part, at least, to the presence of organic acids which are formed during the decomposition of the plant remains of which the muck is composed. The sourness seems to be due chiefly to humous acids, but ulmic acid is present in the browner types of peat and it is probable that tannic and other organic acids occur in small quantities. As all of these compounds are poisonous to a greater or less extent, it is evident that their presence is undesirable and may be harmful to particular plants.

(b). Of the mineral salts which occur in peat, and which are common in Michigan, ferrous sulphate or sulphate of iron, seems to be the most injurious to crop plants and sometimes makes the soil entirely useless. This is most often found in peat formed around springs and upon springy slopes, and the iron is doubtless derived from the water of the springs in which it exists as the carbonate.

Another soluble salt which is poisonous to crops is magnesium carbonate, probably derived from the soil below the peat and brought to the surface by capillary action, during the process of cultivation. This substance gives an alkaline reaction to the soil in which it is present, and is more likely to appear in injurious quantities after the soil has been cultivated for some time.

(4) From the consideration given above, it is evident that swamp

muck as a type of soil is not adapted to all kinds of crops, and moreover, all deposits cannot be treated alike, if satisfactory results are to be obtained from them after they are prepared for use. It must be remembered therefore, that it is often necessary for the owner of a piece of such land to make a special study of its possibilities and peculiarities before he can realize its full value and productivity.

In a large number of cases, for some years after reclamation, the surface of swamp land will be coarse textured and loose, because of the imperfect decomposition of the upper layers of the deposit, which adds to the difficulty of utilizing it to the best advantage, and it is probable that grass for hay or pasturage will generally give the most satisfactory results during the period while the surface is settling and becoming compacted and the coarse material broken down into that sufficiently fine for best agricultural use.

Methods Used in Reclaiming Swamp Lands: It is not the place here to go into the details of the methods of preparing swamp lands for profitable agriculture, but a statement of one essential may not be out of place. This is effectual and complete drainage, no simple matter, it is true, but without this, all authorities agree and experience shows that nothing satisfactory can be done.

Such soils should never be set on fire to improve their texture or composition. This point is enforced very strongly by the reply of the late Dr. R. C. Kedzie to a question as to the advisability of this practice, put to him at a Farmers' Institute in which he said in his emphatic way, "You might as well burn down your barn in order to sell the ashes."

Of the many papers contained in the reports of the Michigan Board of Agriculture, discussing methods of handling this kind of soils and of fitting them for farming and also giving results of actual experiments upon them in various parts of the state, the following are especially to be cited:

Carpenter, R. C.: The Improvement of Muck Swamps.
Report Mich. Board of Agriculture 1886, p. 154.
Rowe, W. A.: Treatment of Peaty Soils after Drainage. 1886, p. 175.
Kedzie, R. C.: Management of Swamps.
Bulletin 115, Mich. Agricultural Exp. Station.
Also in Report Mich. Bd. of Agric. 1895, p. 371.
Crozier, A. A.: Wheat on Muck Land.
Bulletin 141, Mich. Agricultural Exp. Station.
Also, in Report of Mich. Bd. of Agric. 1897, p. 284.
Towar, J. D.: Muck Experiments.
Bulletin 181, Mich. Agricultural Exp. Station.
Also, in Report Mich. Bd. of Agric. 1900, p. 275.
Towar, J. D.: Beet Experiments on Muck Land.
Bulletin 179, Mich. Agricultural Exp. Station.
Also, in Report Mich. Bd. of Agric. 1900, p. 235.

Many other references may be found by consulting the index to the Reports from 1849-1888.

In Holland, large areas of bog, after the peat has been used for fuel, are diked and drained, and make excellent farming lands, which support a considerable population.

Peat as a Fertilizer: Next in importance, so far as agriculture is concerned, to its use as a soil upon which to grow crops, peat has a well-recognized value as a fertilizer for other kinds of soil, particularly for those which are deficient in organic matter. When used for this purpose, it is either applied directly to the soil to be enriched, or after composting it with stable or barn-yard manure, a very desirable practice for which its great absorbent power especially fits it. If used without composting, it should be well rotted and in condition such that it crumbles readily when it is air dry, not in the form of hard lumps or stringy clods, and in order to reduce the coarser kinds to this condition, it should be piled in heaps and left exposed to the weather for a year or longer, until it loses its fibrous character and breaks down into the finer grained, more friable condition. The same exposure to the air and weather should be given the black, wet and sticky peat which is found in bogs below the water level, for if it is taken to the bog and put upon the fields in lumps, it dries into hard masses and clods, which are very difficult to break up when once they have dried and hardened, and are of no benefit whatever to the land. If, however, this material is thrown out upon the surface of the bog in heaps and allowed to drain and dry and to be exposed to freezing and thawing through the winter, it becomes thoroughly disintegrated and powdery, and then may be used with good effect. The drying out upon the bog also makes the handling the material so much the cheaper, since the peat loses a large part of the water which it has in the bog, often amounting to more than 90% of the weight of the whole load, the handling and hauling of which is, in large part, waste work. If a block of this black sticky peat is taken from the bog and measured and weighed before it has become dry, and then after, the importance of this way of treating it will become apparent.

If used as material for composting, peat is mixed in alternate layers with about equal bulk of stable or barn-yard manure, to which may be added weeds, straw, or any kind of undecomposed vegetable or animal matter, piled in heaps. The fermentation of the manure induces chemical changes in the peat also, and these changes make available to crops the nitrogen which is present in the peat in an unusable form, as well as other valuable constituents.

The peat also absorbs and holds a considerable part of the ammonia which is set free in the processes of decomposition, and which would otherwise escape into the air and be lost. Because of its power to take up and hold liquids, it prevents leaching of the more easily soluble solids, some of which are very valuable plant foods, and holds them in such a manner that they are saved to be used by the crops. If used in this way a load of dry peat may well be rated, as it often is, as valuable as a load of stable manure.

The following analyses of the Michigan celery soils show how rich the peaty types of soil are in nitrogen and in other essential elements for the growth of crop plants. In these soils, which are low-grade peat, the amount of mineral matter, as shown by the sand and silicates, is much larger than in pure peats, but as they are from typical localities where extensive use is made of the muck soils, they serve for illustration here.[1]

[1] Bulletin 99, Mich. Agricultural Exp. Station, Lansing, 1893, p. 12.

Kalamazoo Celery Soil, from Kalamazoo, Mich.

	Parts per 100.
Sand and silicates	19.16
Alumina	1.40
Oxide of iron	3.94
Lime	6.09
Magnesia	.81
Potash	.34
Soda	.38
Sulphuric acid	1.31
Phosphoric acid	.88
Carbonic acid	1.95
Organic matter containing 2.53 nitrogen	63.76
Water	6.51

Grand Haven Celery Soil, from Grand Haven, Mich.

	Parts per 100.
Sand and silicates	24.09
Alumina	1.71
Oxide of iron	3.52
Lime	5.02
Magnesia	.62
Potash	.20
Soda	.33
Sulphuric acid	1.04
Phosphoric acid	.69
Carbonic acid	1.05
Organic matter containing 2.32 nitrogen	61.73
Water	10.85

Newberry Celery Soil, from Newberry, Luce Co., Michigan.

	Parts per 100.
Sand and silicates	24.56
Alumina	2.21
Oxide of iron	1.30
Lime	4.18
Magnesia	.75
Potash	.42
Soda	.40
Sulphuric acid	.67
Phosphoric acid	.46
Carbonic acid	1.10
Organic matter containing 1.75 nitrogen	63.75
Water	7.31

In a discussion before the Michigan Horticultural Society, Dr. R. C. Kedzie,[1] than whom we have no higher authority in agricultural chemistry in this country, said in regard to use of muck for composting:

[1] Kedzie, R. C., Report Mich. State Hort. Soc., 1883, p. 168.

"Barn-yard manure composted with equal volume of powdery muck, by placing these materials in alternate layers, then shoveling it all over once, in the spring, a month before it goes to the garden or field, will give double the volume of the manure scarcely inferior to well-rotted barn-yard manure. Such composting is not a process of dilution but a substantial addition of manurial matter. Muck contains nearly the same quantity of combined nitrogen (2%) as well-rotted manure, but this nitrogen is in the inert or inactive form. By composition with barn-yard manure, the active fermentation of the animalized matter induces fermentation of the muck and some of the nitrogen is made active."

Stable and Barn-yard Litter: Peat may not only be used as composting material to excellent advantage, but also it has extensive use in Europe, and a more limited one in this country, (1) as stable litter and bedding for horses and stock, and (2) it is drawn into barn-yards and used there as an absorbent and deodorizer. (1) For bedding and stable litter, the best kind of material seems to be the coarse, top layers of the peat bogs, including the coarse mosses and grass-like plants which often make up the surface covering. In some cases dry, powdery peat is used, especially where a deodorizer is wanted, but the ideal material for bedding is the Sphagnum moss litter. This is very light in weight and from nearly white to light brown in color, when dry, absorbs large quantities of moisture in proportion to its bulk, and forms a springy layer, which is not surpassed by any other material used for the purpose. Aside from these qualities, it is a powerful deodorizer, and a disinfectant of some value, and accumulates and holds, to a marked degree, the nitrogenous materials of the manure, most of which are entirely wasted in ordinary practice. This material should be especially valuable for use in cities, and for bedding in dairy barns where odors, all kinds of germs, and dirt of all sorts, should be reduced to the smallest possible quantity, if the cleanliness and healthfulness, and consequently the value of the product and the health of the stock, and that of the patrons, are to be regarded. It could also be used by lumber companies for bedding horses at the camps in winter.

This form of litter is already in use in some of the large cities along the coast, being so highly valued that it is imported from Europe, and there seems no reason why large quantities of it should not be used in Michigan, where it is an abundant natural product, now almost entirely unused, or even wantonly wasted by periodical burning. At the present writing, a single establishment has put this material upon the market in a few places in limited amounts. This is the plant of the Bancroft Peat Fuel and Cement Company, Lt'd., located at Bancroft.

As it appears upon the market, the material is compressed in a dried state into bales, which makes it easy to handle and ship. The peat, usually the top layers, because too fibrous and coarse for other uses, and the mosses and finer vegetation growing upon them, may be prepared for litter in any disintegrator or fiber picker, or even in a corn shredder. With a hand machine, such as are made in several places in Germany, by Martin of Offenberg, or Paul Reuss, Artem, Germany, two men can prepare several tons of peat litter in a day. With a shredding machine or mill for grinding up turfy peat, and combined with a sifting machine to get rid of the fine dust and dirt, the air-dried peat of the coarse types could rapidly be reduced to a useful product, which, after thorough drying, may be baled like straw. In developing such machinery or adapting the ordinary farm machinery to these uses, it must be borne in mind that the bog is soft and that proper foundation of piles or stone work must be provided if the machinery is heavy and is to be placed upon the peat bog; in some of the German peat presses, however, the construction is such that no special base or support is required and such devices as are necessary can perhaps be developed here, to suit special cases.

In developing large plants for this purpose, it is probable that some form of dryer might be needed to give opportunity to run them during prolonged wet weather or during the winter. In Europe, many types of dryers have been patented for the drying of peat for various purposes, some of which are manufactured to order, and some are on the market continuously. Of these the rotary types seem to be most in favor as doing the work quickly and with economy. In drying the peat for this, as well as for other uses, it is well to remember that it is not necessary to get rid of all the moisture, but simply to reduce the fiber to the air-dry condition, containing from 15 to 20 per cent of moisture. If reduced lower than this, the cost is greater in proportion and the expense is wasted, since the material immediately takes up from the air sufficient moisture to give it the amount given above. In this country, because of the high cost of labor, most of the work of handling the peat for this as well as other purposes, must be done by machinery, and before attempting to develop the industry and to establish it upon a paying basis, no more profitable step can be taken than to thoroughly study the practice and machinery which have been developed in Germany and other countries of Europe, where the matter has been under investigation and has long passed the experimental stages of development; after which the markets in this country need to be studied, to see whether they will take the manufactured product in quantities which will warrant the erection of a plant. It may be said in passing, that some years ago an attempt was made in New Brunswick, where large deposits of nearly pure Sphagnum are found, to use these for the purposes under discussion, which resulted unsatisfactorily, because of the cost of production of the finished product, and the limited demand in the available markets, which, in this case, could be more cheaply supplied from Europe. The fine residue left after cleaning the peat for coarse litter may be used for fuel or sanitary purposes.

(2) The same kinds of peat which are used for stable litter, may often be used in the barn-yard with excellent results, acting both as a deodorizer and as an absorbent and saving much valuable fertilizing material. For this use the peat should be taken from the upper layers of the beds and should be well dried out before drawing. After the surface vegetation is removed from the bed to be used in this way, it may be plowed with shallow furrows in order to loosen up the fibrous peat, and then, after harrowing, the material may be turned over by a hay tedder, until thoroughly dry. The dry material may then be raked up and stacked, and it will keep dry for a long time, since only the outer layers of the stack will be wet even during prolonged rains, or it may be compressed and baled in a hay press, and stored under cover.

Dry powdery peat is also recommended for use in barn-yards and acts in much the same way as the coarser forms.

Peat as a Disinfectant for Farm Use: In many cases in isolated dwellings, the matter of sewage, cesspools and other receptacles of a similar nature, is a difficult one to handle, because of the cost of proper construction, and often, also, of materials for disinfecting them. The results of neglect are often the pollution of the water supply and many forms of bacterial or germ disease, the breeding of flies and mosquitoes and various other annoyances and positive dangers.

Dry, powdered peat, such as the screenings from cleaned peat fiber, or ordinary fine peat, either slightly charred, or in the ordinary air-dry state, mixed with 1% of powdered copperas (ferrous sulphate), is a very cheap and quite efficient disinfectant and deodorizer for all such places and makes the best material known for earth closets, urinals and vaults, being light in weight, cheap, odorless itself, very absorbent of both liquids and gases, and antiseptic, and is much more lasting in its effects and more easily handled than sand or dry earth, lime or ashes. After such use is made of it, it has high fertilizing value, either used directly or composted. Many efficient forms of peat closets, urinals, etc., are advertised by the European manufacturers of such articles.

Peat as Stock Food: At first thought, this would seem to be an impossible use for peat, but in various parts of Europe, especially in the regions where beet sugar is made, the molasses is fed to stock and sheep, and among other materials which have been used to take up the molasses, are peat powder and cleaned fibrous peat, which give the molasses body and make it possible for it to be eaten readily by the animals to which it is fed. This is not its only function, however, for it has been demonstrated, by actual analyses, that the peat has a certain food value and that part of it is assimilated by the animal eating it, moreover this mixture keeps well and does not ferment so readily as does the molasses alone. While such a mixture is not now known to be in use in this country, there is no reason why in Michigan some of the lighter colored peats should not be tried with success for this purpose, in the vicinity of the beet sugar factories, where the molasses may be had at a nominal cost.

For this purpose, also, it would be possible to use the finer refuse, or peat mull, from cleaning the coarser kinds of peat to make peat fiber and litter, if there was not too much actual dirt of indigestible kinds mixed with it, as would rarely be the case.

Peat as a Deodorizer and Disinfectant in Towns and Cities.

As has been pointed out in the previous section, peat is a good, cheap, and effective deodorizer and disinfectant. In 1880, according to Macfarlane[1] Dr. Ludwig Mappe in Braunschweig, first called the attention of the public to the value of peat litter, or "moss litter," as a deodorizer and absorbent for use in towns and cities, and a gradually increasing use for this material has since grown up. Its use as a public health measure has been adopted in several towns in Germany and in Congleton, Cheshire, England. It has also been used for years in Canada, at Caledonia Springs, to deodorize human refuse. The material is excellent for use in all places such as public urinals, stables, outhouses and slaughterhouses, where easily decomposed, noxious smelling compounds, whether liquid, or partly solid, accumulate to become the source of annoyance, or ac-

[1] Macfarlane, Th. Bulletin 97, Lab. Inland Rev. Dept., Ottawa, Can., 1904, p. 33.

tual danger to public health. One part by weight of the peat litter will deodorize and dry at least six parts of mixed excreta, giving a perfectly odorless and inoffensive product, which has a relatively high value, as compared with stable manure, when used as a fertilizer for all agricultural crops except those which, like celery, lettuce, and other vegetables eaten raw, for which it should never be used.

In Montreal, carefully conducted experiments on a large scale by Dr. Laberge, using moss litter produced in Welland county, Ont., show that 100 pounds of the litter dried and deodorized eight times as much excreta from the ordinary privy pits of that city, rendering it entirely free from odor, so much so that a sample of the product was kept in his office for a considerable time without attracting attention by any odor.[1]

There are many towns in Michigan where sewer systems of the ordinary type are lacking, or are practically impossible, and where the pubic health is continually menaced by existing conditions. In most of these, the general use of peat litter by the people and by the public officials would do away with many of the danger spots, which are now the breeding places of disease germs, flies, and vermin, and from which epidemics either have already originated or may develop at any time. For the use of these towns, local supplies of peat could easily be utilized, the product gathered and compressed under contract by the local health authorities, if no one else could be found to attend to the matter. A short period of compulsory use, would result, in most cases in the voluntary adoption of the method, just as the establishment of a system of sewers often results in the general connection with them, of residences along the lines, although compulsory connection at times has to be enforced.

Use in Hospitals: A form of antiseptic and exceedingly absorbent dressing for wounds made from peat has been prepared and used in Europe, where its absorptive power was found to be greater than that of cotton, and even when saturated with blood, showed no signs of decomposition even when not attended to for several days. Peat dressing was reported to be used by the Japanese surgeons during the Japan-Russian war, but no description of the preparation or use has been found. Certainly however, dried, properly prepared Sphagnum peat, or the dry moss, is a clean, very absorbent material and is said to be nearly or quite sterile, i. e., free from bacteria of any sort. In actual practice, however, since no chances should be taken where wounds are concerned, the material should be thoroughly steamed before use, thus insuring the sterilization. In a cotton producing country, it is probably true that a long time will pass before sterilized absorbent cotton will be superceded by peat dressing. A much more practical, and more valuable use for the coarse kinds of peat litter, properly sorted, for hospitals, is its utilization in the manufacture of mattresses and bedding. Here it has the advantages given above, viz.: it is very absorbent, a deodorizer and disinfectant, is practically sterile and more than all else, for this use, it has the advantage of being cheap, so that it may be renewed often. In addition it may be said, it is light in weight, is springy, if properly cured, and makes a better bed than most of the materials now in use for mattress making. The best type of peat for this purpose

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[1] Macfarlane op. cit. p. 35.

would be the superficial layers of either sedge or moss peat, the latter probably being the kind to be preferred. Where the material has been tried in Europe it is reported to be exceedingly satisfactory, and it is to be hoped that wherever beds are needed that have to be changed frequently, this material will be given a fair and impartial trial.

Destructive Distillation of Peat.

Like all other forms of fuel, which are of vegetable origin, peat is capable of being decomposed into a series of simpler chemical compounds when heated in closed receptacles away from the air. Wood and bituminous coal are treated in this way on a very extensive scale, the main products sought being charcoal, from the wood, and coke, or, in certain cases, gas for illuminating and heating, or power, from the coal. The general process, known as destructive distillation, consists of heating the substances of organic origin in heaps or mounds, covered with earth, or some form of vessel or structure, which is so arranged that air is entirely excluded, or is allowed to enter only to a very limited extent, while means of exit are provided for the gaseous products of the decomposition brought about by the heat, either directly to the outside air or through tubes, so that the escaping vapors may be cooled, condensed and saved, since some of them have commercial value. The familiar charcoal kiln, a dome-shaped brick structure in which wood is stacked and a fire started in the stacks, to be controlled by carefully regulated draught openings at the bottom, while the gases escape into the air at the top, is a crude form of apparatus in which wood is converted into charcoal, the gases and other volatile matters being allowed to go to waste, except the heavy wood tar, which usually condenses on the inside of the kiln. More elaborately and scientifically built charcoal kilns are constructed of iron, and are heated from the outside, the gases liberated being conducted through properly built flues, so that they may be saved by condensation and used. If the gases from wood distillation are saved, the lightest ones cannot readily be condensed into liquids, but as gases they take fire readily and burn with great heat, and may be used for illumination, heating or for generating power in gas engines. In good practice, in wood and coal distillation, these gases are used either to heat the kilns, or retorts, or are burned under boilers to generate steam for engines used about the plant, as they are in the best processes in coking peat abroad. With these gases comes a series of substances which are liquids at ordinary temperatures, chief of which, are water, various organic acids, wood alcohol, creosote and tar. In the same way that wood yields charcoal and these other substances, for which thousands of cords of wood involving the stripping of hundreds of acres of woodlands annually in Michigan alone, peat may be used as a source of practically the same series, and, in many cases, to quite as good advantage. This is by far the most rational and scientific way of preparing peat for use as fuel when it is to be transported for some distance from the bog, especially if the by-products are saved.

Peat Coke and By-Products: The coke made from peat is jet black, firm and hard, has the fibrous or columnar structure of coke made from coal, and like it, rings slightly when struck. It is as free from sulphur and phosphorus as charcoal, all of the sulphur being contained in the ash as sulphates and has a thermal value of about 7,000 units (from 6,776 to 7,800 calories). With less prolonged heating, substances less hard and firm, similar to charcoal in efficiency, are obtained by the destructive distillation of peat.

In Germany, where peat coke is said to have been used in the smelting works at Freyburg as early as 1360, and where many unsuccessful attempts have been made since that time to develop a commercially successful product, the inventions of Ziegler and others have carried the process of coking peat beyond the experimental stages, and it is now reported by careful students of the subject, to be manufactured on a paying basis; such of the coke as is on the market sells readily at from $9.50 to $12.00 per ton, and is used for copper refining, smelting foundry iron and for other metal working processes, but the industry is still in too undeveloped a condition to furnish the coke for use in blast furnaces, although it is in every way as desirable for this purpose as the best wood charcoal.

