THE PREPARATION AND USE OF PEAT AS FUEL.

By Charles A. Davis.

INTRODUCTION.

The need of a supply of good and easily obtained fuel is more paramount in Alaska than in most other countries, and although coal and wood are so abundant and so readily procured in many parts of the Territory that the fuel question may be said to be solved already, there are many places where neither can be had except at high prices. In such localities the very generally distributed peat deposits may be made available for furnishing both heat and power by proper methods of preparation. Some of these methods are so simple that they can be applied by anyone without the aid of machinery, a fact which makes them especially useful to prospectors and other isolated individuals and to small communities remote from the coast or from transportation routes; other methods can be used only where large capital is to be had. It may be assumed that peat will not be prepared and used for fuel in places where high-grade coal can be obtained at satisfactory prices, although this is by no means an established fact. The regions where coal of good quality may be found are discussed in another place (pp. 47–62).

GENERAL DISCUSSION.

PEAT DESCRIBED.

Peat is made up of the remains of dead plants of many kinds, in a partly decayed and more or less disintegrated state. It is the light-brown, dark-brown, or nearly black soil found in wet places, such as bogs, swamps, and margins of ponds and lakes, or, in the tundra region, covering the entire surface of the country. It is known by various names besides peat, such as muck, turf, or, colloquially in parts of Alaska, "tundra," although the last term is, strictly speaking, applicable only to the plains on which lies the coarse, silty, turfy peat thus designated.

After it has been dug and dried, peat may vary from light yellowish brown to nearly black in color and from coarsely fibrous, loose-textured, turfy material to that which is very fine grained or even structureless. The upper layers of peat deposits in the far north are generally lighter in color and coarser and more fibrous in texture than those below; in more southern regions the top layers are frequently blacker and more completely decomposed than those toward the bottom of the deposit.

In the wet condition, before digging, peat is darker in color than when dry and contains from 70 to 90 per cent of water, or more, according to drainage and other conditions existing in the deposit.

CONDITIONS FAVORING THE FORMATION OF PEAT.

It is probable that where the climate is so cold that the ground is always frozen, below a thin surface layer of growing plants, as in the Yukon basin and northern Alaska generally, all the changes produced by decay cease after vegetable matter is included in the frozen mass. Such changes as occur, therefore, must take place in the relatively short time before a given layer of plant remains has been buried far enough below the surface to escape summer thawing. Generally this would mean that most of the softer and more delicate parts of plants would be preserved with the more resistant parts, and in this way a deposit of peat would be built up more rapidly than would be supposed from the character and density of the vegetation forming the surface growth. On the other hand, peat thus formed lacks compactness, density, and weight, and requires thorough grinding to make an easily transported and durable fuel. In regions where the climate is cool or cold and moist and where both air and ground water are at constantly low temperatures, but where the ground water is not perennially frozen, the processes of decay and disintegration go on very slowly in masses of plant débris; hence in high latitudes peat is widely distributed and may accumulate to a greater or less extent wherever plants grow.

In dryer regions and in those having high summer temperatures peat is formed only in areas where the ground water rises above or near the surface—that is, in ponds and swamps, for in such places only are found the two important essentials for the preservation of vegetable matter, namely, exclusion of air and uniformly low soil temperatures.

The plants chiefly concerned in the formation of peat in the far north, to judge from the few specimens seen, seem to be such as are found growing on the surface of the deposits at the present time, comprising mosses (mainly sphagnum), low shrubs, and herbs. In warmer latitudes water plants and certain water-loving grasslike plants growing in wet places are important peat formers and, together with some kinds of shrubs and trees, build up deposits of peat by their growth and partial decay wherever drainage conditions permit.

PEAT A VARIABLE SUBSTANCE.

From the foregoing statements it is plain that the peat deposits of one region may be quite different from those of another in structure and in the quality of the material of which they are composed. It is also true that marked variations may be found in different deposits in the same region and even in different parts of the same deposit; in fact it is the general rule that the peat in different layers of a bog varies in structure, degree of decomposition, chemical composition, ash content, and other features. The black or dark-colored kinds make better and more durable fuel; the fibrous brown or light-colored types serve best where quick, hot fires are required, or for kindling, and are less desirable as general fuel unless given thorough grinding in some form of peat machine to destroy the fibrous character of the material and render it solid and compact.