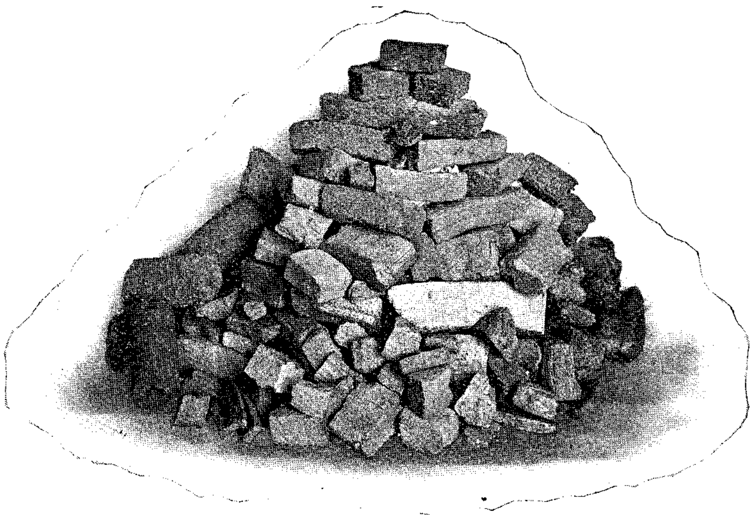
A sample of peat coke from Germany, made by the Ziegler process, was recently examined by the writer. It was jet black in color, as hard and as firm as a good grade of hardwood charcoal, or possibly even firmer than this, and showed the character of the peat from which it was made so well that it was possible to determine this to be of coarse texture, chiefly remains of shrubby plants. Apparently the peat had not been ground or in any way treated, except to cut it from the deposit and dry it, before it was coked. The material appeared to have been originally like that of the uppermost layers of peat in thousands of acres of Michigan swamps of a grade most of which would have to be rejected in the manufacture of briquetted peat fuel, and it would appear that a more compact and finer grained peat, coked to the same degree as this sample, would yield even a better grade of coke.

The makers of this peat coke report that it stands the pressure exerted in blast furnaces better than charcoal, not crushing in an 80-foot blast furnace, and equally as well as coke produced from coal. Whether this statement applies to the charcoal produced in Europe from the softer woods or to that made in this country, as in Michigan, where the sound and largest logs of the finest birch and maple timber are still cut up and converted into charcoal, does not appear. The cost of production is less than that of charcoal and the actual cost is given in another place (page 300).

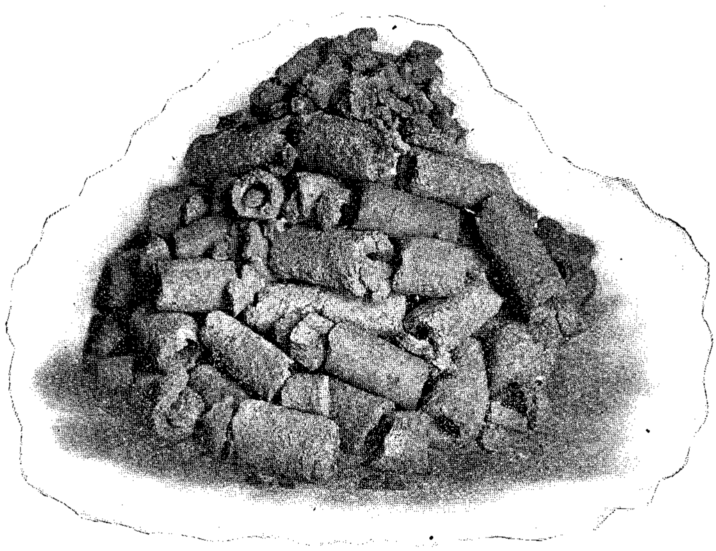
If such fuel can be made from an inferior grade of peat, at as low a cost as quoted, there would seem to be no good reason why the remaining forest lands of the state, and especially of the Northern Peninsula, should be stripped to make charcoal for use in smelting iron, while quite as near at hand to the iron mines as the forests are large deposits of good peat entirely unutilized. Such utilization of peat would leave the vast quantities of timber now converted into charcoal, to serve as the basis for other industries.

It may also be used anywhere and for any purpose where an efficient, smokeless fuel is required, or in industries where such fuel is necessary In domestic use it may be used in base-burner heating stoves, kitchen stoves and in other places where charcoal is now used, but will probably never successfully compete with anthracite for general use.

Besides the coke, there are obtained as secondary products, in this



PEAT FUEL, BROKEN.



PEAT COKE, BROKEN.

method of preparing peat, gas, which is used to carry on the process of coking after this is once started, tar, and lighter liquors which yield various products on proper treatment, and which nearly if not quite, pay for the cost of the whole operation.

The amount of coke yielded from a given weight of peat ranges from 30% to 45%, in round numbers about 1/3, but varying with the compactness of the original material and the length and intensity of heating, the highest yield being obtained, and the best coke, from artificially compacted peat. If heated a shorter time, peat charcoal, much less compact and more friable, is obtained.

According to German figures and prices, a metric ton, nearly equaling the long ton of 2,240 pounds, of dried peat, costing for all charges of digging, handling, drying and delivery to the kiln, $1.19, yields the following returns:

Substances.	Amount.	Value (U. S. currency).
Peat coke	777.6 lbs.	$3.75
Tar	88.2	.52
Wood alcohol	13.2	1.00
Lime acetate	13.2	.17
Ammonium sulphate	8.8	.21
	Total	$5.65

besides gas in excess of the amount required to dry and coke the peat, which may be estimated to be worth for the purposes for which it is used, at least 25% of the value of the coke. No other fuel than this gas is used in drying and coking the peat after the process is started.

Another writer gives as the results of factory tests the products from one ton of peat, as follows:

Peat coke	700 lbs.	
Tar water	800	
Tar	80	
Gas	420	(6,650 cu. ft.)
The tar water yielded:		
Acetic acid	12 lbs.	
Wood alcohol	12	
Ammonium sulphate	8	

The Ziegler process, which seems to be the most successful of those in use in the peat-producing parts of Germany and Russia, is continuous, and, as pointed out below, self-sustaining.

The facts regarding this process are largely compiled from data most kindly furnished by Dr. Otto Zwingenberger, the representative in America of the company controlling the Ziegler patents and manufacturing the machinery for making coke from peat by this method.

The first plant using the process was erected in Oldenburg in 1897, and after careful examination by an expert employed for the purpose by the Prussian State Department of Trade, on his recommendation, this process was adopted for the utilization of extensive peat bogs owned by the Prussian government.

A second plant was built in 1901 in Redkino, for the Russian government. This plant runs 8 furnaces, each manufacturing 5,000 tons of peat coke per year.

The latest plant to be built is that at Benerberg, South Bavaria, where the South Bavarian Coke Works and Manufactory of Chemical Products Joint Stock Company of Munich, which now controls the Ziegler patents, has its headquarters. This new plant has four furnaces and is equipped for recovering the by-products from the tar and tar water saved from the distillation of the peat, and went into operation in 1906. The process used by these establishments consists in carbonizing the dried "machine" or compressed peat in closed retorts heated by burning under them the gases liberated from the peat by the heat. The peat is cut from the bogs, compacted, and molded into square blocks by ordinary peat machines coming out as "machine-peat." It has, at this stage, from 80% to 90% of moisture and is allowed to dry in the open air until it contains only about 50% or 60%. After this preliminary drying, it is removed to drying chambers, heated by the waste heat from the retorts and burning gases from the furnaces, and is passed slowly through these and comes out with from 20% to 25% of water. From these dryers it is carried to the top of the iron retorts of special form by endless belts, and at regular times is placed in these air-tight, vertical receptacles. In this thorough drying to the point of crispness, at no expense for fuel, so that it is rapidly carbonized when placed in the retorts, seems to lie the chief secret of success in the recent process as compared with older ones, for when the peat was placed wet in the kilns, the water was only driven off with great waste of time, heat, and of fuel, so great that there was no margin of profit in the operation. The economy of the Ziegler method of drying the peat, first in the air, and later by waste heat, generated by the combustion of what would be otherwise waste gases, is apparent when compared with processes which used separate drying chambers, heated independently by the use of costly fuel and allowed the combustible gases and other valuable, volatile, but condensible vapors, from the retorts to escape into the air, and be wasted.

The condensible gases are not wasted by this system, but are conducted through proper cooling apparatus and then redistilled by the use of excess of heat, generated by the process of coking, into a number of commercially valuable products.

These vary in quantity, according to the thoroughness of the coking, and the quality of the peat, that with high ash content, giving a smaller per cent of volatile matter than that with low; the coking is carried farther with peats with a small per cent of ash than with those with a large per cent, the resulting products being sold as No. 1 peat coke—that most completely coked, and No. 2 peat coke or "half coke."

No. 1 peat coke is somewhat harder than the half coke, and the latter burns somewhat more freely and with a more noticeable flame, and it is not so well adapted to metallurgical processes as No. 1 peat coke. The peats with high per cent of ash, since this is mineral matter and does not volatilize when heated, give a larger per cent of coke, which, however, does not give good heating results, as the ash will not burn.

The proportionate amounts of the various products obtained by coking

100 parts of air-dry, 20% to 25% moisture, machine-peat, are shown in the following table:

	No. 1 Peat coke.	No. 2 Peat coke.
Peat coke	33.0 per cent.	45.0–50.0 per cent.
Tar	4.5	2.0
Tar water	40.5	38.0
Gases	22.0	15.0

Carrying the processes farther to make by-products by redistillation;

No. 1 Peat coke 33.0 per cent is untreated.		
Tar..........	4.5 " " properly treated yields	2.0 per cent of light oil.[1]
		0.7 " " heavy oil.[2]
		0.3 " " Paraffin.
		1.3 " " Phenolates.
Tar water......	40.5 per cent will give..........	0.2 " " Asphaltum.
		0.34 " " Wood alcohol.
		0.31 " " Ammonium. Sulphate
		0.50 " " Acetate of Lime.

Gases....22.0 per cent not condensible, but burned under boilers and dryers.

The per cents of ash and of tar obtained vary according to the quality of the peat used. The coke may be increased in quality by using briquetted peat. This also gives the coke somewhat greater density.

Products from the tar, and the tar itself, are of considerable value as preservatives of wood used for railroad ties, posts, poles, and timbers for all structural purposes, both when applied as paints externally, or when forced into the wood as impregnating substances. The hydrocarbons of the oils are of the aromatic series, and from them a series of useful chemical compounds can be obtained.

In regard to the cost of producing peat coke, Dr. Zwingenberger says: "Its price is cheaper than that of charcoal; by saving the by-products, the cost of one ton of peat coke is about $2.00 to $2.15 in running the smallest type of Ziegler plant, containing four ovens, taking in consideration the high wages paid in America, and including depreciation, etc. In a larger plant of about 20 ovens, the value of the by-products will nearly pay all the expenses and give the coke free."

Peat coke being cooled in closed receptacles to prevent its taking fire, does not contain water, since after cooling it is not absorbent, while charcoal sometimes takes up considerable water.

In Germany peat coke is used successfully in several places, among which may be mentioned the Krupp-Gruson Works, where it is used in the form of a powder for hardening armor plates, and the Bleymueller Works at Bleyberg, near Schmalkalden, in a blast furnace. Siemens and Halske, Berlin, have found it an excellent raw material for the production of a high grade of calcium carbide.

In Russia, as noted elsewhere, peat coke is being used on the government railways as fuel for locomotives.

[1] Sp. Gr. 0.835. May be used for lighting.
[2] Sp. Gr. 0.838. May be used for lubricating oil.

The capacity of each furnace, or retort, as at first constructed, was about 11,668 pounds of coke, 13,333 pounds of tar water, 1,333 pounds of tar, and 7,000 pounds of gas (110,850 cu. ft.) from 33,333 pounds of air-dry peat (20% to 25% of moisture) in 24 hours. At the Imperial Russian Krons Peat Factory, at Redkino, each of the eight retorts cokes from 24 to 30 tons of machine-peat having 25% of water in 24 hours, a larger output than the above quoted figures show.

The cost of a four-oven plant, for making peat coke by this process, with all necessary machinery for cutting, drying and handling the peat, and the apparatus for making the by-products from the waste liquors, was given in 1903 to be $95,200. Such a plant was estimated to handle 15,000 tons of dry peat per year, from which products could be made, which would sell at the wholesale market prices of that time, in Germany, for about $117,500, nearly one-half of which, after deducting all expenses for the cost of peat, handling, labor and wear of plant, repairs, etc., should be profit.

Another set of figures obtained from Hon. J. M. Longyear, who had them from J. J. Hill, gives the following as the cost of a peat coking plant, German process:

Two peat coke ovens, capacity 30 tons air-dry peat, each yielding 10 tons of No. 1 coke or 13.5 tons of No. 2 coke per (24 hours) day	$20,000
Drying and other machinery	8,000
Apparatus for distilling tar water	7,000
Total	$35,000

A plant of 10 ovens, with a capacity of about 100 tons of No. 1 coke per day can be had for $175,000, and the estimated cost of a second plant after the first is constructed is 25% less than this.

So far as known there are no peat coke plants in this country which are producing the material in such quantities that it is sold in the open market.

Peat coke was also made in Norway for several years by the use of electrically heated retorts, the electricity being generated by water power, the plant using the Jebsen process, which produces a dense, very compact coke, showing the structure of the peat, having a specific gravity of 0.3 in broken condition. Its heating value is about that reported for that made by the Ziegler process. It is reported that it burns well, and gives but little soot and ash, and clinker is small in quantity and does not clog the fire as does that of ordinary coal and of lignite.

This process involves the partial drying and pressing the peat into blocks 30 inches long, by 3 inches square on the ends. The blocks are turned out at the rate of 2,500 per hour and loaded on specially designed carriages with shelves, which are then run into the cool end of a drying tunnel, which is heated by the waste gases from the retorts. At the entrance end, the temperature is about 50° C., while at the exit end, it is from 90° to 100° C., the air being driven through the tunnels by electric fans. From the drying tunnel, the peat is taken to the retorts, which are vertical and are about 6 feet high by 3 feet in diameter, each with a cover above, and a discharging hole below, and each is also provided with pipes for the escape of the gas and with a pressure gauge. After charging with the dry blocks, the top cover is clamped down and the current turned on and the peat is carbonized. When the heating is completed, the retort is allowed to cool to 130° C., after which the coke is discharged directly into cars on tracks below the retorts. The average yield of air-dried peat by this process was given as:

Peat coke	33%
Tar	4
Tar water	40
Gas	23

The coke was said to find ready sale in near-by towns, and the plant had been running three years when described in 1902, but was closed later for lack of financial support.

Analyses of peat coke made by the Jebsen process, reported by the Royal Norwegian High School in Christiania gave the following as the average composition:

Carbon	76.91%
Hydrogen	4.64
Oxygen	8.15
Nitrogen	1.78
Sulphur	0.70
Ash	3.00
Moisture	4.82
	100.00%

Another electric process has been devised in England, but so far as known, it had not passed beyond the experimental stages.

Peat Gas: Because of the undecomposed condition of the vegetable matter of peat and the large amount of volatile matter which it contains, it is not remarkable that it should have been used often, in an experimental way, as a source of gas for various purposes, but in northern Europe, especially in Sweden, the use of the gas for heating and lighting has gone beyond the experimental stages and has reached the stage of commercial success.

In considering the methods of making peat coke just described, the value of the gases developed in the destructive distillation of the peat has been dwelt upon at length. This gas is reported by those who have used it to be a better illuminant than coal gas, to be more easily produced, with simpler apparatus, to be more easily purified than coal gas, and that the yield per ton of the dried material is greater. This last statement is probably true, because of the less complete decomposition of the peat as compared with coal, which makes it relatively high in gases. On the other hand it must be remembered that the peat, with 90% of water, has to be dried by some process before gas can be made from it, and that it is only by using the least expensive process to accomplish this that peat gas can be made economically upon a commercial basis.

The quantity of gas obtained in Sweden from a metric ton (2,204 lbs.) of peat having 8.6%, or more, of ash and high hydroscopic moisture content is given by Dal as 2,520 cu. meters or 89,000 cu. ft. This gas, however, is more than half its volume Nitrogen, as shown by the accompanying analysis:

	Per cent of volume.
CO_2	6.9
CO	26.
C_2H_4	0.5
CH_4	4.4
H	8.5
N	53.7

Better grades of peat yield a larger volume of fuel gases. The amount of gas yielded by English cannel coals per ton, is indicated in the following table:

Newcastle cannel	9,883 cu. ft.
Wigan cannel	10,850
Boghead cannel	13,334

while a ton of peat by the Ziegler process only gives 6,650 cu. ft., which, considering that the peat has 20 to 25% of moisture at the start and costs, at the bog, a little less than a third as much as the coal, really gives the peat the advantage, especially since the peat coke will command a much higher price than gas coke, on account of its freedom from sulphur and other objectionable matter.

The great efficiency of gas engines of the explosive types, the rapid increase in size and the very material increase in the use of these, in many places where steam engines have, until recently, held the entire field, opens up an important field for the use of easily ignited gases; this has resulted in a demand for cheap and efficient gas generating machines, which will furnish gas at a lower price than it is furnished by the large private or public companies which manufacture coal gas, or which can be used where no public plants are in use. This demand has been met by a large number of gas generators of small size, designed to be used in connection with gas engines, to utilize poor grades of coal, some of which are very successful, and it would seem that special forms of these could be developed, in which the gas could be generated from air-dried peat, and thus work up an important field of use for this fuel. By those who have experimented with it in this direction, peat gas is said to be particularly adapted for use in gas engines, and the only phases of development lacking are the proper forms of generator for making the gas and an assured and constant supply of prepared peat which consumers can get as needed.

In still another way may peat gas be utilized on a large scale, as suggested in another place. That is by building large gas generating plants, with proper equipment for utilizing all gaseous by-products, at the margin of large peat bogs and piping the gas to centers of consumption. This would reduce the cost of manufacture, by doing away with the transportation charges on the crude fuel, and would be no more difficult to bring about than piping oil or natural gas long distances. That peat gas is being considered as a possible cheap fuel and is likely to be utilized before long, is indicated by the recent (June, 1906) newspaper notice of a project for the establishment of a plant for producing the gas near Ogdensburg, N. Y., and utilizing it in the manufacture of steel. In developing this, as well as other phases of utilization of peat, a thorough investigation of European experiments and established plants is recommended. It is worth noting here that there are large quantities of peat near the Lake Superior iron mines, which might be utilized in the production of charcoal iron and for furnishing power either steam, compressed air, gas or electric for developing and operating the mines.

Paper Pulp, Paper and Cardboard.

One of the more recent uses to which certain grades of peat have been put, is the manufacture of paper pulp and various grades of paper. This is of interest in this region because of the establishment of a plant in Michigan, near Capac, for the purpose of making peat into paper, which, in this case, is reported to be used for building purposes.

The chief advantage in the use of peat for paper stock is its cheapness of material, particularly as the prices of other sorts of material and especially wood pulp are constantly increasing, as the wood supply becomes more and more depleted. In one of the processes for making paper from peat, the Zschoerner process, the peat is placed in a disintegrator, where it is treated with alkalies in dilute solution and at low temperature, but high pressure, until some of the vegetable and earthy matters are extracted from the fibrous material. This fiber is then oxidized, bleached and washed to further clean it, and again subjected to cold, dilute alkali solution under high pressure to get rid of the remainder of the soluble mineral matter, after which it is thoroughly washed, when it is ready for use. This bleached material may be used by itself, or mixed with other paper stock to make nearly any grade of paper in ordinary use, as the fiber thus obtained is strong and durable. In making the coarser grades of paper and pulp board, less care is taken to cleanse the fiber of all coloring and foreign matter.

The type of peat best adapted to this use is undoubtedly that made by grasses and sedges, since these plants furnish the most fibrous material in stems, leaves and root-stocks. In prospecting peat deposits for this use, care should be taken to find the depth and amount of fibrous layers and to avoid the filled lake basins, unless of large extent, as usually these have only a shallow, surface layer of material suitable for the purpose, while thinner, built-up deposits, may have practically the entire depth of more or less coarse, poorly decomposed, fibrous peat. These will be found in shallow basins and on terraces, and may, at present, be covered by tree or shrubby growth, or by moss. Moss peat, despite many statements to the contrary, contains no strong fibers whatever, except those produced by other plants, such as the sedges, which may grow with the moss as associates.

There were already in operation, in 1899, in Europe, several factories which produced large quantities of all kinds of paper, with peat as the source of most of the fiber, and these were reported as paying institutions. On the other hand, there are serious drawbacks to the economical use of peat in paper making, which may be summed up as follows: It is difficult to get rid of the dirt and waste; the peat is uneven in structure and in texture and often lacks sufficient of the stronger fibers, so that much other material has to be mixed with the peat stock to make paper sufficiently strong even for wrapping paper, so that it is reported that there is little peat paper on the European markets which is more than 75% peat; the peat pulp cannot be bleached to whiteness, so that only brown papers can be made, except in rare instances, hence the principal product of the European industry has been wrapping paper.

Pasteboard made of 40% of peat fiber and 60% of wood shavings is a standard product, both in Germany and in Sweden, and is said to be cheaper, lighter, stronger, and better than pasteboard made in the ordinary way.

Aside from the factories reported in Germany peat paper has been made in England, Ireland and Austria, as well as in the northern European countries, but with what financial success is not reported.

The plant of the American Peat and Fuel Company at Capac in this state, was leased in 1905 for two years, and has since been sold, to the Pilgrim Paper Company of New York, organized for the purpose of manufacturing and selling card-board, bill-board, feather-board, paper, and other products from peat under Austrian patents. The materials in the extensive bog owned by the company, had been carefully tested in the home factory of the company's process at Admont, Austria, and later at Capac, and produced highly satisfactory results, and the company is convinced that the processes have passed the experimental stage, and are confident of the success of their enterprise, for which the Capac peat bog is peculiarly adapted, having been built up, by successive elevation of water level, from the bottom, and hence has much coarse material at various depths.

Similar to a heavy paper, is the material known as "Heloxyle," made by compressing and hardening peat fiber, by a special process, into sheets, tiles and blocks for various building purposes. The sheets are used for lining walls, floors and other parts of buildings, or as flooring. The material is about as light and firm as good cork and is as impervious to moisture, as well as a good non-conductor of sound, heat, and vibration; when impregnated with some mineral substances, it is nearly fire-proof, all of which properties make it very desirable for use in dwellings and buildings, where protection is desired against noise and jar. It is one of the cheapest of all building materials in Germany and is easily nailed or glued, takes paint well, is light, clean and easy to handle, and hence is very desirable as a structural material. Other types of sheathing and builders' paper are discussed below.

Woven Fabrics from Peat.

By a course of treatment which separates and cleanses the fibrous parts of peat, and renders them pliable, they have been made into fabrics of various kinds, so that coats, hats, carpets, rugs, mattings and blankets have been manufactured from them and have proven quite durable. The most successful use of these fabrics has been in the form of blankets and other coverings for horses and cattle and for this use they are said to excel in warmth, durability, absorbent power and cleanliness.

Packing Material.

Peat litter has long been used, when properly cleaned, as packing material in shipping various breakable articles and those which perish easily, such as bulbs, fruit and living plants, by freight. For these purposes, the upper layers of moss peat are most desirable, and considerable quantities of this material are used yearly by florists and nursery-men, where they can readily get it. No industry has been developed, but a small business to supply the demand of the florists and nursery-men of the state and surrounding region, might be built up by someone to whom a moss covered bog of sufficient extent was accessible. The moss would best be compressed and baled for this purpose. Peat might also be used to pack fruits and vegetables to keep them fresh for winter use, as this material has many advantages over sand, the material generally used for the purpose. It is also suggested that it would be a desirable substance in which to pack eggs to preserve them.

Roofing and Sheathing Papers.

As has been mentioned, the extensive peat bog near Capac has been sold to a company which proposes to manufacture, among other products, a kind of builders' paper from the peat. The coarse-fibered peat is well adapted to this use, as well as the making of such material as "Heloxyle" mentioned above as a valuable building material. Coarse, felted material should also be easily made from the cleansed fiber, which would be an excellent non-conductor of heat for sheathing buildings. The paper thus prepared could also be rendered waterproof by soaking it in tar obtained by distillation of peat. The coarser, more fibrous parts of moss peat could be used, as is the marine plant known as "Eel Grass," which is spread in a thin layer between sheets of heavy paper and held in place by stitching through the paper. This material is used in the better classes of buildings, for sheathing paper.

Non-Conducting Packing Material.

Still another use has been made of both the fibrous peats and the finer grained, powdery types, as non-conducting filling or packing. This material is an excellent non-conductor of heat and sound, and has been used as such in Europe. The moss types make light, inodorous, sanitary and effective packing for use between the walls in refrigerators, ice houses, for packing ice, and to put between the walls of dwelling houses, and between floors and partitions to deaden sound. The same material would also be exceptionally valuable in the construction of the so-called caloric cookers. If used in connection with some mineral substances, which would reduce its inflammability, it would make very desirable felted covering for steam pipes, and could in any case be used to protect those buried in the ground from loss of heat, and also water pipes to keep them from freezing, for which use the cheapness and the durability as well as the porosity of the material would make it especially desirable.

Paving and Building Blocks.

Blocks of material for special uses made from peat, by special processes, besides the one mentioned as "Heloxyle," have been made in larger or smaller quantities from time to time, among which may be mentioned imitation terra cotta building material and paving blocks. The latter were as firm and hard as wood and were impregnated and covered with tar made also from peat. If a proper binding material could be found, there seems no reason why a very serviceable and durable, noiseless paving block for residence streets could not be made from some of the more compact peats, and one that would be cheap as well.

Peat as a Source of Electrical Energy.

As shown in another chapter it has been proposed by a European engineer to establish near, or at, large peat bogs, electric power plants, at which the peat can be used for fuel in the air dry condition, without briquetting, thus saving not only the cost of transporting the fuel, but other costs as well. The power thus generated can be transported considerable distances without great loss, as is well known, and if the plan were adopted generally would result in many bogs being utilized, which cannot now be considered, since they are remote from means of transportation. No such plan as the one proposed has yet been put in operation, but, as indicated elsewhere, it seems worth trying in certain parts of Michigan, where large areas of peat are within reaching distance for the transmission of electricity, of good sized towns and cities.

Peat Dye.

It is well known that water flowing from peat bogs is much browner than that which flows only through or over mineral soil, and that such water gives a well marked and quite durable stain to white substances coming into contact with it. Advantage has been taken of this fact to extract the coloring matter from peat, and by proper treatment, a rich brown dye has been obtained which is reported to be very pleasing and exceptionally durable and unchanging.

The Use of Peat in the Intensive Production of Nitrates.

In the Experiment Station Record, XVIII, 5. (Jan., 1907) is an abstract of a recent paper by Muntz and Laine, published in Compt. Rend. Acad. Sci., in which experiments are reported which promise to give new and added importance to the peat deposits of the world, since the authors show that these deposits may be made factors in the production of nitrates. The nitrates are among the most expensive and most important of the constituents of fertilizers, being of limited natural occurrence, and having very important commercial uses aside from the demand for agricultural purposes.

The experiments reported show that "when a 0.75 per cent solution of Ammonium sulphate is passed over a peat bed impregnated with nitrifying organisms, it becomes charged with nitrates to the extent of 0.82 per cent. This can be increased to 4.17 per cent by adding a further quantity of Ammonium sulphate to the solution and again subjecting it to the nitrifying action, the operation being repeated 5 times. The most suitable temperature for the reaction is 30° C. (86° F.), and the fuel necessary for maintaining this temperature is afforded by the air-dried peat. Further the nitrogen contained in the peat, which amounts to 2 to 3 per cent, can be obtained in the form of Ammonia to the extent of 1.79 to 1.612 per cent by distilling the peat in superheated steam, the other products of the distillation (hydro-carbons, water-gas, tar, etc.), forming the fuel required for the operation.

"Peat, therefore, is singularly well adapted for the intensive production of nitrates, since it forms an excellent medium for the growth of the organisms, supplies the fuels necessary for the various operations, and finally supplies the ammonia required for the production of nitrates."

The immense consumption of chemical fertilizers in this state, the very considerable manufacture of these in Michigan from imported nitrates and the great extent of the peat deposits throughout the state, suggest the importance of investigating this method of intensive production of nitrates from peat to determine whether it is not applicable, upon a commercial basis, to American conditions. The great development of chemical manufacture based on the salt deposits of Michigan, in the not distant future, may be equaled by a similar development based upon the peat deposits, to the great advantage of all agricultural interests, of the chemical manufacturing industry, and of the promoters as well.

THE USE OF PEAT AS FUEL.

Historical: The use of peat as fuel in Germany goes back beyond the historical period into the time of the semi-savage stage of the early tribes, and Pliny, the Roman naturalist, tells us that the Teutons on the borders of the North Sea dried and burned "mud," or, as we would call it now, peat. In Ireland, Great Britain, Russia, Scandinavia, parts of France and the Netherlands, there has not been a time within the historical period, when the use of peat for fuel has not been a general practice among the common people, who still cut it from the bog in the form of long rough bricks or "sods," drain and dry it on the surface of the bog in the sun and wind and stack it, much as the American farmer piles his cut wood.

In Ireland and parts of Germany and Holland the use of peat is well nigh universal among the poorer people, and in other countries of Europe it is extensively used for cooking and other domestic purposes. This is due to several causes, among which the scarcity and high prices of wood and coal, and the great abundance of peat bogs and the large aggregate area covered by them in the countries of Northern Europe, Germany alone having an area of about 11,000 square miles of peat moors, while Great Britain has more than 3,000,000 acres and Ireland an equal extent, or about one-seventh of its entire area covered by bogs. The most widespread use for domestic purposes was probably in the 18th century, after the forests were so depleted, that wood was no longer easily obtainable by the common people, and before coal had come into use.

While this general use of peat by the people for domestic purposes has gone on century after century, there was little attempt to increase its efficiency as fuel, or to improve the methods of gathering it, except some simple attempts at compacting the coarser types by kneading with the feet, grinding in small mills, etc., until within a hundred years or so when various forms of machinery were introduced to assist in cutting the peat and getting it out from the bogs more quickly and less laboriously than by cutting it out by hand with a narrow spade or slane, as it is called, and which is still the most common and perhaps the most efficient tool for the purpose.

Much later, after the need for cheap and abundant fuel for use in generating steam for manufacturing purposes began to be felt, as the prices of wood and coal advanced, machines began to be built in Germany and other parts of Europe where peat was abundant, for the purposes of increasing the output, of reducing the bulk of the finished product, and at the same time of making it more clean to handle, more easy to transport and more efficient as fuel.

A pioneer in the invention of machinery and processes for making compressed peat in Northern Europe, seems to have been Mr. C. Schlickeysen of Rixdorf near Berlin. His first two machines were of vertical construction and were built in 1859, for a steam peat-compressing plant near Riga, Russia, where they worked satisfactorily for many years, turning out daily about 80,000 pieces of wet, compressed peat, which, after drying, were used as smokeless fuel in a large cloth factory at that place. Since that time, many improvements have been made by this and other manufacturers, both in the types of machinery and methods of work, to try to improve and cheapen the product, and to substitute automatic machines for hand labor, until a very satisfactory product in the form of compressed peat blocks and efficient machines for making them, are the results.

A much more recent development and one which seems to be considered by all experts in the question of fuel, perhaps the most important advance yet made in the utilization of peat, as it is the most scientific and theoretically correct, is the working out of good processes for coking peat and converting it into a compact, hard and very efficient and desirable fuel. This kind of process for the purpose has been sought for many years and seems now to have been found, as is pointed out in another place (p. 301) and the matter needs no further elaboration here.

Another recently used method of increasing the efficiency of peat for fuel, has been brought about by the development of machinery for converting other fuels, such as coal slack and other waste of coal mines, lignite, etc., into briquettes. The process consists of compressing the fuel, either with or without a binding material, in specially built presses, capable of exerting great pressure, which shape it into cylindrical, rounded or prismatic briquettes of great firmness and hardness. In some of these processes the peat is mixed with other combustibles, in others, it is briquetted without mixture.

Parallel with the development of these processes in Germany, have gone similar ones in England, Russia, Norway, Sweden, Austria and the Netherlands, but Germany has led the way, and it is there that the most modern and scientific methods and machinery for the manufacture of peat into efficient fuel have been worked out. In fact, there has been much labor and a great amount of capital used up in various unsuccessful processes of handling peat in Germany, and no better step could be taken by the would-be inventor of new and especially desirable processes of converting peat into first rate, cheap fuel, than to make a thorough study of the history of German inventions and experiments in this direction, for it would doubtless save him much time and trouble as well as much money and disappointment.

Use in America: In America, with its great stores of fuel, in the form of wood, and the various types of coal, widely distributed, cheap and abundant, the history of the use of peat is very brief. It was used in parts of New England by early settlers from peat-using stocks, and in the region of Cape Cod and the adjacent islands in Massachusetts, where the original forests were poor and soon destroyed, the use of peat, taken from the numerous bogs of the region, has, according to Shaler[1] been general and continues until the present time. In other parts of New England, its use was discontinued years ago. In the latter part of the 19th century some peat fuel was manufactured at Lexington, Mass., by T. H. Leavitt, but no general use of it has been made in any part of the country, except this, so far as is known, and it was not until the great coal miners' strike of the winter of 1902-03 created a widespread interest in the possibility of utilizing the extensive deposits of various kinds of peat known to exist in the northern parts of the United States, that the public took much notice of it.

Use in Canada: In Canada, the history is slightly different, though similar. There, the deposits are more extensive, than in most parts of the United States, are easily accessible and the land was settled from the more northern parts of Europe, and especially from Scotland, Ireland and Germany, by people who were used to gathering and using peat for fuel. These facts, taken in connection with remoteness from coal supplies, undoubtedly led to a more extensive and earlier use of peat for fuel than in this country, so that in the early sixties, there was a small output of machine-made peat, and a little later, carbonized pressed peat, was placed on the market and tested by manufacturers and railroads. This was followed by a slow development of briquetting machinery, until several plants were established to make peat briquettes, none of which were successful in getting a good product from the process used, that of air drying, grinding and pressing the peat, and after a season or two of attempts, were abandoned. The next series of attempts were made in the direction of pressing the peat after it had been dried by artificial heat, and in 1902 several establishments in Ontario were operating, and with more or less success, were supplying local markets with briquettes made by modifications of this process. The whole development, including descriptions of bogs, processes and machinery is fully described in Bulletin No. 5, of the Ontario Bureau of Mines, and in a later report by the same bureau.[2]

Use in Michigan: In Michigan, since it was, to a large extent settled as was Canada, by people from the countries of Northern Europe, it is probable that there was some use of peat by individuals, especially in the German and Hollander settlements, but the great amount of wood, and its cheapness for fuel, together with the immense quantities of waste

[1] Shaler, N. S. Peat Deposits. 16th Ann. Rep., U. S. G. S., Part IV, 1894–5, p. 306.
[2] Report of the Bureau of Mines, 1903, Toronto, Ont., 1903.

mill wood, and drift, or flood wood from the streams on which lumbering, or river driving operations, were being conducted, in the earlier days, and later, the development of the Michigan coal fields, and the close proximity to those of Ohio, all tended to make the use of peat unnecessary, and it was only a short time ago, that the possibilities of utilizing the great areas of peat in the state, attracted general attention. The past five years, however, have seen a marked change in the attitude of capitalists, owners of bogs and the citizens of the state in this matter and a widespread interest, due partly to the rising price of wood and coal, and partly to the constant discussion of the value of peat fuel in the public prints, as well as the effects of the coal famine already referred to, has been aroused and there are few of the citizens of the state who would not now be glad of the opportunity to test the new fuel, if it could be had. Within the period named, there has been an attempt on the part of capitalists to meet this demand for peat fuel and a considerable number of plants have been built in the various parts of the Southern Peninsula and have put out small quantities of finished product, which have found a ready market, and at present writing it appears possible that before long a flourishing industry based upon the utilization of this great natural resource of stored fuel may be built up. Michigan has abundant and good peat deposits, and all that is needed to make them useful is honest, intelligent, carefully planned exploitation.

Descriptive.

Because of its diversified origin and the very different conditions to which individual deposits have been subjected, peat is entirely lacking in uniformity of structure, is of very unequal fuel value, and varies greatly in texture and color, not only in different bogs, but in parts of the same bog. These peculiarities are discussed at length elsewhere and are due to differences in the age of the deposits, in the form of basin in which they lie, the kinds of impurities present, the amount of oxidation and decomposition, the kind of plants from which the peat is formed, and other more or less important factors.

The chief kinds, as discussed by most writers, are given as those which are light brown in color, coarse in texture, and low in specific gravity; those which are dark brown in color, dense and fine grained in texture and comparatively heavy; and those which are intermediate in characters. To these should be added the light colored and very fine grained types, which have been described as formed by the algæ in the bogs of Northern Michigan (p. 247) and there are all sorts of intergradations between these various forms. In Michigan, in the deposits of the lake basin type, it is not infrequent to have the light colored, coarse type, end abruptly, and pass without gradations into the dark colored, compact variety, while in other cases the deposit may pass gradually from one kind to the other. It is therefore very difficult to secure a product from peat which shall have uniformity of structure, of cohesiveness or of fuel value, and impossible to do so unless artificial means are employed to insure this.

These physical characters have to be considered when the problem of preparation for market is being worked out, whether for individual bogs, or for general application, especially since all of the methods now in use, depend, more or less, upon compression and molding into some form of rather small blocks, which must take and hold their shape readily, and not disintegrate too easily when handled or burned.

It is manifest that the coarser types, or those of coarse and fine material mixed, will retain more moisture and air and be slower about drying, than the others and will thus be less satisfactory for making briquettes without some treatment before they are compressed. Such treatment of the coarser kinds is usually given in the form of grinding or kneading, or often a combination of the two, by the use of mills and toothed and smooth rollers. This treatment breaks up the coarse fragments, works out a large part of the included gases and air, and some of the water held by the various constituents, thus making the whole mass uniform in texture and reducing the bulk; for some processes of preparation, the finely divided kinds do not need such preliminary treatment so much as coarser ones, but in practice, it is usual to give all the same preparation in order that any coarse material mixed in with the fine may be broken up. In making machine-compressed blocks, the finer grained types of plastic peats need very little grinding or kneading, for they are homogeneous and compact already, but the coarser varieties need a good deal of preliminary treatment before they make a satisfactory product by such process.

In Southern Michigan, and less frequently north, there are quite extensive areas of the dark colored, often nearly black peat, which is sufficiently plastic so that it can be molded when wet, and which holds its form when dry. In the dry state it becomes almost as black and hard as coal; such material would not be greatly improved by being pressed through a mill, but would have to be crushed, if it were first dried and then pressed into briquettes.

The lighter colored and coarser types would need thorough grinding and much working over, before being put to any use, and it is often difficult to make them sufficiently plastic and cohesive to form good blocks even when they are molded wet. Certain components of this kind of peat, notably the grass and sedge leaves, may be sufficiently abundant and so poorly decomposed that they clog the rolls of the grinding mills and cause much trouble in handling. When ground, dried, and formed into briquettes by pressure, peats of this kind are full of irregular flat particles of sedge leaves, which arrange themselves with their long axes at right angles to the length of the block and thus develop cleavage planes in the briquettes, which cause them to exfoliate when burned, thus reducing the efficiency of the fuel, and to split away readily when handled, hence they do not bear transportation well.

Prospecting Methods.

In the first examination of marshes, swamps, or bogs, for peat, attention should be given to the following matters and notes should be made regarding them: (1) The exact location by Township, Range and Sections; (2) The distance from the nearest transportation lines; (3) The approximate area of the surface of the peaty tract and character of the surrounding lands; (4) The kind of plant growth on the surface of the area, whether grasses, (or sedges), shrubs and mosses, or trees. If the latter, the kinds and size. If the trees have been cleared off or burned off, this should be noted, with the kinds taken off, if this can be determined. (5) The possibilities of drainage, streams through the bog or near by. It should be remembered that as peat is drained, the surface slopes in the direction of the main ditches, so that a certain amount of fall can be made by draining. (6) The depth of the surface layers to good peat, and of the whole deposit, should be tested in a few places, for even if of large extent, a very shallow bog is not worth much for fuel purposes. (7) The amount of decomposition of the lower layers below the surface litter, and its color and plasticity should be noted. It is usually true that the deeper parts of the bed are formed from different plants than are the top layers. These facts should be noted regarding every bog or marsh visited, whether any other work is done upon them or not. It is highly important also, in the more thorough preliminary investigation of a peat deposit, to find out, not only about the depth and extent of the beds and their purity, and the heating qualities of the peat, but to consider also the plasticity, the mechanical texture, the degree of decomposition, and the uniformity of the various beds at different depths below the surface. To do this thoroughly is no simple matter, and is often expensive, but the expense is slight compared with that caused by too hastily making the assumption that a peat deposit is available for use and establishing a plant upon it, and then finding that a marketable product cannot profitably be made from the peat.

Tools for Prospecting: In making the first prospecting examination of a deposit, the usual tool which is used is a long iron rod made of gas pipe, cut into convenient lengths, and provided with ordinary couplings, or unions, for screwing these together. The size of the pipes is a matter of some importance, since if too large it is very heavy to carry, and if too small it bends and breaks easily where the threads for the couplings are cut. Probably for practical work nothing smaller than ½ inch pipe should be used, except for light reconnaisance work, in which but few tests have to be made. For convenience in carrying, the lengths of pipe ought not to be greater than four feet, and in order that the couplings shall not work loose too easily, it is well to have each one pinned to one end of a length of pipe, so that the pipe and not the coupling will unscrew. The threads in the pipe should always be cut carefully and fit the couplings as perfectly as possible, and yet be neither too tight nor too loose. If cut slightly tapering they seem to work best, as they then hold firmly when screwed into place, but are easily released when it is necessary to take them apart. A pair of pipe wrenches, preferably the "alligator" pattern, should be taken into the field at all times, in case the sections of pipe get screwed together too tightly to be taken apart by the hands alone. In most cases, unless the beds are to be worked to an unusual depth, a pipe sounder of five four-foot sections will be sufficiently long for all practical purposes, since in actual practice abroad, the peat is rarely taken from a wet bog, such as most of the Michigan bogs are, from a depth of more than 10 feet.

Final Sampling: For taking samples from various depths, many devices have been used, one of the most common being a two-inch auger, which, if of the open spiral type, like an earth auger, is quite satisfactory if bored down into solid peat, and a clean hole made. If simply pushed down, turned around a few times to clean the pod, and then draw up, it is likely not to bring up a satisfactory sample; in fact, little dependence can be placed upon getting a clean sample by such a method, from even a few feet below the surface, and the auger is not recommended unless used carefully, in compact, solid deposits; of course in the nearly liquid types of deposit no samples can be taken by an auger.

Another form of sampling apparatus which has been used with good results is made by splitting a length of one or one and one-half inch pipe, and spreading it so that a narrow, longitudinal opening is made nearly the entire length. One edge of this is sharpened by filing it and raised above the other so that the cross section is something like the accompanying figure (Fig. 18). This is pushed down to the desired depth

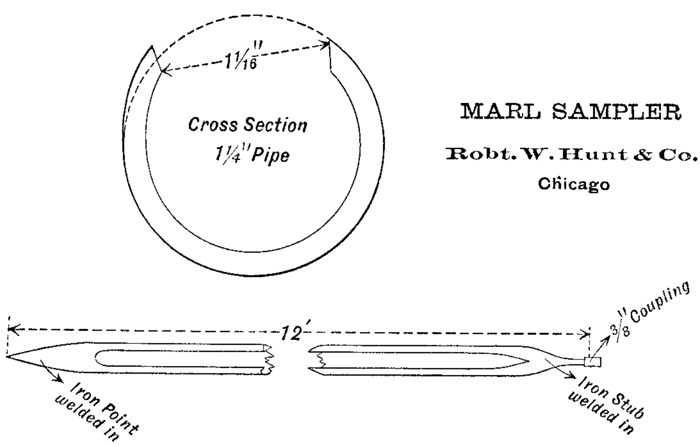


FIG. 18. Hunt Marl or Peat sampler.

and then turned several times until the sharp edge has cut off enough of the surrounding peat to show its character. A removable pointed plug should be put in the lower end of this sampler to keep it from filling with peat as it is pushed down into the beds, unless a hole has been previously bored down about to the depth from which the sample is to be taken. If steel tubing is used for this form of sampler, it will be lighter and more easily sharpened and kept sharp than is the common wrought iron tubing which is ordinarily used.

A sampler for taking small, pure samples from any depth, was used by the writer, and consisted of a short cylinder into which fitted a metal plunger, which, when pulled out a definite distance, locked automatically; in use, the cylinder was screwed on to the end of a gas pipe sounding rod and pushed into the peat the required distance, less the length of the cylinder. The rod was then drawn up until the catch-lock was heard to click and then pushed down the length of the cylinder, or a little more, in order to insure completely filling it. The sample thus obtained was free from all outside impurities.

Importance of Thoroughly Proving a Deposit: In making the tests for the final proving up of a bog, before preparing to exploit it, holes should be dug at regular intervals, to such a depth as will insure cutting through to the deeper layers of the deposit, from which large samples of material should be taken and worked up by the process it is proposed to use in developing the bog. The holes should be dug in parallel lines equally distant from each other and if marked differences are found in certain consecutive holes, which are considered of sufficient importance to warrant it, intermediate test holes should be made. For making such tests, some prospectors use a common, long-handled spade, others a post-hole digger or auger, and still others use a peat spade or slane, but the important thing is to have the testing at this stage done thoroughly and to such depth that there is no doubt as to the good quality and large quantity of the deeper layers of peat, which are frequently the only ones which are of value in the preparation of fuel for commercial use.

Factors Affecting the Commercial Value of Peat Deposits.

In considering the possibility of developing a deposit of peat, by constructing a plant, certain other matters than those mentioned above, have to be taken into account, as it is often upon such preliminaries that the financial success of the contemplated investment will depend.