ASH CONTENT.

If peat is very high in ash, its fuel value is low, and the ash content may be so high that the material will not pay, in heat units, for the work of getting it ready to burn. Roughly stated, the heating value of peat decreases about 1 per cent for each 1 per cent increase in the ash, but if the ash percentage remains below 20 there are many exceptions to this statement. With increase in ash above 20 per cent, the decrease in heating value is marked. In Europe it is customary to consider all peats with more than this proportion of no commercial value for fuel. Locally, in the absence of better fuels, such material could be used, however, either for heating and other domestic purposes, or in the generation of power by firing under boilers or in gas producers.

The ash in a sample of peat may be determined roughly by burning a small thoroughly dried block of the material to be tested in a tin can or cup, the bulk of the ash in proportion to that of the original block indicating the relative amount of ash. It should be remembered, however, that the ash of peat is very light and bulky compared with that of coal. If means of weighing are at hand, the percentage of ash can easily be obtained. The can or cup is weighed before and after putting the peat into it, the difference being the weight of the peat; after the peat has been burned the can is weighed again, and this weight, minus that of the can, is the weight of the ash. The percentage of ash can then be found by dividing the weight of the ash by that of the peat and multiplying by 100.

It is generally possible to tell by inspection whether peat has a large percentage of ash. The mineral matter that it contains is brought to it either by the wind, as dust, or by water, as floating mud or as dissolved matter, which may reach the deposit from streams, rain rills, or springs. Peat which becomes gray or contains rusty or whitish spots on drying, or which is gritty when ground between the teeth, or is greenish or grayish when wet usually contains much ash.

DISTRIBUTION OF PEAT IN ALASKA.

The cool, moist climate of the greater part of Alaska favors the formation of peat because the remains of such vegetation as grows are preserved under climatic conditions and accumulate as peat beds.

In the mild southeastern parts of the Territory, along the Pacific coast, the growth of plants is luxuriant, and forests, with a dense undergrowth of shrubs and herbs, and in many places carpeted with mosses, cover the lowlands and slopes. Beneath such forest growth, beds of peat of considerable thickness have been observed where streams have cut into them, and it is reasonable to expect that they may be found in similar places away from streams.

In the dryer southwestern part of the Territory, although there are no forests, shrubs, grasslike herbs, and mosses cover the plains, the floors of valleys, and the greater part of the mountain slopes with a dense growth and build deposits of considerable thickness by the accumulation of their remains.

In southern Alaska many beds of peat having a thickness of 15 to 20 feet have been noted, and although they have not been tested the peat was apparently of good fuel value.

In the central and northern sections of Alaska, where there is less rainfall than in the parts already discussed, but where the lower average temperature keeps the air very moist and prevents evaporation, the ground is in general fully covered by grasslike plants, chiefly sedges, and by mosses which form a loose spongy turf.

On the treeless low plains, the tundra bordering the Arctic Ocean and Bering Sea, the turf-forming plants are especially abundant, growing on a frozen substratum composed of their own remains and ice. In some places along the Arctic Ocean, where the sea is now encroaching on the tundra, peat beds rising 8 to 10 feet above sea level receive the impact of the storm waves, while peat in the form of bowlders or finer material strews the beach or makes it up entirely, covering the shore with a stratum of water-soaked mush. In these parts of the Territory the subsoil is always frozen, and the turf, except in the dryest times, is saturated with water, so that decay is retarded or entirely prevented. On the other hand, growing plants get the moisture they need to make luxuriant growth, so that peat is very generally formed and is of widespread occurrence. In places in these regions beds of peat that were 30 to 40 feet deep have been exposed by natural agencies.

It seems evident that peat beds of workable extent are to be found in most parts of the Territory. As to quality of these deposits, little can be said. It is known that the surface material is very fibrous and poorly decomposed, and it is quite probable that the lower parts of the deeper beds will give material that is much more compact and better for fuel.

METHODS OF ESTIMATING AND WORKING PEAT DEPOSITS.

INTRODUCTION.