Market and Transportation: Of primary importance is a good and steady market for the product, after it is ready to sell. With a standard article, well known and with large use, the location of the place of manufacture is not of great importance, since buyers will seek it to supply their needs. With a little known and practically unused commodity, however, competing with others of equal value which have been in use a long time and in which there is not only a closely organized trade and an iron-clad agreement between producers, who may also be favored in the matter of transportation, but also a close organization of retailers to control the prices and markets, the matter of an immediate and near-by market is not to be overlooked. The nearness or remoteness of market, is the more important, also, because of the bulkiness of all forms of peat fuel, and the ease with which it disintegrates when subjected to moisture, or to rough handling, so that it can be sold at less cost and in better condition near the place of production than it can if shipped long distances; moreover the loss from handling is much less after short shipments than after long ones. It would, therefore, seem probable that it would be unwise to attempt, in the beginning, before the peat fuel is well established, to exploit bogs which are far from some large town, and which are not on or near some well developed railroad line, which will give assurance of good freight rates and a sufficient number of box cars for the shipment of the finished product.

Area and Depth: The area and depth of the deposit is also a matter of importance, the area probably of more importance than the depth, since, according to European practice, the deposits are rarely worked below 10 or 12 feet in depth, although there seems to be no reason why, with dredges or even pumps, the peat from the deep deposits should not be used, if it has the proper texture and composition. The statement has been made that about 200 tons of finished peat fuel can be made from an acre of peat of average density, for every foot in depth, or, as is frequently stated, 200 tons to the acre foot. With this in mind, it is easy to calculate the amount of fuel which can be made from a bog of any size and depth, and whether it will pay to develop it. In this connection it is well to remember that the upper foot or more of the peat is often of no value for manufacturing into salable fuel, but most of it may be used in running the plant, with no other preparation than cutting it from the bog and drying it by exposure to wind and sun.

Physical Condition of the Peat: The importance of the physical condition of the peat in given bogs has been mentioned. This will depend largely upon the way in which it has been developed. If in a basin which had filled largely from top and sides, the peat will consist of a well defined top stratum from one to several feet thick of more or less fibrous and coarse, light-colored material, which has below it a deeper mass of darker, homogeneous, plastic peat, often very soft and full of water, but of generally good fuel value and easily handled by properly adapted machinery.

On the other hand, if the basin has been filled by stages of growth, from the bottom, the peat is likely to be coarse and fine alternately, or made up of mostly coarse, partly disintegrated material, and may have beds containing stumps and logs at intervals from bottom to top, which will make it difficult to work by the usual types of machines for cutting peat. In making estimates of the amount of peat contained in deep bogs, care must be taken not to overestimate this, for it has been shown by the experience of prospectors, and of railroads[1] crossing such deposits, that they are not infrequently not solid, but have only a relatively thin covering of dense peat, from 4 to 6 feet thick, formed of closely interwoven stems and roots of various plants, including trees, on the surface, below which is a body of water of considerable size which contains no peat or only suspended fragments of vegetable matter. Below this water may be more peat, but so far below the surface as to be useless. Such a condition is not revealed by testing with an auger, as the pod of the auger is filled with peat from the surface coverings as it is drawn up, unless very careful borings are made.

Deep Bogs with Thin Stratum of Peat with Water or Marl Below: Another matter of similar nature is the frequent presence of marl, several feet below the surface of seemingly deep peat beds. In one case, in which prospecting was done by the writer, in a bog which had been looked over for marl, and none found, and which was supposed, from auger tests, to be made up of solid peat, the peat was only 8 or 9 feet deep with good marl below. In another place the peat was said to be 10 or 12 feet deep by the owner who had often sounded it, and was found to be about 4 feet deep and the rest marl. The cause of the discrepancies was the replacement, in the auger, of the marl by peat as the tool was drawn through the latter, which apparently is a frequent occurrence in the use of the auger.

Sampling for Other Purposes Than Fuel: If the bog is being examined for peat for other purposes than for fuel making, such as paper or pulp stock, or for litter manufacture, similar precautions should be taken to see that there is an abundance of the proper kind of peat for the uses which are to be made of it. The best type of bog for these uses would be the one built up from the bottom with numerous layers of sedge and grass remains.

Chemical Composition and Ash: These should be determined by the chemist, together with the fuel value, before final arrangements are made

[1] See Part I, p. 154.

for putting in a plant. The best way to test the fuel value, however, is to make actual working tests, under a boiler, in which samples of the fuel are used, made up in the machines to be used in the proposed plant, from the peat taken from the test holes made in the final prospecting. Such tests are expensive, but can be made very satisfactory, as they show the real efficiency of the fuel better than the ordinary chemical analyses and calorimeter tests. If the fuel does good work in these practical tests there will be little question about the amount of ash present.

Possibilities of Drainage: These are usually considered of importance, and sometimes excellent bogs have been left unutilized, because they were not capable of being effectively drained. In Sweden, however, peat fuel has been satisfactorily and very cheaply made upon floating establishments of small capacity, and there seems no reason why the peat should not be excavated from the wet bogs, without draining them, by the use of scows and dredges just as ditches are cut through marshes. In recent practice in Germany, indeed, the peat is sent to the mill from the bog by floating it in a liquid form through shallow trenches, which have an artificial fall, into a storage basin, hence the more nearly the peat approaches the fluid condition when taken from the bog, and can still be handled, the better it is for the purpose, so that drainage is not an essential, or even a desirable thing, especially if some such system of transportation is used.

Character of the Surface Growth: A bog which has been cleared, is more desirable than one covered with a dense growth of small trees and bushes, and one free from stumps has that much advantage over that from which a heavy growth of timber has been cleared, but the matter of clearing up the surface is a relatively small one, since it can be done a little at a time, and need not be hurried, after a sufficient area has been cleared for actual work. From what has been said in the discussion of the development of peat deposits, it is evident that the surface vegetation, except in very shallow deposits of no commercial value, indicates nothing as to the origin of the peat, or its physical condition, or its fuel value, for the plants present may only recently have established themselves, and the only thing which they indicate is the position of the water level with regard to the surface of the peat.

Acidity: Some types of peat, notably the brown ones, are said to become nearly impervious to water after they are once thoroughly dried out, because the organic acids which they contain are colloidal, or gluelike, in form, and when they dry, they become insoluble, so that the acid, brown peats may make a slightly stronger and more resistant pressed block fuel than the black ones, but it is doubtful if in practice the difference would be of importance and it can be of no importance where briquetting after drying is resorted to, since the cementing effect of the acid is slight.

Sources of Contamination Producing High Ash Content.

Importance of Ash: The ash content has to be considered, because, if it is high, the fuel value of the final product from the bog must be reduced, and by so much the cost of handling increased, since the ash constituents are mineral impurities which do not burn, and in considering the availability of a peat deposit, for fuel manufacture, the possible sources from which mineral matter may get into the bog to increase the normal ash content, should be taken into account, of which the following are worthy of notice:

Flooding by Streams: A chief source of such matter is flooding by streams, which bring silts, muds and even sands into the basins through which they flow and deposit them, or leave them upon the part of their flood plains which they overflow. Streams flowing through a cleared and cultivated country are much more likely to have floods and carry abundant sediment, than those which flow through forest covered regions. Peat deposits along such streams, especially in the river swamps, oxbow lakes and bayous, and in their deltas in lakes, are usually so filled with the various forms of sediment that they have little if any fuel value.

Flooding by Rain Wash: Flooding by rain wash from higher ground, is a form of contamination to which many otherwise good deposits of peat have been subjected to in Michigan since the hillsides have been cleared and cultivated, and it is no uncommon thing to see sand and gravel piled several feet deep upon the surface of the margin of a peat bog, while the water of the adjoining marsh is colored a deep brown by the finer matter which has been carried in suspension and has not yet settled. Where such wash has been going on for any length of time, the ash content of the superficial layers of the bog is very high, hence if it is found that a bog is subject to flooding from high ground during heavy rains, the peat should be studied to ascertain how deep the silt has affected it, and if there is any means of checking the wash, since this may reduce the value of the bog after exploitation begins.

Spring and Terrace Bogs: Certain classes of peat deposits, notably those on terraces of streams, and on slopes, are formed by the outflow of springs. These are particularly likely to be high in mineral matter, for the water which is constantly flowing through and over them, has considerable dissolved mineral matter in it, which may be precipitated in contact with the air, especially after the excess of the gas, carbon dioxide, which most spring waters contain, has passed off into the air. Such mineral matters are calcium carbonate, calcium sulphate, or gypsum (in some regions), iron compounds and sometimes other mineral matters. The calcium carbonate is the most common of these substances and is generally precipitated by a plant, Chara, which grows in the shallow water of the spring outlets and often forms a considerable part of the deposit in which its remains can be felt as granular, gritty, particles scattered through it. Sometimes one of the mosses also forms deposits which are more stony in their character and of large size, one in Seville Tp., Gratiot county, covering an area of several acres. The iron precipitates first appear as a thin, oily-looking scum on the surface of the water standing in small holes and along the spring outlets, and later as a reddish, rusty-appearing sediment of hydrous iron oxide, "bog iron," farther along the stream, as thin, rusty streaks in the peat, or sometimes below it, in masses.

Not infrequently, when bogs of this sort are burned, the iron which was in the peat appears as a dark brown or even deep red deposit of ochre. The mineral matter of such bogs is also added to by the shells of mollusks, chiefly land snails, which are usually very abundant in them, and may be seen lying on the surface or buried in the peat. When to these internal sources of mineral matter is added the liability of flooding from the higher lands around, to which this type of bog is especially liable, it is evident that it is not usually worth while to consider spring-formed deposits of peat, of the terrace and mound types, as sources of fuel supply, in the region under discussion, even where they have good-sized areas, which is not, however, frequently the case.

Shore Wash in Lakes: In some larger lakes, and occasionally in small ones, there may be extensive bogs along parts of the shore, while other parts have sand, gravel or even marl exposures. During times of storm and high water, the waves and shore currents may carry a good deal of finer, silty matter to the bogs and in this way make the peat impure. Where it is found that after storms or strong winds, the marshes, under which the peat lies, are covered with muddy water, the top layers will be found to have an abnormally large amount of ash. Such bogs are frequently not so situated that they can be used profitably, even when they are extensive enough to be considered as worthy of exploitation; if, in any case, they are examined for this purpose, the question of the amount of ash in the lower layers of the peat should be given more than ordinary attention.

Mineral Matter From the Water of Lakes and Streams: This is of two kinds, that held in solution and that carried by the water, in the form of fine sand, silt or clay in suspension during floods or in less amount at other times, or washed directly from the high lands to the bogs. There is a considerable quantity of the suspended matter, which is so very fine that it remains suspended for a long time and eventually may become entangled by water plants, and upon their decay, become a part of the peat, or it may settle slowly to the bottom with fine vegetable matter and be incorporated into it. In order to become convinced of the importance of this factor, one has only to examine the washings from some of the floating aquatics with finely divided leaves, from even a small pond, under the low power of a compound miscroscope, for they will be found to consist quite largely of small angular particles of mineral matter, often silica.

Dissolved Mineral Matter: The mineral matter held in solution in the water, is a more constant, and, on the whole, a more important source of impurity to the vegetable matter which makes peat; in fact, it is the source of all mineral, or ash constituents, except those mentioned above, for the plants get all of their mineral matter from the soil waters, and build it into their tissues. Aside from that which is used in this way by all plants, there is a considerable amount which is precipitated in one way or another by the water plants, which goes to increase the amount of ash in accumulations of their remains.

Precipitation by Plants: Two distinct types of plants, the seed-bearing and the Algæ, precipitate calcium carbonate in considerable amount upon the outside of their leaves and stems, or, in the case of the lower Algæ, over the entire plant. Where the higher plants are most numerous, the amount of the mineral matter accumulated is small in comparison with the amount of vegetable matter formed, but where the Algæ, Chara and lower types, are the dominant vegetable forms, the amount of mineral matter is often so large that marl, and not peat. is formed. Where there is any considerable quantity of Calcium-secreting Algæ growing in the deeper parts of the lake or body of water (even shallow spring outlets an inch or less deep are not free from these plants, as pointed out above), the ash content of the resulting peat is certain to be high. It may be worthy of note here, that Chara, the important lime-secreting plant, not infrequently grows in shallow water among the bulrushes and sedges and contributes considerable mineral matter to the resulting vegetable débris and its presence in such places may often account for the presence of more mineral matter than could otherwise be easily explained.

Another type of Algæ, the Diatoms, secrete silica in the form of delicate transparent shells, and while these plants are very minute, their number is sometimes so enormous that their shells have made deposits of considerable economic importance in various parts of the earth. These plants are always present in the water of peat bogs, and their silicious shells undoubtedly add an appreciable amount to the ash of most types of peat.

An additional source of precipitation of dissolved mineral matter from the water of bogs, lakes, springs, and streams are certain filamentous Algæ which form local deposits of lime and iron in bogs and swamps, and at times this becomes sufficiently general to seriously affect the quality of the peat.

The chief contributors to the ash of the coarser types of peat, are sedges and grasses, which, in the course of their growth, secrete considerable quantities of silica in the cell walls of stems and leaves. This silica is then a normal constituent of peat, and is to be expected where the plants mentioned have had any considerable part, as is generally the case, in building up the deposit.

Another group of plants, representatives of which are sometimes found either growing on the surface of bogs, or in the water along their margins, in large quantities, has silicious cell walls. This is the Horsetail family, the Equisetaceæ, the surviving remnant of the Giant Calamites of the Carboniferous Age, which grew in similar situations, and by their growth and decay helped to form coal.

Relation of Deposits of Peat to the Bottom.

In relatively shallow peat beds, it is sometimes a matter of some importance to determine the quality of the underlying stratum of mineral matter, as this may, in some cases, affect the lower strata of the bog, rendering them impure, or make it difficult to harvest them.

In the Southern Peninsula of Michigan, ordinary till or boulder clay is a common type of material found below bogs. This never is found above the bottom of the peat, hence never interferes with working the bog to the bottom.

Where clay forms the substratum, however, as it often does, the lower layers of peat are usually impregnated with it, and it is apparent that at the time the peat was laid down, conditions were such that considerable mud was being held in suspension from time to time in the water of the depression in which the bog grew up and was deposited with the peat. The clay content of the peat may continue to be excessive for a foot or more above the bottom, so this amount of material has to be left in the bog in utilizing it for fuel manufacture.

In the Northern Peninsula, many of the shallower bogs have been built up over sand, and in such cases there seemed to be no intergrading between the sand and peat. Indeed, it is not easy to see how sand could be mixed with the peat by ordinary water action, since the force of current which would carry the sand would wash the vegetable matter all away. In some cases there were thin layers of clay between sand and peat, but the amount of this material was small and its effect upon the peat did not seem to extend above the bottom to a greater distance than an inch or two.

When, as has been mentioned above, marl lies below the peat deposit, from the origin of the two substances, there is likely to be a zone of some thickness in which they will be mixed so intimately that the peat will be of no use for fuel. Such a zone will show the presence of the marl by its grayish color when dry, and the large per cent of ash which even the darker peat leaves when burned. This zone of mixed material may vary in depth from a few inches to two feet or more, but usually it is quite narrow, although where present it must always be taken into account.

Bog iron is sometimes found at the bottom, a short distance below peat beds, but rarely in them, except as indicated above. It usually forms a hard pan, or, frequently, irregular masses, when it is at the bottom of a bog, and may, in some cases, render it difficult to use machines for cutting out the lower layers of the bog.

Summary.

Color: The type of peat which would be called a good commercial peat for fuel use, that is, one which could be readily handled by some one of the processes now in use, and make a desirable type of product, at a price which would not prohibit its manufacture, should have a color, when wet, which varies from medium to dark, rich brown, or to nearly, or quite black; the deeper layers of peat are frequently darker than those at or near the surface; in a few, probably rare, types however, the color may be much lighter. When dry, good peat may vary in color from medium light to dark brown of the richer shades or to black. That which shows much straw color when dry, should be looked upon with more or less suspicion, as should those kinds which are of light brown shades when wet, although the degree of decomposition and structure should be considered in connection with color.

Those samples which show much chalky matter when dry, or have a rusty color running through them in streaks, or are generally rusty when dry, are probably impregnated with lime and iron and will run high in ash. If the dry peat shows grayish, either in streaks or generally, it is likely to be rich in sediments and unusable for fuel.

Weight: Good average peat, when air dry, contains from 15 to 25 per cent of water, and weighs, without compression, about 12 pounds or more per cubic foot as cut from the bog. Those types which are darker and more compact than the average are heavier, while the ones which are of light color usually weigh less. A very heavy sample which has not been compressed, should be rejected as certain to contain too much ash, while a very light one is liable to yield a finished product that will be so bulky as to be at a disadvantage in the markets, because of high freight rates, and the amount of storage room which it requires, as compared with other fuels, for it must be borne in mind that peat fuel, unless in the form of coke, must be stored under cover, and since its bulk is eight times that of coal of the same heating capacity, it can readily be seen that the very light weight kinds, will be at a disadvantage, as they may require 15 to 18 times as much space as coal which will give the same amount of heat.

Texture: The importance of considering the texture and coarseness of peat must already be apparent from what has been written, regarding the matter. In general, the coarser peats are lighter in color and in weight than those of finer texture, which is in part due to the greater age, and more complete decomposition of the latter, and in part, to the different species of plants from which they were derived and different conditions under which they have been formed. With fineness of texture goes greater plasticity, which is desirable to a degree, in peat to be used for fuel manufacture.

While peat of the coarser types will usually give a fuel that burns readily, with a good degree of heat and with a minimum of ash, it yields a more bulky fuel, it is likely to break up quickly on burning, it needs much more preparation before manufacture, is more difficult to dry and keep dry, is harder to compress, and is almost certain to produce easily broken briquettes. On the other hand, the plastic, black peats are higher in ash, are more difficult to burn, and are harder when dry, reaching nearly the consistency of soft coal, which makes the compressed blocks durable but not unreasonably hard to crush, if briquetting, after drying, is resorted to.

Relation of Ash to Commercial Value.

In considering this matter, it is assumed that no peat having over 20 or at most 25 per cent of ash would yield heat enough, so that it would find a continued market, but when the ash of the dark colored peats, which are highest in ash, is below 15 per cent, it would usually find buyers, if it burned well, as the ordinary consumer will not be over particular regarding the per cent of ash in the fuel he buys, as is shown by readiness with which all kinds of coal and wood are purchased. The apparent amount of ash from peat fuel is very small, because of the large bulk of the fuel and the small bulk and freedom from cinders and clinkers of the ash, which makes it seem that the absolute per cent is small also. If, as is frequently done in Northern Europe, a body of peat is utilized for generating steam to run a single factory, using it in lieu of other fuel brought from a distance, the various precautions regarding ash and quality, texture and other characteristics may be waived, since, in such a case, proximity to the factory and quantity of material, are of more importance than quality. There is no difficulty in generating steam quickly and in any quantity, by using air-dried cut peat, even of rather poor quality, and with a small cutting and compressing plant, the efficiency of the fuel may be readily increased, so that at a small cost per ton, an excellent product, and a good substitute for coal or wood can be obtained from the immediate vicinity of the factory. That such individual plants, making a few tons of peat fuel per day, from the numerous small bogs scattered through Michigan, are not in existence, is evidence either that the owners of small factories are sufficiently prosperous, so that they do not need to practice small economies, or that they are not yet fully aware of all of the resources which may be exploited to their advantage.

Parmelee[1] divides the peat tested by him into three classes, (1) high grade peat, ash ranging between 0 and 10 per cent, (2) medium grade peat, ash 10 to 15 per cent and (3) low grade peat, ash 15 to 25 per cent. The lowest ash reported in this series is 5.04 per cent of the weight of the peat after it had been dried in an oven at 105° C. until the weight was constant and the number of heat units obtained from this sample was 5,876 calories. The heating value diminished as the ash content increased, in these tests, as would be expected, but not regularly, a sample with 8.34 per cent ash developed 5,521 calories, while another with 6.24 per cent ash developed only 5,098 calories, a less amount than another with 14.26 per cent ash which was reported as having a heating value of 5,193 calories. Still another sample with 16.44 per cent ash had a heating value of 5,117 calories. In general the low grade peats ran below 4,500 calories, the medium grade peats below 5,000 calories, and the high grade peats between 5,000 and 5,900 calories, only a small number, however, going above 5,500 calories. These tests were all made with peat dried in an oven at 105° C. until the weight was constant, hence give higher heating values, than would be obtained with air-dry samples, as the author notes, and also for the same reason, higher ash percentages. The same lack of definite relationship between heating value and ash content is shown in the discussion of Allen's analyses of Michigan peat below.

Location and Extent of Peat Beds in Michigan.

As has been stated in the part of this work dealing with the Northern Peninsula, the greatest continuous area of peat in the state lies along an extensive tract of flat country in the eastern end of that peninsula. In the Southern Peninsula,[2] there are no areas comparable with this in extent, and relatively few covering more than a few hundred acres. Of these, the most extensive lie in river valleys and are hence likely to be shallow, and more or less affected by silt which has been brought into the valleys from the hills or by overflow from springs and streams. Of the smaller areas of bog and swamp, there are many in the morainal, or hilly, region north of Detroit, in Oakland county, and extending across the state east and west as well as northward. If one takes a map of the state and examines it for regions where lakes are most numerous, then visits these, he will, in such regions, find bogs and swamps filled with more or less extensive beds of peat, since the lakes indicate an abundance of undrained or partly drained depressions, and, in these, bogs have grown up, as shown by the parts of this report describing the development of peaty formations. The original

[1] Parmelee, C. W. & McCourt, W. E. A report on the peat deposits of Northern New Jersey. Ann. Report of the State Geologist of N. J. for 1905, p. 261, Trenton, N. J., 1906.

[2] See also Winchell, A., Peat in Michigan, Leavitt's Peat Journal I, 1, Boston, 1867.

distribution of swamps, containing more or less peat, in Michigan, is shown by the maps, (Plates XVI and XVII).

These deposits range in depth from a few feet, to as much as 60 to 70, though more often only to 25 or 30 feet, and from a few acres to a series of connected basins, which may cover many hundreds of acres, and in which the depth of the peat may more than compensate for the relatively small area. In some of these basins, however, the peat is shallow, being underlaid by marl a short distance below the surface. On some of the broad, flat divides and especially in the valleys lying in the morainal region of the state, there are excellent deposits of peat of good depth and quality, some of which have been brought under cultivation, however, and are not available for exploitation for fuel, or other purposes.

There is no question in the minds of those who have investigated the matter, or of that of the writer, that there is an abundance of excellent peat for all the uses to which the material has been put, to be found in Michigan and that good deposits for the manufacture of fuel, on any reasonable scale, are to be had near enough to the large towns, so that a good market can be built up as soon as the product is made upon such a basis, that it can be profitably sold in competition with moderate priced, or cheap, wood and coal.

For those types of peat which can not be made into transportable fuel, special forms of utilization could be devised, such as those suggested by Adolf Dal in an article in the London Engineering Magazine, November, 1902. He recommends that the peat of large deposits be turned into electric energy at the beds, and conveyed to the manufacturing centers in that form, rather than try to transport it in fuel form. There is also the possibility of distilling it, and piping the resulting gases long distances, for use in gas engines and for heating and lighting purposes. It seems probable that such methods of exploitation would be quite as satisfactory, and more simple than any method for converting the peat into a portable fuel, except possibly into peat coke, which would be done in any case, if the gas were the object of the utilization.

The Composition of Michigan Peat as Shown by Analyses.

The following analyses, a few of the many which have been made by various chemists, and others, who have investigated the suitability of our peat deposits for fuel,[1] show that these compare favorably with similar deposits in other parts of the country and of Europe.

Analyses by J. R. Allen.

The following report of analyses of peat from three counties in Southern, and one in Northern Michigan, was kindly furnished the Geological Survey for this report by Prof. John R. Allen, of the Engineering Department of the University of Michigan.

Prof. Allen makes the following explanatory statements of the methods used by him in testing the peat samples.

"The analyses, the results of which follow, were made solely for com-

[1] See also Geol. Surv. of Mich., Vol. VIII, Pt. 2, Coal of Mich., p. 119.

mercial purposes, without any thought of publication. They are, therefore, not as complete as they would have been had the original intention been to publish them.

Before being tested, the peats were thoroughly dried at a temperature of about 160° F. The reason for drying at such a low temperature was that it had been found that peat loses a part of its volatile matter when dried at a temperature exceeding 200° F. Tests were made with a Parr calorimeter. The instrument used was a special one of large size, to accommodate the large bulk of peat that it was necessary to use in order to have sufficient weight to give accurate results, but otherwise it was the standard Parr[1] calorimeter.

The chemical analysis of the peat was made in the ordinary manner with a platinum crucible. The crucible was filled with the peat, covered with a platinum cover, weighed and heated until the volatile matter was driven off. Then the crucible and residue were weighed and this weight subtracted from the original weight of the crucible and peat, which gave the weight of the volatile matter. The cover was then removed and the remaining material heated for about 24 hours over a gas flame until all the fixed carbon was driven off. The crucible and contents were then weighed and the result subtracted from the previous weight, the difference being the fixed carbon. The crucible was then cleaned of the residue and weighed, and this weight subtracted from the previous results; this gave the weight of ash. As the tests were made only for commercial purposes, no peats containing over 20% of ash were fully tested. Peats with over 20% of ash were considered unsuitable for commercial purposes.

The results of the tests are given in the following table:"

Number.	County.	Per cent ash.	Per cent fixed carbon.	Per cent volatile matter.	B. T. U.'s per lb.	Remarks.
1	Luce	4.4	....	....	10,600	Peat very fibrous in appearance.
2	Luce	....	....	....	10,000	
3	Luce	4.0	....	....	8,250	Very fine structure.
4	St. Clair	3.5	....	....	9,550	
5	Jackson	9.0	27.3	63.7	8,000	
6	Jackson	3.2	28.6	68.2	8,600	
7	Jackson	8.8	24.0	67.0	8,200	Dense black color.
8	Jackson	5.15	30.0	64.7	9,700	Very light peat.
9	Jackson	5.8	25.0	69.8	10,280	Very light peat.
10	Jackson	7.6	31.0	61.3	8,400	
11	Jackson	10.3	29.4	60.5	8,750	
12	Jackson	10.1	30.8	58.8	9,100	
13	Washtenaw	7.7	30.9	61.5	8,900	Dark reddish color.
14	Washtenaw	10.1	23.6	66.2	8,200	
15	Washtenaw	10.2	26.7	63.2	8,600	
16	Washtenaw	1.8	30.3	68.0	9,500	Fibrous structure.
17	Washtenaw	1.3	29.8	68.5	10,300	Fibrous structure.
18	Washtenaw	2.0	28.0	70.0	10,100	Fibrous structure.
19	Washtenaw	18.8	26.3	55.2	7,550	Celery farm land.

The per cent of ash plus the per cent of fixed carbon will give the per cent of coke obtainable from any sample.

[1] For description and figures of the Parr calorimeter, see Geol. Surv. of Mich., Vol. VIII, Pt. 2, Coal of Mich., pp. 73-76.

On making a comparative study of these analyses, it becomes evident that the ash content of the 18 samples in which it was determined, is low, since in only one of these does it rise above eleven per cent of the total weight of the dried peat. It is difficult to compare these results with those which Parmelee obtained from work on the New Jersey peats, and which have been cited in another place, since those were based upon tests of peat which had been heated to 105° C. or 221° F., before weighing, this temperature involving some loss of volatile matter, as pointed out above, and therefore higher ash in the final statement of analysis, but it is fair to assume that all except one would fall well within the two classes of high and medium grade which are made by that author.

Considered by themselves, Prof. Allen's figures show, as do others also, that heating value does not vary regularly according to any except very considerable variations in the ash content, and that there is no close and definite relation between the heating value and any of the elements reported here. Thus, if these analyses be arranged in order of their heating value, the highest first, and compared with another arrangement in which the lowest in ash is placed first, No. 1 in heating value is No. 7 in ash content. The relations are still farther shown in the following table, made up by arranging the analyses in order of each of the elements of analysis reported, all except the ash from high to low per cent, and the ash from low to high per cent:

Table of Comparative Values of Peat Samples Given Above to Show the Lack of Relationship Between Heating Value as Expressed in B. T. U. and Other Factors Reported.

Original number.	Order for heating value, B. T. U.	Order when arranged according to per cent of ash present.	Order when arranged according to per cent of fixed carbon present.	Order when arranged according to per cent of volatile matter present.	Remarks.
1	1	7	....	....	Only ash and B. T. U. reported.
17	2	1	6	3	
9	3	9	13	2	
18	4	3	9	1	
2	5	....	....	....	Only B. T. U. reported.
8	6	8	5	8	
4	7	5	....	....	Only ash and B. T. U. reported.
16	8	2	4	5	
12	9	14	3	14	
13	10	11	2	11	
11	11	17	7	13	
15	12	16	11	10	
6	13	4	8	4	
10	14	10	1	12	
3	15	6	....	....	Only ash and B. T. U. reported.
7	16	12	14	6	
14	17	15	15	7	
5	18	13	10	9	
19	19	19	12	15	

In a general way the table shows that the higher calorific values are obtained from the peats lowest in ash, and where the ash is present in large quantity, the heating value is reduced, but as stated above, within the range of ash for high grade, commercially valuable peats, this relation is not demonstrable, and a sample with only three per cent of ash may yield less heat units than one having 9 or 10 per cent. In like manner it can readily be seen that the other components usually determined in peat analyses have little demonstrable connection, within limits, with the heating value.

For explanation of these irregularities it seems probable that it will be necessary to consider the type of plants which predominated in the plant associations from whose remains the peat has been built up, the degree of decomposition, the general conditions under which the plant remains were converted into peat, and other minor factors, which, taken together, make the problem one difficult of solution, especially as many minor accidental causes may affect changes in the ash content, and complicate the problem in other ways. It is evident also, from what has been shown regarding the varying origin the different strata of the same bed of peat, the type of plant remains will vary, generally, from layer to layer, from the top down to a considerable distance and that it would be often impossible to determine quantitatively the different species of plants present in the peats, even when it would be easy to tell what ones were present. The peat which contained much of the remains of the resinous coniferous trees would have a high heating value, and should be low in ash if mineral matter from other sources than the plant débris were not present.

It is not likely then, that peat, lacking as it does homogeneity of structure, composition and origin, can ever be depended upon to give uniform heating tests, even when the samples are collected from the same bed, and with considerable care, but in spite of this fact it will usually be advantageous to thoroughly sample and test all beds which are to be commercially exploited before any development is attempted, since in this way only will it be possible to determine the quality of the peat.

The analyses given above indicate that Michigan peat may run very low in ash and that it has a calorific value quite equal to the best grades of peat found in other parts of this country and of Europe, as examination and comparison of the records of analyses will show.

Analyses by A. N. Clark.

Samples collected near Ludington by A. N. Clark, Alma.

Sample No.	Per cent H_2O.	Per cent sand.	Per cent dry peat.	Heating value.
				B. T. U.
1, 3, 5 and 7	86.5	1.6	11.9	
4	87.0	3.0	10.0	
2	90.0	2.0	8.0	
6	88.0	....	....	8,633

No. 6 was the only one tested to determine the heating value and was dried in an oven at 105° C. until the weight was constant, before testing. The heating value of this sample is about that of good hard wood with no treatment except thorough drying.

In the series of four samples from a large bog in Sanilac county, given below, there is a greater divergence in the ash and water content of the various samples. It is an interesting fact that Nos. 1 and 2 are from the same hole, No. 1 from about 5 feet below the surface, and No. 2 about 10 feet. No. 3 is also from about 2 feet below the surface, and No. 4 about 5 feet from another hole about 300 yards from the one from which Nos. 1 and 2 were taken.

Analyses by J. N. Courtney.

Sample No.	Per cent H_2O at 106°C.	Per cent ash.	Per cent combustible matter.
1	83.82	0.88	15.30
2	75.26	3.56	21.18
3	86.94	0.58	12.48
4	81.34	2.86	15.80

The same series of samples was also dried at 106° C. and the carbon, ash, and calorific value determined as follows:

Sample No.	Per cent carbon in peat dried at 106°C.	Per cent ash.	Heating value in calories.	Heating value in B. T. U.
1	47.35	5.70	3,826	6,866
2	32.10	21.10	2,594	4,655
3	35.60	4.45	2,876	5,162
4	30.00	13.00	2,424	4,350

These analyses are instructive, in that they add to the evidence showing that the heating value of peat high in ash may be greater than that with a much lower ash content, and they also indicate that in some bogs the peat from lower strata may have less water than that from nearer the surface; they also give ample testimony as to the high quality of Michigan peat as fuel.

A further idea of the average quality of Michigan peat is given by the analyses for the Chelsea company by W. H. Allen, cited on page 119 of the report on coal (Mich. Geol. Surv., Volume VIII, Part 2), the average of which is as follows:

Moisture and volatile combustible	59.192
Fixed carbon	31.006
Ash	9.802
	100.000

The annual report of the State Board of Geological Survey for 1902 (p. 15) also contains the average result of 10 analyses by Prof. Delos Fall, of the MacMillan Laboratory at Albion, as follows:

Moisture and volatile combustible	64.935
Fixed carbon	28.843
Ash	9.222
	103.000

Mr. Waterbury, in connection with the Haslett Park sink hole, already referred to, had the following three analyses made at the Agricultural College:[1]

Sample No. 1.

Taken south of hole and one foot from surface.

Moisture	8.92	per cent
Organic matter	79.06	" "
Mineral matter	12.007	" "
Total	99.987	" "

Sample No. 2.

Taken 100 feet south of hole in crust, from ground exposed by a tree which had been blown over.

Moisture	10.	per cent
Organic matter	80.	" "
Mineral matter	10.	" "
Total	100.	" "

Sample No. 3.

Taken from water at north side of hole.

Moisture	10.57	per cent
Organic matter	83.74	" "
Mineral matter	5.691	" "
Total	100.001	" "

The percentage of ash in the Allen, Fall and Waterbury analyses is fairly constant.

Fuel Value of Peat.

Raw peat as it exists in the bog is made up of from 85 to 90% or even 95% of water, 8 to 13% of combustible matter, and about 2% of mineral matter or ash. It is evident that such material will not burn, until some of the water is dried or drained from it. If weighed when cut from the bog the heavier and denser qualities may weigh as much as 100 or 125 pounds to the cubic foot, but if allowed to lie on the surface of the ground a few days the water will be reduced to about one-half its former quantity and a still farther exposure to sun and wind reduces it to from 15 to 25%, where it remains stationary, or gains and loses slightly, according to the amount of moisture present in the air which surrounds it. In this air-dried condition, it will have about one-half its former volume, and will weigh from 12 to 40, or even 60 pounds per cubic foot.

[1] The Michigan Engineer, 1903, p. 39.

If set on fire, in the air-dried condition, the lighter and more spongy kinds of peat take fire at about 200° C. and burn briskly, with a red, smoky flame, and give off a characteristic, strong, pungent odor, due to the destructive vaporization of the imperfectly carbonized organic matter. The denser, more compact kinds do not take fire so readily, burn more slowly and in some cases require a higher temperature to start the combustion. The ash of peat is light and powdery and small in bulk, compared with that of the original blocks, and when the surface of the fire is covered with ash, or the draft is reduced to the minimum, the fire is able to maintain itself indefinitely in a smouldering condition, as long as the supply of fuel lasts, it is said because the peat contains a quantity of oxygen in composition, in excess of that possessed by other fuels, and some of which becomes available to support combustion, when the material is decomposed by heat. For the same reason, peat fuels do not require as much draft as other fuels.

Compared With Other Fuels: In crude peat the heating power is small as compared with coal, only about one-half as much, or more exactly the ratio is given as varying from 1:1.6 to 1:1.8, or from 5-8 to 5-9; and it requires for the same evaporating effect from 8 to 18 times as much bulk of crude air-dried peat as of coal, hence large storage room and good-sized fire-boxes are required for the fuel in this form and it is for this reason and also to increase its efficiency, and give it staying power, that various processes of compression, etc., have been devised, In spite of its disadvantages in the more bulky forms, either of the air-dried, hand-cut blocks, or of the compressed blocks, it is reported by those who have used it to be a very satisfactory fuel for all domestic uses, that it is easily kindled, burns freely, gives a rapidly developed and strong heat, is light and easy to handle, and very clean, and with it the fire is easily regulated, for any purpose. For heating-stoves it is also well liked, giving out a gentle but sufficient heat. In burning it, its value and the amount of satisfaction it gives, is said to lie as much in the way it is handled and the form of stove used, as in the fuel. In Europe, where it is extensively used, very few special forms of stoves have been devised for the use of peat fuel, but it probably should be burned in smaller quantities, in less draft and with narrower grate openings than are used with coal and the fire should be tended more often. For open fires in grates, it is said to be a good fuel, and, by some, to be superior to wood. The smoke from open peat fires is said to be beneficial in cases of throat and lung diseases.

When used for the generation of steam under the boilers the manufacturing establishments, power and lighting plants, however, the efficiency of this fuel, in comparison with others which are to be found in the market, is at once questioned, and if it is found that the same money invested in any other fuel will produce as much or more steam, or more heat units, than peat, or can insure a more easily obtained and certain supply, or even one liked better by the men who handle it, the probabilities are much in favor, in most cases, of the other fuels being given the preference and the use. The makers of peat fuel, then, have to produce a fuel that is cheaper, better and more convenient than those already in the market, and must insure a sufficient supply the year round, if they expect it to be generally used for the generation of power, as it must be to make large investments in peat fuel factories profitable. Considering now the heating power of peat fuel of various types, it is well to inspect carefully the following table[1] in which its theoretical value is compared with that of other, commonly used, and easily obtained fuels. The quantity of fuel taken in each case is one pound:

	B. T. U.
Wood	5,760
Ordinary air-dried peat	6,840
Pressed peat	7,290
Bituminous coal	11,000
Ordinary gas coke	12,060
Peat coke	12,676
Semi-bituminous coal	13,000
Peat briquettes	13,330
Charcoal	13,804
Anthracite	14,600

The B. T. U. (British Thermal Unit), is the amount of heat required to raise a pound of water from 50° to 51° F. (Tait). The French unit, or calory, is the amount of heat required to raise a kilogram of water from 0° C. to 1° C., and is occasionally used in quotations in this paper. The relation between the two units is such that Calories may be changed into British Thermal Units by multiplying the quantity to be converted by 9 and dividing by 5. From this table it seems that peat either air-dried or pressed into blocks, is theoretically a more efficient fuel than wood and not so good as good bituminous coal or coke.

It must be remembered, however, that both ash and moisture affect the heating value of peat, as shown by the table given below, cited by Parmelee,[2] from Hausding's Handbuch der Torfgewinnung.[3]

	Calories.
Dry peat without ash	6,500
Dry peat with 4% ash	6,300
Dry peat with 12% ash	5,800
Dry peat with 30% ash	4,500
The same peat with 25% water	4,700
The same peat with 30% water	4,100
The same peat with 50% water	2,700
The same peat with 0% water and 15% ash	5,500
The same peat with 25% water and 0% ash	4,700
The same peat with 30% water and 10% ash	3,700

As the reports regarding the calorific value of fuels, including peat, are made from tests upon samples as free from moisture as it is possible to get them, the value of the fuel in actual working tests is usually considerably less than that indicated by the laboratory determinations. This must always be true of all forms of peat fuel, except peat coke and in certain types of seared briquettes.

[1] See also the table in Mich. Geol. Surv. VIII, Pt. 2, p. 118.
[2] Parmelee, C. W. A report on the peat deposits of Northern New Jersey. Ann. Report of the State Geologist of N. J., 1905, p. 237.
[3] Hausding. Handbuch der Torfgewinnung und Torfverwertung, 2nd Ed. Paul Parey, Berlin, 1904.

Pressing the peat increases its heating power somewhat, and coking it about doubles its value as a heating agent, but does not bring it up to the standard of the best anthracite, although it makes it approach it, since tests reported by various authors give the calorific value of the best grades of Scranton (Pa.) anthracite, as 13,805 B. T. U., and briquetting is even more efficient, since the heating value of peat briquettes ranges from 9,000 to 12,000 or even to 14,000 B. T. U., thus equalling anthracite as a heat producer.

Aside from the evidences of actual heating power, admirers and others who have used peat fuels for generating steam in boilers, state that it gives a quick and lasting heat, raising steam in about one-half the time taken for coal, that it is nearly smokeless, forms no ash of any consequence, makes no clinkers whatever, or cinders, is entirely consumed in the fire-box, none dropping into the ash-pit, makes no soot, does not corrode the grate bars, fire-boxes or boilers, because of its freedom from sulphur, does not clog up the flues with any form of deposit, and that it is the most easily handled of all fuel. Farther, in burning under a boiler, the volatile hydro-carbons of peat are not driven off in a black smoke, as with bituminous coals, but burn above the bed of fuel, thus making a quick, hot, fire, which raises steam rapidly, and the temperature is afterwards maintained by the slower combustion of the fixed carbons. The facts that it ignites so readily, burns up so completely and gives a high temperature without producing cinders, sparks, soot, clinkers, and but a very little smoke, tend to increase its actual efficiency; and while ordinary coal is capable of giving more heat, pound for pound, when usual forms are taken into consideration, it clogs the flues with ash and soot, covers the boiler with a constantly increasing film of rust, destroys grate bars, is not all burned, and in other ways decreases its capacity for generating steam, so that much of its theoretical superiority is lost, and even if these things were not so, when the comfort and convenience of the public are taken into account, and the defacement and damage to property by soft coal smoke, the smokeless feature of peat combustion is alone worth some sacrifice of heating power. As to cost of production, the peat, occurring as it does, at, or just below, the surface of the ground, is mined with less danger and much more cheaply than it is possible to mine coal, and if it needed no further preparation than digging, could be produced for a very small sum per ton. In the form of air-dried, slightly compressed blocks, an acceptable and quite efficient form of peat fuel, it can be produced at from 75 cents to $1.25, or $1.50, per ton, and with automatic machinery, on a large scale, probably for less even than the lower figures, where some of the more highly decomposed, plastic types of peat are used.

But it has been pointed out above that the heating value of this product is only about 1:1.6 to 1:1.8 that of coal, and that the bulk is rarely less than eight times as great as coal of the same heating power, and may be, for the lighter kinds of peat, much more. These are disadvantages, and in the several ways already discussed, but two tons of peat, prepared in this way, will produce more heat than a ton of coal, so that the chief problems involved in introducing it for general use, are the cost of transportation, and of storage under cover, since in this form it can not be long exposed to the weather. The first of these problems is solved where cheap transportation can be depended upon, or by using the peat near the bogs from which it is taken, and the second is readily dealt with in most cases, after consumers have learned the value of peat fuel.

As Affected by Methods of Preparation: Peat is, however, most easily handled, and gives results most nearly in accord with those obtained from the use of an equal weight of the best coal, when pressed dry into the form of small, compact briquettes, either alone, or with some other fuel, such as coal-slack, sawdust or some binding material, and it is to put it into this form, or one even more compact, cheaply, quickly and satisfactorily, that the energies of experts in dealing with this difficult matter, have been bent for many years. The chief problem involved, seems to be to find some way in which peat taken from the bog may be quickly and efficiently deprived of the water which is in it, and compressed rapidly, cheaply and continuously into briquettes, so that a constant production of the finished product can be insured, on a scale sufficiently large to warrant the maintenance of a plant involving, perhaps, the expenditure of a hundred thousand dollars or more, for establishment and equipment, for while smaller units may be built, the cost of running these is apparently disproportionately great, and the returns reduced by that amount. The great obstacle to success in these efforts is found in the fact that the real problem, as stated in simplest terms, is how to recover from a mixture of 85 to 90 per cent of water and 10 to 15 per cent of peat, this small portion of the latter substance, which, when received in a dry state, and burned, will only give heat enough to dry the water from one-third as much more. It is evident that such a problem is not easily solved if the fuel has to be all dried out by artificial means. It is undoubtedly a vital objection which can be urged against all systems of artificially drying peat, that they use three times as many heat units as the resulting fuel will produce, and therein lies the chief reason why such processes have not, in the long run, proved profitable, even where a large amount of waste fuel, in the form of peat refuse, has been available. The cost of drying, figured in tons of peat, is three tons of dry peat, or its heating equivalent, for every ton of dry peat produced, and after it is dried, to this must be added, to determine the selling price, the cost of digging, taking to the drying machinery, the removal from this to the presses, the operating and maintenance of these, the interest on capital and the charges for storing and selling.

Questions naturally arise at this point, as to why the water is not pressed out, thrown out by the use of centrifugal machines, or even filtered out. As to these questions, it may be said that very many attempts have been made to press the water from peat, the most exhaustive and complete of which, were conducted with great care and at large expense under the auspices of the German government. These were on a factory scale and resulted in practically total failure. Peat containing about 80% of water was given a pressure of more than two tons per square inch and when taken from the press still contained over 63% of water. In a report to the government of Norway upon some of the German experiments, which he had followed with care, J. G. Thaulow pronounced them to be complete failures, as it was shown by them that it was difficult to reduce the water to even 66% by pressure alone, and to get even this result required such a great outlay of capital, and such high remaining costs that the expense was all out of proportion to the output. Similar results reported from Canada on the use of hydraulic presses, and from other experiments, are not to be doubted and it is evident that pressure will not expel the water from peat.

Almost the same results have been obtained from attempts to drive the water from peat by the use of centrifuges, and it becomes evident that some internal cause for this behavior must be sought. This was pointed out in the first part of this report (p. 161), namely, that the water in the peat is largely held in the walls and cavities of the cells and vessels of the partly broken-down plant tissues, from which it can neither be squeezed by pressure, nor thrown by whirling, and no amount of contriving machinery is likely to make it possible to do this.

A recent process devised in England, it is claimed, breaks down, to a certain extent, the plant tissues in peat by electrical action, the mass under treatment being at the same time heated by the passage of the current, so that the water liberated is evaporated, but, when it is known that one unit of electricity, cannot develop more than 3,410 heat units, and that about 3 pounds of coal are required to generate this, it is difficult to see how such a method can successfully compete with evaporation by direct heating. If the coal, or other fuel used for the generation of electricity in the above process, were burned directly to heat the peat mass, it would produce more than 10 times as many heat units than are obtained by converting its energy into steam, then to electricity and back again to heat by the resistance offered to the current by the wet peat.

Still another, and apparently a perfectly feasible device for getting rid of the excess of water in peat has recently been described by a writer in Engineering.[1] By the method there discussed the excess of water from peat containing about 95 per cent of water, in which condition it reaches the factory through ditches from the dredging machines, is allowed to drain down to about 80 per cent and then is fed directly into the boiler where the water is evaporated and the steam pressure raised until sufficiently high to run engines and pumps and furnish heat to dryers, etc. The peat obtained in the dry state as the result of the evaporation is briquetted and used under the boilers. If peat with a less amount of water than the 80 per cent is used in the boilers, an excess of the amount of dry fuel required to run them is obtained, and may be briquetted and sold, but with this less fluid peat, the amount of energy used to work the feed-pump and briquetting machine for the boiler is greater, and with very dry peat may be about 30 per cent of the whole energy produced by the boiler. It is evident, therefore that only a relatively small amount of peat briquettes in excess of the needs of the boiler could be obtained by the use of the peat boiler, but large plants for the manufacture of peat fuel, or any form of peat product, could use this type of boiler for the production of fuel as well as steam, for driving the engines and other equipment requiring steam, instead of using the old type of boiler, and drying the fuel by some more expensive or time-consuming process.

After all this experimentation, it has been concluded by the most careful engineers working on the subject, that the most feasible way

[1] Utilization of peat on a large scale. Engineering, May 12, 1905.

to dry the water from peat is by evaporation, using artificial heat, but as has been pointed out, this is too expensive to be practicable for the results obtained, and the processes or treatments which are proving most successful, are those which provide large covered spaces upon which great quantities of peat, after it has been ground and kneaded and slightly compressed into blocks, can be exposed to drying winds out of the reach of rain, until the amount of moisture is reduced to a satisfactory minimum; after which it is farther dried out artificially and sold in this form, or ground and compressed into briquettes.

Many forms of drying apparatus have been devised and patented, and some are regularly manufactured for use in artificially drying peat, and the last stages of the drying can be done in these cheaply, quickly, and very satisfactorily.

One property which peat possesses, in common with other matter of vegetable origin, is its power to rapidly take up moisture from the air, after it has been thoroughly dried (to 2 or 3 per cent of moisture, until it will have almost as much water as it had in the normal air-dry condition, 15 to 20 per cent, about as soon as it is cold.

This is shown in the following table, which is the result of a series of tests made in 1904 upon peat of several different types, by L. Kirschbraun, at that time analyst for the Michigan Geological Survey:

No.	Peat.	Sample wet, gr.	Dried.	Wt. dried.	Moisture, per cent.
1	Jackson bog	5.0036	100=110°	.7339	85.33
2	Jackson bog	5.1971	over H. SO_4	.7709	85.17
3	Jackson bog	5.1447	150°0 C	.7213	85.98
4	Capac Peat Co	4.7013	100=110°	.5173	88.99
5	Capac Peat Co	4.7350	over H_2SO_4	.5081	89.25
6	Capac Peat Co	5.9224	150° C.	.5418	90.86

No.	Exposure.	Wt. after 12 hours.	P. C. gain.	24 hours.	P. C. gain.	36 hours.	P. C. gain.	48 hours.	P. C. gain.	72 *hours.
1	Sat. Atm. 34°C	....	....	.7811	6.29	....	....	.7832	6.73	....
*2	Sat. Atm. 19=26°C	....	....	.8817	14.39	....	....	.9127	18.92	.8848
3	Open air	.8099	12.28	.8296	15.01	.8163	13.17	....	....	....
4	Sat. Atm. 34°C	....	....	.5399	4.34	....	....	.5409	4.56	....
*5	Sat. Atm. 19=26° C	....	....	.5606	10.33	....	....	.5740	12.96	.5605
6	Open air	.5821	7.44	.5977	10.32	.5814	7.31	....	....	....

* Per cent gain 72 hrs., No. 2, 14.77.
No. 5, 10.33.

Nos. 3 and 6 were exposed during a rain storm between 12 and 24 hours.

The Jackson specimens were very dark colored, fine grained and compact; those from Capac bog, dark brown and of rather coarse texture. The gain in moisture at the end of 24 hours in all of these specimens was sufficient to make a considerable change in the heating value of the samples, and shows the inadvisability of carrying the process of driving off the moisture below 15 or even 20%, except possibly from very black, finely divided types, which show experimentally that they only absorb a limited amount of water after they are once dried thoroughly. The same analyst tested the moisture content of a sample briquette made at the Capac factory, which was reported, when made, to contain but 3 per cent of moisture. It has been kept in a dry room constantly from the time of making until analyzed, but was reported as follows: Capac briquette, moisture, 14.75 per cent.

Because of this property, it will be seen that it is not necessary to go to the expense of completely drying the peat to be made into briquettes, unless the process is one in which the dry peat runs directly from dryer to briquetting machine, and in which the briquettes are coated with a layer of tar at the time they are formed, for if the dried peat in uncompressed form is exposed to moist air while in storage bins, it will almost immediately absorb water from the air to the extent of 10 or 15 per cent. If, on the other hand, peat after complete drying, is compressed immediately, without water-proofing, and the briquettes thus formed are allowed to stand in the air for a time, it will be found, upon analysis, that moisture has been taken up by them from the air, just as it was by the uncompressed peat. That is, even briquetted peat is hygroscopic, actively taking moisture from the air, so that it is useless to dry it much below the air-dried condition of the peat, since in the end it produces no appreciable good results, and entails expense for drying which is relatively high when compared with that of reducing to the air-dry state. It may also give the retailer a marked advantage in handling freshly briquetted peat, in that it enables him to buy the product with a low moisture content and sell it after it has taken up 8 or 10, or more, per cent of water, although this may not more than compensate for shrinkage due to breaking and crumbling of the briquettes in handling.

It is apparent, from what has been said of the peculiarities of peat, that the manufacture into briquettes in large quantities and in such a way as to produce a steady output throughout the year, is not as simple a matter as it would seem at first thought, and while there are in Russia and other European countries numbers of large factories which do produce them, and which seem able to do so with a satisfactory margin of profit, the questions relating to entirely satisfactory processes are not yet settled, and new and improved methods of production are constantly being proposed. Russia is reported as producing annually 4,000,000 tons of peat briquettes, and as receiving $938,000 for leases of peat deposits. Germany produces more than 2,000,000 tons, and Holland and Sweden each more than a million tons of this type of fuel each year.

Assuming, then, that peat can profitably be made into briquettes, there are two types which can be made from pure peat, besides those in which other combustible material is mixed with the peat before compression. The two types in somewhat common use are cold-pressed briquette and the seared briquette. In the first, the peat is dried, ground, and then compressed by hydraulic or other heavy pressure, since no cementing material is used, in a specially constructed molding press, into blocks of a given size and shape, which will be easy to handle and burn. These blocks, which may be cylindrical, egg-shaped or prismatic, with, or without, rounded corners, are not covered with any moisture-proof substance, but have a slightly polished surface due to the pressure of the mold, and, when wet, absorb moisture readily and swell up to the original bulk of peat and disintegrate if allowed to remain moist, as well as break down rapidly when burned, thus, in part, defeating the purpose of molding it. They are also liable to show cleavage planes when examined closely, where the larger fragments of the coarse peat have arranged themselves at right angles with the direction in which the compressing force is applied, and it is quite easy to break them apart along these planes so that they must be handled somewhat carefully, and be transported and stored so that they will not get wet or very moist.

On the other hand, they form a good heating and steam-producing fuel, which burns rapidly without smoke, and has a high calorific value, having lost considerable of its volatile matter by heating, in the processes of preparation and briquetting. It is for the production of this type of briquettes from peat, that several companies have built plants in Michigan.

In the second type, the "seared" briquette, the peat is first pressed into hard, dense, blocks by the presses, after having been put through about the same treatment as in the cold pressed method, and then the blocks are heated sufficiently to free some of the tar and tar oils, which appear at the surface and form an impervious coating, preventing the absorption of moisture. This covering, also, gives a dark, smooth, oily or varnished appearance to the block and make it dense in texture on the outside. Not only this, but the varnish of tar has a certain cementing power to make the block resistant, and also brings the most easily ignited part of the block in contact with the fire. It is said that the briquettes of this type are slightly less rich in volatile matter than the cold pressed forms, but that they have nearly the heating value of hard coal and do not crumble in the fire as do the other types of blocks. These may be used for any purpose where hard coal or any smokeless, very efficient fuel is required, as they burn readily in grates, heating-stoves, and furnaces, kitchen ranges, and steam boilers, giving a flame somewhat like that of wood, and a strong heat from the time the fire is kindled, while, because of the density of the blocks they hold their shape until consumed. In all forms of briquettes the combustion is so complete that none of the free carbon or unconsumed gases escape into the open air, so this form of fuel has a considerable economic advantage over either soft or hard coal. A large plant at Whitewater, Wisconsin, and a smaller one at Bancroft, Michigan (closed), have been established for the manufacture of this type of briquettes.

So much has been said in other parts of this paper regarding peat coke and peat gas that little need be said here.

The following analyses published by the Prussian Board of Trade and Agriculture, show the ultimate composition of Peat Coke I of the Ziegler process as compared with charcoal.

	Peat Coke I.	Charcoal.
Carbon	87.8% — 86.0%	87.6%
Hydrogen	2.0% — 1.9%	3.1%
Nitrogen	1.3% — 1.3%	0.4%
Sulphur	0.3% — 0.3%	0.3%
Oxygen	5.5% — 5.2%	4.7%
Ash	3.2% — 3.0%	0.9%
Water	0.0% — 0.43%	3.0%
	Fuel value=7,800 calories	Fuel value=7,800 calories
	14,800 B. T. U.	14,500 B. T. U.

Analysis of Peat Coke II.

(According to the Royal Chemical and Technical Experimental Station in Berlin.)

Carbon	73.89%
Hydrogen	3.59
Nitrogen	1.49
Oxygen	14.52
Sulphur	0.20
Ash	2.50
Moisture at 105° C.	3.80

Fuel value, 6,700 calories
12,450 B. T. U.

The fuel value of the coke is high, as is shown in the comparative table given above, and it differs from the other forms of peat fuel in having little volatile matter, this having been driven off by the process of distillation. This gives to coke the characteristics of charcoal in its combustion and it burns with little flame and no smoke, and when once thoroughly started, with intense heat, the temperature reached through its combustion being higher than that obtained by using any grade of coal. For this reason it might, as Hess has suggested, be useful in cement-burning rotaries. It is a clean, free-burning, smokeless fuel, easily handled, has small ash content, contains no substances which will injure boilers or furnaces, and, under forced draft, will give a very high temperature. It is especially adapted to all metallurgical processes where ordinary coke and charcoal are now used. But for its cost and scarcity, there is no fuel more satisfactory.

The quality of peat which yields the best coke is that rather low in ash, which will easily compact itself into a firm, dense block, after it has been ground and worked into a plastic condition.

It is reported that, in Russia and Northern Germany, peat coke is used to some extent for firing locomotives, and that it is so satisfactory in that use, that the Russian government is now making and storing it for emergency uses upon important railway lines. At present this form of peat fuel cannot be expected to compete, on a large scale, with coal in this country, but it could be used wherever charcoal is used, and, as has been suggested, it might find extensive use in metallurgical operations, especially in blast furnaces, for the manufacture of charcoal iron as a substitute for charcoal prepared from wood.

It thus becomes apparent that the preparation of peat for fuel in such form that it is easily transported, and approximately equals in heat-giving power the efficiency of the other fuels with which it must be compared, and with which it must compete, is no simple matter; that with each increase in compactness, portability and calorific power, an additional treatment must be given it, requiring more complicated and expensive machinery than the processes giving the less compact forms. In these more extended and elaborate forms of treatment, if they are to return a profit, the processes must be largely automatic and continuous, doing away with human labor as much as possible and depending largely upon well-planned and carefully placed machinery, which must be capable of handling, grading, and preparing large amounts of heterogeneous crude material, rapidly and cheaply and of turning it into the maximum amount of marketable and efficient fuel. If this can not be done, then it is better to hold to the simpler forms of machinery which are easier to operate, and very much less expensive to buy, and with these, to make a smaller amount of the compressed, air-dry fuel, and supply small and perhaps purely local markets, with a fair margin of profit and success.

As Affected by Cost of Preparation: The cost of preparing peat fuel for market is, of course, governed somewhat by the extent to which the preparation is carried, but in the more elaborate methods the cost is increased by the necessary charges for maintenance of the expensive plant, as well as for the more numerous operations, so that while cut peat, air dried, may be produced for less than 50 cents per ton, the cost of producing a ton of peat coke, having about double the number of heat units, is 5 or 6 times as much, $2.50 or $3.00 per ton, at the German mill, to which must be added the cost of selling, transportation and handling. The cost of preparing the briquetted peat is given by various writers as ranging from 1 to 2, or even 3, dollars per ton, and probably would exceed the latter figure in many cases where errors were made in planning the plant. It should also be considered, that the situation, and especially the mechanical condition of the peat, affect the cost of production, and it is only the best adapted and most uniform beds which can be made to produce a uniform and satisfactory product. It is probably true that it will be found, when all things essential are taken into account, that the cost of making briquettes of peat which will stand transportation and other tests satisfactorily, will not be below $2.00 per ton at the factory, and that this cost will be much exceeded in very many if not the majority of cases.

Conclusions: It may also be well to call attention in this place to statements frequently made by advocates of the simpler methods of treatment of peat, that compressed peat is the only form in which the material has continuously and successfully been placed upon the markets abroad, and that while the briquetted form is made and sold, that it is not a commercially successful article even in the best European markets, as yet. These statements are in part, at least, substantiated upon a report on peat utilization in other European countries to the Norwegian government made in 1903, and quoted by the U. S. Consul-General[1] to Norway in a report to the home government, in which it is stated that "Common hand or machine made peat is acknowledged to be the most promising article."

So much of the literature relating to this question is of the nature of advertising, or booming matter, that it is not easy to be certain as to all of the statements which are to be found in print, even in places where reliable statements would usually be found, hence the apparent contradictions appearing in this summary.

[1] Bordewich, Henry, Special Consular Reports, Volume XXVI, p. 119, Washington, 1903.

MACHINERY FOR THE PREPARATION OF PEAT FUEL AND PEAT LITTER.

In previous sections of this paper, various stages of the development of the manufacture of peat fuel have been discussed, and the underlying causes which have brought about the extended experiments have been briefly considered, and in this section a short account of some types of machinery for the gathering and preparation of peat for fuel and other uses will be given, and in addition, the names of a few manufacturers of similar types from whom illustrations, catalogs and other information relating to their machines may be obtained. It is not intended to make this a descriptive catalog, but simply to show how the machinery for the preparation of peat for fuel has grown in complexity and efficiency as the experimental work of inventors and investigators has gone on.

The Slayne or Slane as Used in Different Countries.

The earliest tool used in preparing peat for fuel, and one still in use, even where machinery has been introduced to perform the same work, is the slayne (Plate XXIX), or slane, a modified spade, with a blade nearly or quite two feet long and from 4 to 6 inches wide with a projection or flange 4 inches long and 5 inches broad, at right angles to the blade, having a sharp edge, which cuts the side of the block. This tool may be made wholly of iron or steel, or of wood, with steel cutting edges. The surface of the peat is first stripped of plants and the coarse and partly decomposed plant débris making up the top layers, which are unsuitable for manufacture, by the use of ordinary tools used in clearing land, and straight ditches, with perpendicular sides, are dug for drainage. When the usable peat is exposed, the workman cuts into it with his slane, tears a block of it off from below and lays it out on the surface. The blocks may be 5 or 6 inches square on the ends and from 15 to 18 inches, or even more, long. Such blocks will weigh, as cut out, from 12 to 25 pounds apiece, according to the amount of water present, and the degree of decomposition of the peat, and a skilled man, used to the work, is said to be able to cut sufficient material to keep two teams busy drawing it away, since he only cuts the peat and places it on the surface of the bog beside the trench from which it is taken, the loading being done by helpers. In South Germany the workman stands upon the surface of the peat bed, which is from two to four yards broad, and makes vertical cuts, while in Middle and Northern Germany, the horizontal cut is more commonly used. In these regions, one workman cuts or marks out the blocks, with perpendicular strokes, beginning at the outside edge of the cleared space, and a second one cuts them off the bottom with horizontal strokes, using a specially constructed spade, and lifts the blocks up and lays them to one side, on the ground, to dry.

In Ireland, it is said, that the vertical cut is generally used, the blocks being lifted by the cutter to the side of the trench made in digging them, whence they are removed after they have somewhat dried, or they are taken green to a more favorable spot, a good workman keeping two helpers busy moving the blocks, or sods.

The only preparation given hand-cut peat is to dry it by exposure to sun and air, generally upon the surface of the bog, but since rain causes the freshly cut blocks to break down quite readily, they are sometimes protected by rough shelters for a time, the blocks being frequently turned over to insure thorough drying on all sides. After the blocks have been dried for a time the surface is much less readily penetrated by water, than when they are first cut, and they may then be exposed to the weather with little or no damage.

In parts of Europe, in extensive hand cutting of peat, the workmen are employed in gangs of five, one who clears the surface of disintegrated and worthless peat, two cutters, who cut and lift the blocks from the trenches, and a loader, who picks up the blocks left by the cutters and piles them upon wheelbarrows, and the man who wheels the loaded barrows to the drying ground, usually the cleared surface of the bog on one side of the trench, which is smoothed up for the purpose. The peat is turned from the wheelbarrows onto this space and left to drain and dry for a time, after which it is taken away and piled up in rows, each row being allowed to dry, in part, before another one is placed on top of it. Usually the blocks are left here to dry for about a month, during which time the water content is reduced about one-half, and then are piled up in store houses, or in large stacks, to be more fully dried. The stacks are usually built up on the higher parts of the bogs themselves and after the blocks are thoroughly air dry, they are carted away to storage.

In the bogs where the peat is too wet, and soft, or too uneven, and irregular in structure, to permit of its being cut into blocks, it is either lifted in nets or dredges, as in Holland, and parts of Germany, or dug up in small blocks, which, after being drained, somewhat, are trampled under foot until ground up and rendered even in structure, and then cut into pieces and pressed into molds with the hands like brick clay. Peat treated in this way, is more compact, and therefore better fuel, than ordinary cut peat.

Machinery for Making Cut Peat.

Machinery for cutting peat from the bogs was one of the earliest forms of improvement which was made in the process of making peat fuel, and it is stated that a machine for this purpose was invented in France, as early as the middle of the 18th century,. and not much later, machines were in use for cutting peat in Germany, to a limited extent.

A typical peat cutting machine, used at the present time in various parts of Germany, and extensively advertised, is the Brosowsky machine (Fig. 19) made at Jasenitz, which was first introduced in 1843, since which time it has been much improved, and of which the manufacturers claim they have sold over 8,000. By its use, peat can be cut and raised from a depth of 20 feet, or more, below the surface whether covered by water or not, hence wet bogs need not be drained, but may be cleared of peat without trouble, or those which have been worked as far as possible with hand labor, may be still further worked by this machine. The essential part of the machine is the cutting apparatus, which consists of a set of three knives, forming a box open at top, bottom, and one end. This three-sided knife is fastened to the back of a wrought iron bar, by means of which the knife is forced into the peat. The bar is operated by a rocking pinion, and a shaft and crank. By turning the crank, the cutting apparatus is moved up and down, and with the weight of the knife as it is lowered, the cutter may be forced into soft peat as much as 36 feet, but it should be noted that the machine can only be used at the side of the hole where the peat has been taken out.

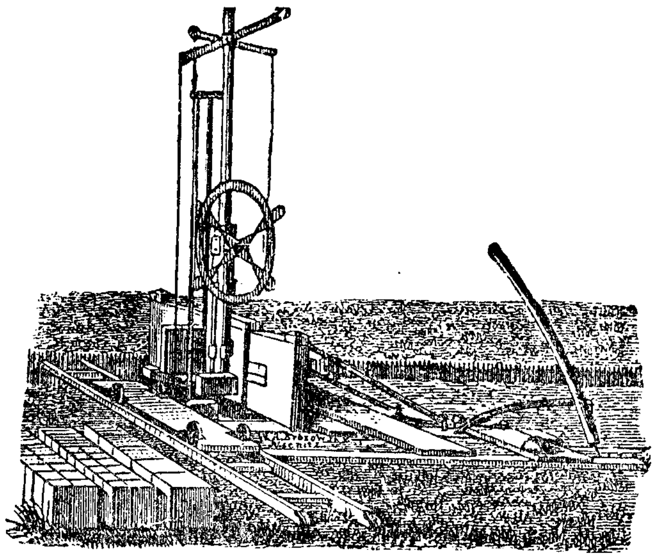


FIG 19. Machine for cutting Peat.

As the cutter has three sides of the block of peat to cut, on the side where the bar is fastened, there is fixed a sharp, flat knife, the purpose of which is to cut off the form or prism of peat made by the downward passage of the large three-sided knife. This cross-cutting knife is provided with two chains which pass over two cylindrical rollers, and by means of two levers, may be turned backwards or forwards. When the cutting apparatus is drawn up by means of the rocking pinion, this knife at the base holds the column of peat in place, since it forms the bottom of the box, and there are guides to prevent the column from falling over, which it might easily do, as it has a height of 3 to 6 yards, and base of 24 by 28 inches. After one block of peat has been taken out, the cutting apparatus is moved its own breadth sidewise on a frame. This frame is of such width, that 4 cuts may be made side by side before the machine has to be moved back the width of the knife. To aid in the backward movement, one side of the three-cornered frame supporting the apparatus is fitted with two small wheels which fit into a groove in the supporting timber and lie underneath it. By means of a projecting level, the machine is started upon the two wheels and is then moved back by another level which fits into holes in the underlying beam. The price of these patent machines varies according to the depth to which the cutter can be forced, from about $110.00 for 2 yards, to $145.00 f. o. b., for 6 yards.

Two men can cut about 3,000 cubic feet of peat with one of these machines in 10 hours, and with two helpers can produce from 10,000 to

12,000 blocks 8 inches long and about 5 inches square at the end, including the arrangement of these in rows upon the drying floor.

Another cutting machine which is in somewhat general use in Europe is that made by C. Muller of Dominion, in Pomerania, which is recommended for use under water and is also said to be capable of digging deeper than other similar machines. This cuts and lifts the peat in a cylindrical form from 2 to 6 yards high, according to the thickness of the layer. It is so arranged that four columns of peat can be cut without moving the machine. When the cutting cylinder is pushed down to the desired depth into the peat, the column is cut off by a knife, operated by levers, and this knife also holds the peat in the cylinder by forming a bottom for the cutting tube. As the cylinder with the column of peat is raised by one man, a second workman, with a spade, cuts the column into pieces of uniform length, and lays them on a car, by which they are carried to the drying floor, after which they are cut into smaller blocks and arranged for drying.

A third peat cutting machine is that made by Karl Weitzmann at Greifnagn, which cuts the peat to a depth of four feet into rectangular columns, which are then drawn to the surface and divided into cubical blocks as before.

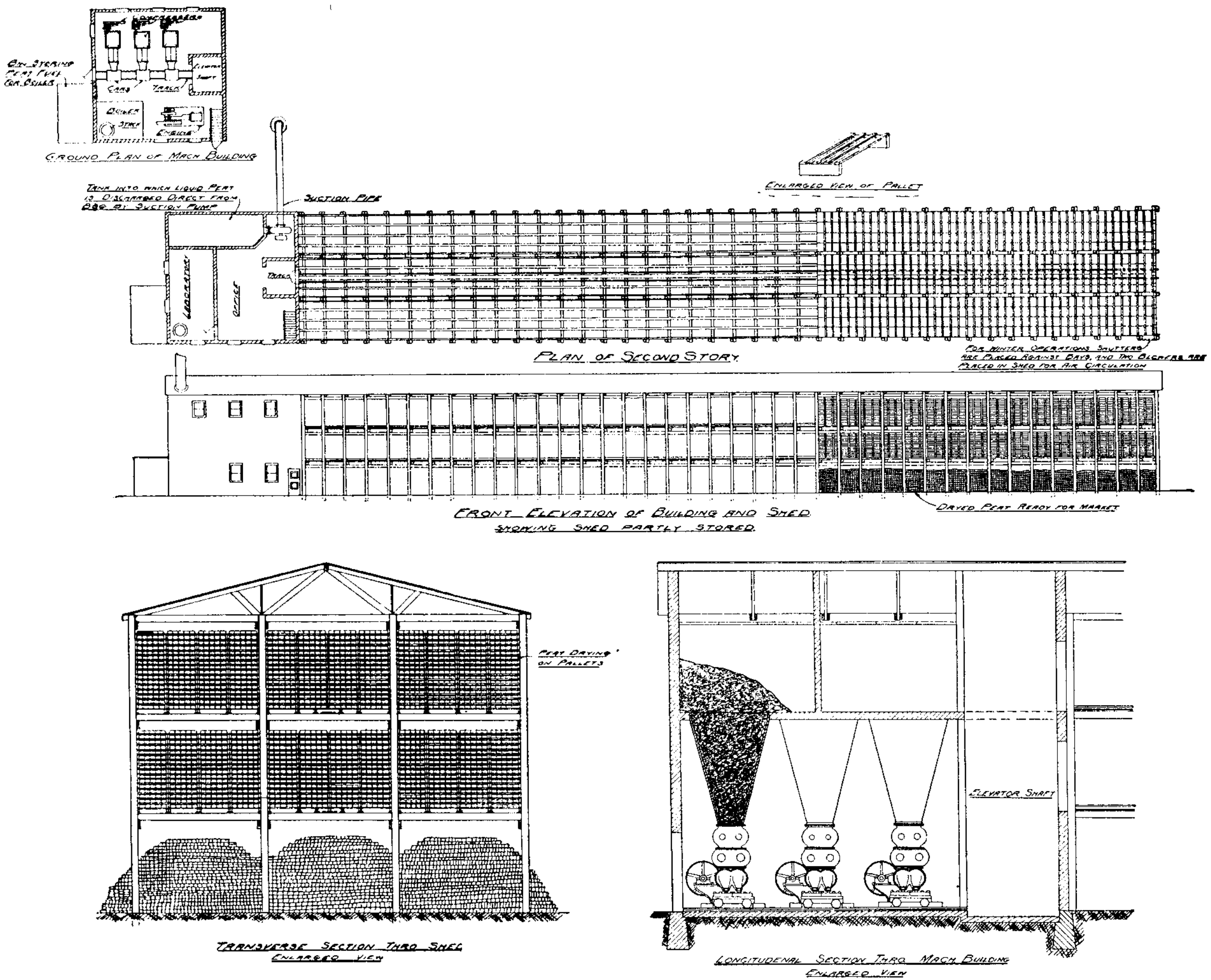
Another German machine of similar type is that of R. Dolberg of Rostock, Germany, German patent 43106, but, while it is an efficient machine, it is not necessary to describe it here.

Of digging machines, which simply dig the peat from the bogs from a greater or less depth from the surface, and convey it by mechanical means to carts, cars or presses, and which are usually considered as essential parts of the outfit necessary to make compressed peat on any but the smallest scale, may be had in a variety of forms, to be run by man, horse or steam power, at prices ranging from less than $50.00 to several hundreds. They do not cut the peat into large blocks of regular size, but are constructed for the purpose of removing the material rapidly from the bog and giving a constant and sufficient supply to the presses or other machines used with them, at small expense. These diggers according to claims of the makers, may be used down to depths of 25 feet, or more, below the surface, and are operated by a series of Archimedian screws, or may consist of an endless chain of small shovel-shaped buckets, each of which takes a small load of peat as it rises and carries it to the top of the elevator and drops it, much as the buckets of a grain elevator work.

Machines for Making Pressed or Condensed Peat.

It has so frequently been pointed out that cut peat is bulky and fragile, as well as indifferent fuel, and that its efficiency and other desirable qualities are improved by compression, that it need not be discussed again here. The simplest process to improve the quality is compression or condensation, the latter being the better term, since very little actual compression is used by the machines producing this sort of fuel. As the result of the treatment by the more improved types of machines, about one-third of the bulk of the peat is lost, and when dry, it becomes hard, firm, nearly waterproof and is increased in efficiency as fuel.

Mention has already been made of the treatment of soft, or very coarse



PLAN AND SECTION OF PEAT FACTORY.

peat, by which it was shaped in small molds by hand pressure, and the earliest methods of machine compression were not much more elaborate than this, since the early forms of press were simple rectangular boxes, with a close fitted piston, which could be pushed down into the box by screws or levers, holes being provided for the water liberated by the pressure, to run off. Compressed peat was made in Saxony, as early as 1820.

Later machines show development along many lines, but in addition to mere compression, most of them grind, or roll, the peat and subject it to a kneading process to break up the vegetable structure of the plant remains in it, in order to make it easy to get rid of the air and water which may be entangled in the cavities of these structures. Some of these machines have combined rolling, cutting, and filtering through coarse cloth, as the Mannhardt and Koch press, described by Percy[1] as follows:

"The principal feature of this press consists in the use of a pair of large horizontal rolls covered with cloth to serve as a filter. On the circumference of the roll, ribs of hoop iron are fixed obliquely about one inch apart, which support drilled iron plates surrounded by an endless band of cloth. The wet peat is torn to pieces and put in two hoppers, one over each roll, whence it is drawn by rake rollers; but in its course to the large rolls it passes through a series of three small rolls, fixed above each large roll, whereby it is deprived of most of its water. There are thus two streams of peat descending from the two hoppers and passing, first through a pair of small rolls, then through a pair of spiked rolls and lastly through the two large rolls by which the remaining water is pressed through the remaining filter-cloth into the interior of these rolls. The peat now forms a compact sheet which is conveyed to a knife-like apparatus, which divides it transversely, and then to circular cutters, which divide it longitudinally into blocks of the required dimensions. The peat is thus freed from water to such an extent that its further dessication may be effected in favorable weather, in the course of a few days, under covered, airy sheds, or in unfavorable weather, by artificial heat in suitable apparatus."

The same writer describes a number of other forms of presses, some of which are still in use, having been improved from time to time up to the present. A good peat-pressing machine must be simply and strongly built, must run easily and without requiring excessive repairs and should be built so that it can be moved from place to place readily. It must do its work quickly, grind and mix the peat thoroughly and deliver the blocks well formed and of uniform hardness, which, however, need not be very great. The peat should be easily fed to it and the completed blocks readily removed to the driers.

There are machines meeting all these requirements now manufactured in Germany, in this country, and in Canada.

One of the most generally used machines of this kind in Europe, is that made by C. Schlickeysen of Rixdorf, near Berlin, which has been mentioned already. This machine first appeared about 1860 and has been constantly improved until the present time. A late pattern has an excavating machine which cuts the peat from the bogs, when not too full of

[1] Percy, John, Metallurgy: Refractory materials and fuels, p. 231, London, 1875.

logs, stones, etc., and delivers it by means of a long, sloping belt-and-bucket elevator, into a cylinder, in the axis of which a shaft revolves, carry strong, projecting blades, which have cutting edges and which are arranged spirally, so that they force the peat along. The blades are nearly, but not quite, in a true spiral, so that they act unequally on the peat, thus grinding, cutting and mixing it, the more perfectly. There are no projections or blades on the inner surface of the cylinder and the finely divided and condensed peat pulp is finally forced out by a horizontal screw, in the form of a continuous flexible, prismatic, block, 3 by 4 inches in section, at the tail of the machine, where it is received on boards 3 feet in length, which, as soon as filled, are loaded onto small cars and run out to the drying grounds, where the blocks are laid out in rows and cut with a knife into bricks, 10 inches long, and left to dry. They lose in ordinary weather one-half their water content in a period of two weeks, after which, they may be quite profitably dried artificially, or be left for a longer time exposed to the air. By the use of this type of machine, the peat is reduced one-third in bulk, so that a machine handling 21 cubic yards of raw peat per hour, delivers only 14 cubic yards of condensed peat in the form of bricks, or blocks, 10 inches long, by 3 by 4 inches in section, and weighing when dry, from 2½ to about 4 tons, in which condition it is good fuel, hard and tough and easily kept dry. A plant of this kind includes besides the excavator, elevator and grinding press, a 10-horsepower portable engine, which uses peat refuse for fuel, and cars and tracks for removing the blocks from machine to dryer, etc. Since the whole plant is portable, it may be placed on the further side of the bog to be worked and moved backward as the peat is taken out. The cost of such a plant complete, is about $5,000, ready to operate and its operation when used without machine or digger, takes 19 men including the engineer and fireman.

Horsepower peat machines for compressing peat are manufactured by a number of European makers, among which is that made by R. Dolberg, which requires to run it, a good stout horse, 6 men, and a boy to lead the horse. The machine is placed about 8 yards from the edge of the peat bed, with the opening to the press turned toward the bog, so that it may easily be reached. In operating this machine the horse is hitched to a traction beam about 18 feet long and 4 inches square at the smallest end, and if the ground is soft a board or plank track must be laid, or broad shoes, such as are used in gathering marsh hay, fitted to the horse's feet. The peat is dug by hand and thrown into irregular piles, from 25 to 50 feet broad, according as the peat is deep or shallow. The digging requires one man, and a second wheels the peat to the machine, which is fed by a third, who is general foreman and especially has to see that the horse keeps up a uniform gait. A roller is fastened under the mouth piece, in the same direction with it, to receive the finished peat as it comes from the orifice of the machine, hence the roller must be more or less inclined according to the consistency of the peat, so that the manufactured blocks may neither choke the machine nor be torn apart; the rollers must be adjusted high enough so that the peat table rolling on them stands about 4 inches from the mouth-piece.

The boards on which the condensed peat is received, are placed on the rollers and the peat block is cut into bricks with a knife as it comes out. As fast as the boards are full, they are lifted into a cart, and when the cart is loaded, it is driven off to the drying ground by two other workmen, who unload and arrange the blocks upon the ground. In this work, two-wheeled carts, taking about 16 boards of 10 blocks each, and running on board tracks, are used. The wheels of the cart are so placed that the weight of the peat balances the load and makes the work of pushing them easy.

The machine itself, consists of a revolving, spiral cutter and is enclosed in a stout, iron casing, with a hopper-like opening at one side near one end, and the opening for the condensed peat at the other. If, at any time, the spiral, or the mouth piece is stopped by pieces of undecomposed wood, sods, stringy material, or too dry peat, it can be cleaned through openings in the side of the casing, provided for this purpose, or the mold and mouth-piece may be opened and the cause of the trouble quickly found and removed.

If the horse is to work the machine easily and satisfactorily, the peat should be put into the machine so wet, that when the blocks are cut off at the tail of the machine, they will be only sufficiently solid to hold their shape on the board. This is contrary to the belief of inexpert workers, who think that the peat should come from the machine dense and solid, but a much larger and more satisfactory output can be obtained by working the peat wet, and the drying goes on about as rapidly, since the grinding and kneading increases the capacity for drying and contraction so that in 2 weeks of good drying weather, the bricks can be piled.

With the horsepower machine, the chief points to look out for are that the horse keeps going steadily and that each man keeps up with his special part of the work and the duty of the man who feeds the machine, and who is also foreman, should be to see that the horse keeps an even gait. If this is done the quality of peat blocks produced is uniform and each set of men has to be prompt in bringing up the raw material and in taking away the finished blocks. Where this is done, and especially where the work is paid for by the thousand it is not hard to get a production of from 14,000 to 16,000 bricks per day with a single horsepower machine. When in use, and peat has to be brought more than 75 steps, the machine should be moved to a new spot nearer the supply.

In the Heinen horsepower machines made by A. Heinen, Varel, Oldenburg, Germany, the essential parts are a vertical cylinder firmly attached to a timber base, in which is the grinder and condensing apparatus turned by a long beam at the top. At one side of the cylinder near the bottom is the delivery spout, so that boards for the reception of the finished product can run in it. The peat bricks made by this machine are about the size of those made by the others and are handled in much the same way. The manufacturer estimates from 8,000 to 10,000 peat bricks per day with one horse, as the capacity of this machine.

Another manufacturer of machines for making condensed peat, is Weitzmann, who makes a machine which may be either used by horse or steam power, and which is said to work all kinds of peat without difficulty. This consists of a horizontal cylinder, somewhat larger at one end, where the hopper is placed, than at the other, or outlet, end. On top of this smaller part, is a short transverse cylinder of about the same diameter. In the long cylinder is a long axis turned by a fly wheel geared at right angles with it, upon which is bolted a series of powerful steel blades arranged spirally, so as to give a forward motion to peat while cutting it and in the upper cylinder is a deeply corrugated roller, the depressions of which fit over the blades of the cutting apparatus, and materially aid in reducing the peat to a finely divided state. The pulp is pressed forward to the tail of the machine and out through a pipe, where, as in other machines, the block is received on a moving table and cut up, and taken away to be dried.

Peat presses are also made by G. Traskatis, Lyck, East Prussia, and Stutzke Brothers, Lauenberg, Prussia. Of American made machines which make condensed peat, the best known, and longest used is the Leavitt Peat Machine (Plate XXXI), invented by T. H. Leavitt, recently deceased, who became interested in peat fuel manufacture about 1865. This is a machine operated by steam power, in which it is designed to break down the vegetable tissues and cells in the peat, liberate the air and water contained in these, and thus render the material plastic, so that it will become compact and hard when dried after slight compression. The machine may be considered in two parts, the condenser, and the molding mill, which are separate but connected by a belt conveyor, and which together occupy a space 6 x 10 feet on the floor and 10 feet high, exclusive of the engine and boiler.

The condenser has a revolving cutter or "ripper" consisting of a series of spirally arranged knives on a small shaft just below the hopper, where it receives the crude peat and cuts and tears it to pieces. From the ripper, the peat enters a series of three pairs of cast iron rolls, each three feet long, with the lower roll of the first pair heavily corrugated to help move the material along. These rollers perform a rubbing or grinding process which is brought about by a different rate of rotation for each roller of each pair. The upper roller of the first pair makes 40 revolutions, to 20 of the lower; the upper one of the second pair 90, while the lower one makes only 40, while in the third pair, the upper one revolves 180 times while the lower one turns 60 times. After passing through these rolls, the peat, finely divided, and deprived of most of the air which it originally contained, has shrunk in bulk from 30 to 50 per cent, and has about the same amount of water it had to start with. It is then in a pasty condition, and is received by the belt conveyor, which is enclosed in a wooden casing, and carried to the hopper of the molding machine. This is an upright cylinder supported upon a heavy cast iron base nearly five feet high; below the upright part is the molder, or press proper, consisting of two horizontal revolving cylinders, which are similar to the molds of brick making machines. Below this is a table made up of boards supported by a belt carrier, which receives the peat bricks as they come from the machine. The upright cylinder contains a series of semi-circular shelves, arranged alternately on opposite sides of the chamber, and each with a series of radial slots one-half inch wide. A central shaft, carries, just above the shelves, a corresponding set of two-armed sweeps and a less number of single-armed ones. The former rubs the peat against the shelves and the latter help to press it down into the pockets of the molding cylinders, from which it is forced by plungers onto the boards of the table below in the form of blocks or bricks, 4 by 8 by 2½ inches. The capacity of the machine is 108 blocks per minute, or about 65,000 per 10 hour day, which, after drying, amounts to about 40 tons of good hard fuel. The blocks taken from the machine may be conveyed to the drying grounds or sheds by any convenient way, and may be spread out in rows or piled in racks, and left to be dried by the wind and air. The wet blocks commonly weigh about 3½ pounds, contain 80 cubic inches, and have a surface of about a square foot. The blocks shrink as they dry, and get to be nearly as hard as stone and impervious to water, the drying taking from four days to 2 weeks, according to the weather, when they are ready for the market. A plant using this machine is in operation at Orlando, Florida, where it makes all the fuel used by the Orlando Water and Light Company which develops 500 horsepower. The capacity of the peat molding machine can be increased by increasing the speed, trial runs showing that it can produce as much as 400 tons per day without difficulty. The cost of putting up a plant equipped with this machine is figured at $5,000, divided as follows:

Machine	$1,500
One engine and boiler, 12 horsepower	1,500
Shafting, belting and fixtures	500
Roughly constructed building	1,000
Incidentals	500
Total	$5,000

The cost of labor is also a very important item, which must be taken into account in considering the possibilities of manufacture of peat fuel. With this machine using 100 tons of crude peat per day, four men will be required to cut the peat from the bog and load it on cars; a boy with a single horse, and two cars running on a tramway, can handle the transportation to the mill. One man is needed to feed the mill, one to put molds into the mill, two to take the molds from the mill, a boy, one horse and three trucks to transfer the molds to the drying ground, two men on the drying ground to empty the molds, a boy to take the molds as they come back from the drying ground and put them in the proper place, and engineer and superintendent. There will also be needed two or three men and a boy, with a horse, to care for the dry fuel and house it at the proper time. The men and horses should be hired for less than $40 per day, and except in very wet weather, should produce an average of 25 tons or more of fuel per day. The air drying makes the production somewhat uncertain, as in very wet or cold weather, evaporation of the water from the bricks is slow and uncertain, unless there are covered drying sheds provided, which will increase the cost of the plant somewhat. It is supposed that all steam for operating the plant will be generated by the use of waste material from the bog. The product from such a plant should sell at from $3.00 to $4.00 per ton, where hard coal is sold at about $6.00 per ton, and for more where it is higher. By increasing the number of machines the cost of production could be lowered materially by substituting mechanical devices for some of the hand labor.

There are numbers of other condensing and compressing machines upon the market abroad, a single maker sometimes advertising a half dozen types, ranging, in power required, from 1 to 50 or more horse-power, in productive capacity, from 5 to 50 or 60 tons of condensed peat per day, in price from $300 to $1,500, and in the number of men required to run them, from 7 to 25. All of the German makers mentioned above advertise some form of press for making condensed peat.

An estimate, given by Julius Bordollo, 38 Kingsbridge Ave., New York, agent for several of the large European makers of peat fuel machinery, for a plant having a daily capacity of 40 tons of condensed peat, is as follows:

To be imported from Germany.	1 peat press, latest design, with double breakers and mixers, mounted on wooden frame	$1,200
	1 chain elevator, 30 feet long, complete with rollers and shovels	950
	2 appliances with axles and wheels for moving press and engine	700
	1 cutting table	100
	100 feet of rails	250
	6 iron cars for transporting the peat to drying grounds	300
	18 horse-power engine	1,500
	Belting, boards, and sundries	100
	F. O. B. New York	$5,100

This estimate does not include the cost of buildings and installation of plant, but these need not be large, since the press and engine are portable and can be sheltered by a very small structure.

The cost of production per day, with this plant, is estimated as follows:

1 foreman	$5 00
1 engineer	5 00
8 laborers	12 00
5 boys	5 00
Office and selling expenses	10 00
Boiler fed by refuse peat and waste from bog	......
Total expense for 40 tons peat fuel	$37 00
Or cost per ton	92½

A rather low estimate, at the present prices of labor, and should be adjusted for each locality where a plant is to be established.

Machinery for Drying and Briquetting Peat:

The advantages and disadvantages of drying peat by artificial means have already been dwelt upon at some length, in a previous section, and no further space need be devoted to the matter here, except to again enforce the statement, *that no form of drier can take raw peat from the bog, and dry it by artificial heat, even to the air dry condition, except at a loss, unless the heat thus used is waste from some other industry or process.* It must also be remembered that where the peat is dried at high temperatures, it loses some of its volatile matter, which, by so much, may reduce its value as fuel for certain purposes.

Early attempts at drying peat made use of chambers, in which the peat was placed and subjected to drafts of heated air or other gases, sometimes forced into the bottom and sometimes at the top of the drying chamber, or kiln, by the use of exhaust fans.

Of different type is the Schonomen dryer, in which the raw peat is sifted, in order to extract from it the fibers, the non-fibrous part passing into a vat of heated water, where it is thoroughly mixed into a fluid mass or "slurry." From this vat it is pumped by slurry pumps, into a so-called chamber filter-press. As soon as the chambers are full, the slurry pumps are changed about so that they pump air instead of slurry into the filter chamber, and a high air pressure is produced, which can be raised to 20 atmospheres, 300 pounds per square inch. The compressed air drives out all the overlying water and about one-half of the original water contained in the peat, through the bottom of the chamber. The cakes of peat formed in the press, fall out when the chamber is opened, and are broken up and transported to drying ovens heated by steam, where the partly dry peat is quickly and thoroughly dried. The steam drying ovens can be heated by waste steam from the briquetting machine, which is used in connection with this process.

The Stabler process feeds the peat through rollers until it is crushed and ground very fine, after which it falls on a heating plate and is pushed forward by workmen to the farther end of the same plate, where it falls between rollers which grind it still more, and it is then conducted on intermediate heating plates back to the starting point. This process is repeated until the peat is sufficiently dry.

By the Stauber method, the peat is dried in the open air for a time, then dumped into conveyor pits to be conveyed to the condensing apparatus. The latter is a band of wire gauze of large mesh, which passes under two rollers. These press the peat against the gauze and the free water is pressed out. At the end of the gauze band, which is 5 feet wide and 15 feet long, an endless chain, provided with scrapers, causes the compressed peat to fall upon a kind of sieve shaker, which separates the larger pieces, the proportion of which should be as small as possible, and these are sent to be treated again by the rollers. The fibers and undecomposed vegetable matter which stick to the wire gauze are cleaned off by a revolving brush which runs below it. From the shaker, the finer peat is taken by a vertical conveyor, and is broken into small pieces in a special mechanism, as it passes along to the drying oven. This is a metal drum, 5 feet in diameter and 25 feet long, placed horizontally on rollers. The cylinder is rotated, and a spiral stirrer inside of it is used to push the peat forward, as it is dried by coming in contact with hot gases from a furnace. The cylinder is driven by a 50 horsepower engine, and the dried peat, after removal from the dryer, is crushed and briquetted. By this process, a ton of raw peat is reduced to about 1/4 ton, containing about 100 pounds of water after it leaves the dryer, and is ready for the briquette press. Mention should be made of the tunnel type of drying chambers such as are used in drying brick in some of the modern brick plants. Selwid and Lange have patented such a chamber in Germany, patent number 22,223, and a similar device was used at the Jebsen peat coke plant in Norway. At the latter place the air-dry blocks of peat, loaded on cars, provided with racks of shelves, were run into the cool end of the tunnel and subjected to a gradually rising temperature, until they reached the warm end, where they are heated slightly above 100° C. The heat, in this case, was supplied by waste gases from the coking ovens, the dry, warm air being drawn through the tunnels by fans driven by electricity.

The Cooley dryer, recently patented in the United States, consists of a series of broad, shallow, galvanized iron pans, arranged one above the other in steps, in such a way that they can be given a rapid vibratory, shaking motion. The series is divided into two parts connected by a chain elevator and each is enclosed in a chamber, the first of which is heated by steam pipes and the second by hot air from a furnace provided for the purpose, and which burns the refuse material from the crude peat. The peat, air dried, or even wet from the bog, is ground by passing through toothed rollers, then elevated by a belt conveyor to the top of the first dryer where the coarse matter is screened out, the fine falling on to the top pan of the dryer, from which it is shaken to the one below, and so on, to the bottom one of the series, from which it is elevated to the top of the second set of pans and again passed down, this time subjected to a higher temperature, after which it emerges, with less than 3 per cent of moisture, in the form of a fine powder, and is conveyed either to the briquetting machine, or to storage bins. The whole process by this system of drying takes less than an hour, if the peat is air dry, and but little longer when wetter than this.

Machines for Briquetting: The great development of the manufacture of various kinds of fuel into briquettes has led to the invention of many forms of presses in Northern Europe, where coal slack and washings, lignite, or brown coal, coke, sawdust and peat, either pure or mixed with each other, or with petroleum refuse, pitch, tars and other binding material, are all made into briquettes by the use of pressure and heat. When the question of using peat for fuel in this country was raised a few years ago, the highly finished, regularly formed, compact and exceedingly neat, as well as efficient peat briquette, attracted the eye, as well as appealed to the imagination of those who decided to make an investment in the new fuel, and, as a result, most of the plants for the manufacture of peat fuel in America are briquetting plants, using, in some cases, foreign made presses and in others, specially invented machines.

It has already been stated that two kinds of briquettes are made from peat, the cold-pressed and the "seared." It may also be said that several types of presses are used for making the first kind of briquettes, of which the open and closed mold systems are the most important. The first of these gives large production, is easy to work and keep in order, and is simple in construction, while the second permits the use of higher pressure, hence gives a more compact product.

The open mold system has, as its basis, a tube, open at both ends, into one end of which, a piston fits, the other end being left open, and whose cross section is that of the finished briquette. The resistance produced by the friction of the peat in passing through the mold gives sufficient pressure to make compact briquettes. In practice, when a proper amount of material has been put into the mold, the piston descends and compresses it, then more material is put in between the piston and this briquette, the piston moves forward and forms a new briquette, and at the same time forces the finished one from the open end of the pipe. By this system, in practice no very great pressure can be used, as the amount developed is dependent upon the length of the tube and the friction of the finished briquettes against its walls. For when a long tube is used and the resulting high pressure, due to increased friction is obtained, excessive wear, due to heating and strain, causes rapid deterioration of the machinery. To give increased resistance, with short tubes so that higher pressure can be used, the tube is sometimes made to taper from the piston to the lower end. The machines in which the open mold type of press is used generally have the molds arranged in pairs, so that continuous motion may be obtained. This is reported to be the favorite form of briquette press in France and Germany and many modifications of it have been patented and manufactured.

The Dickson press used in the manufacture of peat briquettes at the Welland, Ontario, bog, is of this type, and, according to Carter,[1] in this press, for a mold or tube $2\frac{1}{2}$ inches in diameter, a length of one foot will give a frictional resistance equal to a pressure of 8 tons per square inch on the piston. By the use of this type of mold, with the highest practicable friction, heat may be developed sufficient to liberate tar from the peat and give the briquettes a waterproof covering.

The closed-mold system is capable of many variations, but in one of the simpler forms, consists of a revolving table containing holes the shape of the briquette, but deeper than its smaller diameter. In operation, the holes properly filled, are passed in turn under a powerful hydraulic press by the revolution of the table, and the briquettes thus formed are then immediately thrown from the mold automatically.

In another form, the material is compressed simultaneously by two pistons forming the top and bottom of the molds, and in still another the molds are formed by depressions in rolls or wheels, which revolve either vertically, horizontally, or in a more or less inclined position. Where rollers are used, the product is frequently in the form of balls or egg-shaped masses, which are known as "boulets," or bullets, in France, where various types of coal waste are commonly sold in this form.

The Dobson press, used at the Beaverton works at Beaverton, Ontario, is of the closed mold type, the bottom of the mold being formed by a block of metal, and the molds are arranged in groups of 8 under each of the two compressing pistons which work reciprocally, and each time the piston is raised, the mold cylinders turn one-eighth around. With each down stroke the piston forms a briquette on top of one which has been made by a former stroke of the same mold, thus compressing it a second time to make it as compact as possible. The power used with this press is furnished by a steam engine and the mold cylinders make about 50 revolutions per minute, making about double that number of finished briquettes.

The cost of briquetting machinery is higher than that for making condensed or cold compressed peat, and ranges in average price from $10,-000 or less, for plants of small capacity, 25 tons or less per day, to

[1] Carter, W. E. H., Peat Fuel, Its Manufacture and Use, pp. 23-25, Ontario Bureau of Mines Bulletin No. 5, Toronto, 1903.

$30,000 or more, for those having a possible output of 200 tons per day; these estimates are based on European figures and do not usually include the cost of buildings and many minor sundries.

In an estimate made in 1902 and furnished Mr. F. H. Mason,[1] U. S. Consul General at Berlin, by the company controlling the Stauber process of drying and briquetting peat, the following quotations are made for a plant with a capacity for putting out 50 tons of briquettes per day:

Buildings	$14,280
Machinery	17,850
Steam engine and fixtures	3,570
Tram-ways and cars, etc	3,570
Total	$39,270

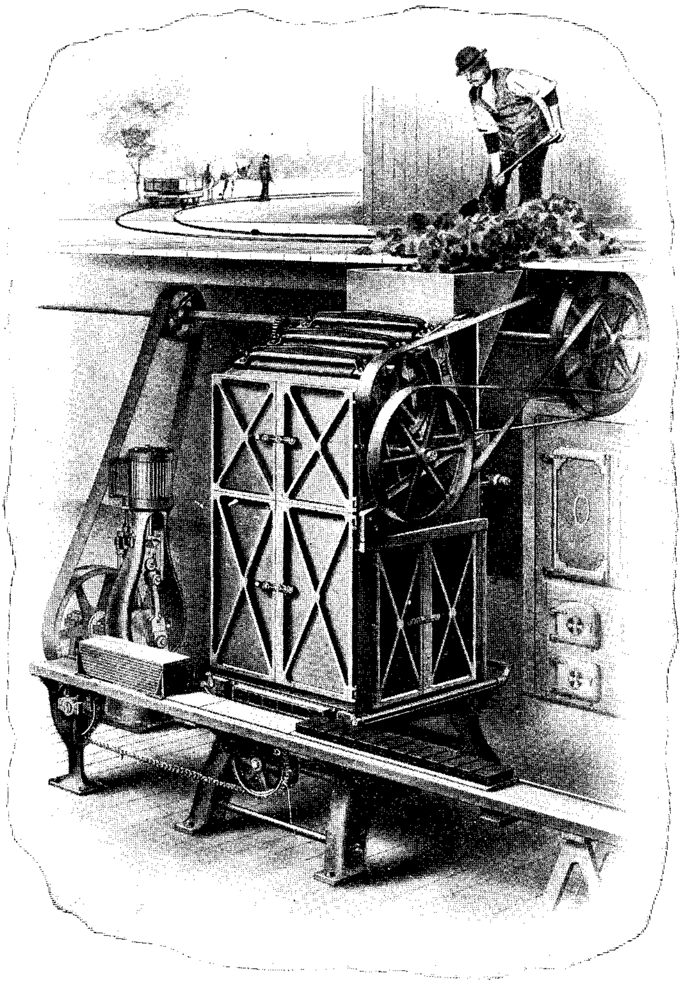
When it is remembered that a plant for producing cold compressed or condensed peat, air dried, with a capacity of 40 tons of finished fuel per day, may be had for about 1-7 of this sum, it is not remarkable that the statement is frequently made, that in Europe the cold compressed peat is much more largely made and used than the briquetted type, but it is also to be borne in mind that large peat briquette factories have been in operation in Germany and other parts of Europe for some years, and have been apparently successful, especially in Russia, and it is probable, that where the conditions are favorable in this country, peat briquettes can be made on a large scale and sold with profit, especially when the plant and equipment are properly planned, and economically and scientifically managed. It must be considered, however, that it is likely to be the case that for a long time to come the demand for peat fuel will not be from the large consumers, except in regions remote from the coal fields, but from those who use only small supplies, mainly for domestic purposes, and that this demand is relatively small, hence there is no reason for the development of large plants at the present time.

It may be said regarding this matter, however, that existing plants, wherever they have been built in this country, have had orders for more fuel than they have been able to make, and if they could have filled them would have been able to build up a still larger demand, since customers have expressed themselves as pleased with the qualities of the briquettes as fuel. Whether the same results would not have been obtained with a well-prepared article of condensed peat, made at much less cost, is still an unanswered question.

Machines for the preparation of seared briquettes are of the nature of molding machines of the roller pattern, in which the rolls are heated sufficiently, either to simply liberate a part of the tar of the peat, or, in some processes which have been patented, to liberate most of the volatile matter, and form a coke, or carbonized briquette. The former has passed beyond the experimental stage, as noted in another place, but so far as has been found out at present writing, the latter process is not yet fully perfected.

There are so many manufacturers of machinery for briquetting various

[1] Mason, F. H., Special Consular Reports, Vol. XXVI, p. 81, Washington, 1903.



LEAVITT'S PEAT CONDENSING AND MOULDING MILL.
PERFECTED.

fuels and other substances, that no attempt is made her to give a list of them, but it may be said that in a publication[1] of the State Department, at Washington, already mentioned, the names of some of the principal European makers of such machinery are given, together with much other valuable information relating to the manufacture and use of briquettes. J. C. Bordollo & Co., whose address is given below, are the American representatives of some of the prominent European manufacturers and can be consulted where immediate information is required, and are prepared to furnish various articles on peat.

Methods of Coking Peat.

Processes for coking peat have already been quite fully discussed, and the cost of plants for this purpose mentioned. But little special machinery for the actual operation of coking has been required, since this is performed in some kind of kiln, or closed retort, similar to that used for making coke or charcoal, although several types of closed kilns of the retort type have been patented, but for rendering the preliminary operations of digging, grinding and molding, drying and conveying to the kilns, automatic, and as cheap as possible, several patented machines have been developed, as well as those for recovering by-products from waste. Of somewhat different nature from others, is the patented coking process covered by U. S. patent No. 732,097 and controlled by F. C. Rockwell, Hartford, Conn. In this process, the standard kilns are 32 feet long, 3 feet 9 inches wide, and 5 feet high, each costing about $1,000, and having an estimated capacity of 6 or 8 tons of coke in 24 hours, the product costing, according to published figures, not to exceed $3.00 per ton at the mill. Not less than four of these kilns should be used for a single plant, and a larger number can be cared for by one man. In using these kilns, the peat has to be molded and dried before coking, as it does in other processes, and no special devices are mentioned for these purposes, in the description of the process.

Machinery for the Manufacture of Peat Litter.

A considerable development of special machines for the manufacture of peat litter and peat mull, or peat dust, has been made by the European manufacturers of peat working machinery. Those manufactured by A. Heinen, Varel, Germany, are of excellent patterns and construction, ranging from a small hand machine, which has a daily output of about 4 tons of litter, to one having a capacity of about 20 tons and requiring an engine of 6 or 8 horsepower to run it. These machines consist of toothed rollers, of large diameter, the teeth being long and more or less curved, to shred up the coarse material in the peat. The shredded mass in the hand power machine passes directly from the shredder to a horizontal, revolving, cylindrical sieve, where the finer parts are screened out, after which the coarse stuff may be baled, either by hand, or power balers, made by the same makers.

Peat mull is the name given to finely ground peat, prepared and used in Europe for various purposes, especially as an absorbent and disinfect-

[1] Briquettes as Fuel in Foreign Countries, Consular Reports, Volume XXVI, Washington, D. C. 1903.

ant. This substance is prepared in upright grinders run by power, or even by hand. The material falls upon a sieve which sorts it, the finer parts falling into a receptacle and the coarser retained upon the sieve. The capacity of these machines is from 5 to 15 tons per day of coarse and about one-half as much of fine mull per day.

In a properly arranged plant for the manufacture of these products, the dried peat would be dumped from the barrows or cars which bring it from the drying ground, into the shredding machine, from which both fine and coarse material could be elevated to a properly placed screen hopper, so that the finer parts of it could be sent by chute to a mulling mill, while the coarse material passes on to a revolving cylindrical sieve which still further cleanses and sorts it, the finer parts going to the muller and the coarse to a baler placed below. The fine material could pass from the mulling machine directly to the packing machine. Such a plant should not be expensive and could be run in connection with an establishment for making peat fuel, to utilize the fibrous top layers of the bog, these being plowed up and dried just as hay is, by exposure to sun and wind. See Plate 31.

Hand machines for making peat litter are also advertised by Martin, of Ofenberg, by Paul Reuss, of Artern, Saxony, and by the Iron Works of Luneberg, and it is probable that Dolberg and other makers also produce some forms of these machines. It is probable that a corn shredder, with somewhat stronger knives than usual would answer very well to shred the less woody forms of peat for small consumers.

Devices for Carrying Peat from Bog to Factory.

Devices for conveying the peat to the factory have been numerous, but mostly simple. In more extensive plants portable tramways of light rails are laid on the surface of the bog on which cars of small size are run, by man, or horse power, or infrequently by electric trolley. The latter could well be used where a lighting plant was used, or where electric power for any other purpose is developed, and would prove, in the end, economical and more efficient than other forms of motive power in use. In small plants, the peat is wheeled by hand in barrows, or in small carts, drawn by a single horse, where the surface of the bog is not too soft. Both of these are expensive methods, even for a small plant, for the loads which can be drawn are light and progress is slow. In a few cases, it has been reported that the peat has been dredged from in and around bodies of water and placed on flat boats, which are poled or rowed to the factory, but much time would be consumed in this way in most cases, and a more satisfactory way, if scows were used, would be to tow them, when loaded, by a small steam or gasoline motor tug boat.

In one case it was reported that the peat, in slurry form, was piped a considerable distance to the factory. A recently recommended method[1] is that the peat, in liquid form, be removed from the bog to a large settling or receiving basin, through trenches cut in the bog and given sufficient artificial fall to insure the flowage of the peat. This plan is feasible, provided that the water is present in sufficient quantities to mix

[1] Bordollo, J., Peat Fuel Production. The Engineer, May 15, 1906, p. 335.

with the peat, but in many Michigan bogs it would have to be pumped into the ditches, and mixed with the peat, to make the latter substance fluid enough to flow.

It is apparent from statements made in this and preceding sections of this report, that the study of this interesting natural resource has gone much farther in the countries of Northern Europe than it has in America, and especially has the investigation of the commercial possibilities of peat, and the development of compact, handy, and durable machines for the manufacture of the various products to be derived from it, gone far beyond the experimental stages. It is, therefore, not necessary for manufacturers or inventors to begin at the beginning to develop machines or processes of utilizing peat, since, in the great majority of cases, they would probably only repeat the errors of those who have gone over the same ground abroad. At the present time it would be a great saving of time and money to study the latest and most improved products of the most progressive foreign manufacturers, especially those of Germany, and the recently prepared reports of investigations into the possibilities of peat utilization, issued in the technical journals or in form of manuals and popular guides, and in the proceedings of the European peat culture societies, before deciding upon inventing new machinery, or new processes of preparing peat for fuel, or for other purposes, for in many cases, most in fact, it would be found that the projected plan had already been tried, and if a practicable one, had long ago been embodied in a machine, and perhaps abandoned for a better one. As was recently stated, there is no such thing as a really secret process for making peat fuel, since all the secrets of the substance were long ago discovered and made known, and the sooner investors and inventors realize this, the sooner there will be in the United States a well developed industry based upon the peat deposits which are so widespread and extensive within the nation's boundaries.

Peat Factories and Peat Prospects in Michigan, Established or Projected.

There are several plants for the manufacture of peat fuel established in the Southern Peninsula, some of which have, within the year (1906), produced some peat, but none, so far as known, are yet running on full time, or are producing peat fuel in quantities. The plants of the American Peat and Fuel Company, near Capac, was, as noted elsewhere, leased after a trial of 30 days, and later sold, to a company which took over the property to manufacture paper and other products from the peat, which seemed especially adapted for this purpose, being rich in fibrous sedge and grass remains below the top layer.—The Pilgrim Paper Co. of N. Y. and Capac.

The Peat and Fuel Company was to make briquetted peat, using the Cooley dryer, and a specially constructed press. The briquettes made were of sufficient density, and of a light brown color, but were easily split and quite brittle, so that they did not stand handling well. This seemed, in part at least, due to the coarseness and lack of cohesiveness of the peat, but as it was compressed into briquettes without any preliminary treatment except drying, it is possible that this might have been remedied. The Capac bog is described in Part I of this report.

The National Peat Fuel Co., of Chelsea, has a good deposit of peat on the border of the town, and near the Michigan Central R. R. The building is a substantial but small brick structure, and small openings have been made in the surface of the bog and some peat has been taken out by hand, but no great amount of fuel has been made. The plant is equipped with a press for making briquettes developed by the owners. The plant was, at last accounts, closed down indefinitely.

The Bancroft Peat Fuel and Cement Co., Ltd., Bancroft. This plant was equipped for making briquettes after the system in use at Whitewater, Wisconsin, to manufacture seared briquettes. The peat was dug from the bog with a steam digger and it was reported that the surface material was used for litter. The plant was operated a part of the summer of 1905, but no report was obtained of the actual output of fuel. The bog on which it is located is reported as having an area of 700 acres and has been partly cleared, ditched and drained, the draining, as usual, causing some settling of the surface.

The Michigan Peat Co., Eaton Rapids, are reported as having a plant equipped for making briquettes, using a patented English system in which the peat is electrically treated before briquetting, to hasten the process of drying.

The following companies have established factories for making condensed, or cold compressed air-dry peat fuel:

The Michigan Peat and Marl Co., Grand Rapids, equipped with a Heinen press.

The Wolverine Peat Co., Vicksburg, equipped with a Dolberg press.

Carl G. Kleinstück, Kalamazoo, is reported by local newspapers to have manufactured some pressed peat fuel for local consumption, but no details of his equipment have been obtained.

A company called the Van Buren Peat Co., Gobleville, has been organized, and is planning development of bogs in that vicinity.

A plant is reported as in operation in Mecosta county near Big Rapids, but no information relative to its equipment has been obtained.

Beds of peat of considerable extent, which have at some time been the basis of prospective plants, or for the organization of companies for their utilization, are reported at or near the following places:

Kalamazoo, large extent.

Three Rivers, large bogs, 2 miles distant.

Minden Tp., Sanilac county, near Croswell, 6,000 acres.

Quanicassee.

Summerfield township, Clare county, 100 acres in one body. 6 to 12 feet deep. (Harrison the nearest town.)

Hanover, 40 acres.

Decatur, 100 acres, 6 to 8 feet deep.

Bass River, 100 acres, 6 feet deep.

Morenci, 200 acres or more.

The latter bogs are all too small for large establishments but would supply fuel for local consumption, for many years, provided the peat is of average density and fuel value, since each acre would furnish from 150 to 200 tons of dry fuel for each foot in depth, after the surface material has been passed through.

Conclusion.

It is probable, as has been intimated elsewhere, that the best way in which quick and sure returns may be realized from peat bogs, is by developing them with the idea of supplying small local markets, rather than attempting to compete with the better known and more widely used fuels on a large scale. Where the former course is taken, a relatively small bog, a small investment, and a local market, with a limited requirement in quantity, should make a combination which should be satisfactory to the owner and investor, who could then afford to give his customers a fair price, which should run considerably below that paid for ordinary fuels and still give good profit. When the numerous bogs of Michigan are thus utilized, as many of them will be, before many years, the peat fuel industry will be placed upon a proper footing.

Acknowledgments.

In the preparation of this paper, the writer has made free use of the relevant matter contained in numerous short articles and papers by other writers, to which no special reference has been made, since many of them were anonymous. The daily and weekly papers, magazines, both popular and scientific, technical periodicals, and scientific reports and manuals have all furnished much valuable material and in this place the writer's obligations to these sources are acknowledged. The catalogs of European manufacturers of machinery and their agents have given a great deal of important matter. The late T. H. Leavitt, of Boston, a pioneer in the development of peat fuel machinery in this country, and J. Bordollo of Kingsbridge, N. Y., have kindly loaned cuts which have been used in illustrating this paper.

Especial thanks are due to Professor J. R. Allen, of the University of Michigan, for analyses furnished as well as for much information based on a wide experience with the practical side of peat utilization, and to Mr. Alfred C. Lane, State Geologist, for many suggestions as to the treatment of the subject, for innumerable references to literature and citations of authors, as well as for information relating to the progress of the development of factories for the utilization of peat in the state and for much other matter of interest.

Thanks are also due to the owners of peat bogs over which the writer has made his way and for the interest and co-operation of these, whenever they have been asked for information.

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