The principal consideration in prospecting peat deposits in so thinly settled a region as Alaska is that of an assured market near at hand; the area and depth of the peat are of much less consequence. The depth may be determined by boring or digging holes; these should be near enough together to show whether there is enough material of good quality to make an attempt to work it a commercial possibility. The least area that can be exploited successfully depends on several factors, such as the method of manufacture, the depth and quality of the peat, the amount available, the competition of other and better fuel, and the capital to be invested in the plant for its utilization.

The quantity of fuel obtainable from a given peat bed may be estimated roughly as 200 tons of air-dried product per acre for each foot in depth. For dense, heavy, dark-colored kinds of peat the amount will be more than this, and for very fibrous, mossy, light-brown types it may be somewhat less. The quantity of fuel that may be obtained for a power or lighting plant from even a small and rather shallow peat deposit is very considerable, as may be illustrated by the fact that in Sweden a producer-gas plant for generating electricity has been built at a bog having an area of about 35 acres and an average depth of 5 feet, which, it has been estimated, will furnish a full supply of fuel for thirty years. The quantity of fuel contained in this deposit is estimated at 44,500 tons, or 330 tons an acre for each foot in depth, indicating that it is unusually well decomposed and dense. From this and similar facts it may be deduced that small areas of rather shallow peat beds may be utilized to advantage to produce from 1,200 to 1,500 tons of fuel a year for many years, and that, if the plant is equipped with the best types of machinery and worked by modern methods, the cost of production will be low enough so that the income from the enterprise will be satisfactory.

For the most successful manufacture of raw peat into fuel it should have such physical properties that it can readily be put into a form in which it is easy to handle and use without excessive loss; it should not be very high in ash, nor too fibrous or woody to be readily reduced to a pulp by properly designed, simple, and easily operated machinery.

DRAINAGE.

It is the practice in Europe, where peat is dug extensively for fuel by hand, to drain the bogs carefully before they are worked. Aside from the greater convenience in digging which this practice insures, it frees the peat from water to some extent, although not so much as would be thought at first, because of the water-holding properties of the peat. If, however, the water in the peat averages 90 per cent in the undrained condition and draining reduces it to 80 per cent, the weight of water in the peat, and consequently the waste, will be reduced 50 per cent. If the land is to be drained, the bog should first be surveyed and levels taken to find the fall of the land and the distance and fall to the nearest main watercourse. The removal of the peat should begin at the lowest part or outlet end of the deposit and proceed toward the higher parts. This will make draining a relatively simple matter, and will reduce it to the smallest amount possible; it will also, by keeping the parts still unworked wet, protect them from fires.

THAWING.

Where the peat is frozen, as it usually is in the regions of Alaska where it is most likely to be utilized as fuel, the protecting top layers of growing vegetation, the mat or turf of moss and mingled grasslike plants, should be stripped from considerable areas, in order that the underlying more thoroughly decomposed material may thaw out. Gravels and sands are reported to thaw to a depth of 10 to 12 feet in a season, but it is unlikely that peat will thaw so readily, on account of its poor conducting power, and if it can be worked for a few feet in the ordinary way described below this is all that can be expected.

If the peat does not thaw quickly enough, it can be cut or quarried into small blocks by the use of suitable tools, and, after thawing, these can be cut into bricks or blocks of the right size for fuel and exposed to the air until dried, or the blocks can be treated and dried by the processes outlined below, in which case they should not be allowed to dry much while thawing.

The material stripped from the surface of the peat, when dry, makes excellent bedding for horses, packing material, or insulating material for covering steam or water pipes laid underground, or for filling in between the walls of buildings to keep the cold from penetrating. When used for insulating it should be as dry as possible.

THE PLANT.

CHARACTER.

The kind and extent of the permanent plant will be determined largely by the method of preparation chosen, by the extent of the proposed operations, and by the capital available.

No buildings will be required for making cut peat beyond the rough sheds needed to protect the product from the weather after it has been dried and to protect the tools.

If machine peat is to be made, the only buildings needed will be light, cheap, wooden structures for the protection of the boiler, engine, pulping machine, and the stored product. The buildings may be of the cheapest and simplest construction consistent with durability for the expected lifetime of the plant.

Recent European practice and the most advanced construction in the United States favors small, cheap, compact, portable plants, which dig, grind, and lay or spread out the peat as a continuous operation, engine, boiler, and other machinery all being mounted on a platform on wheels or rollers. Such plants are automobile, and either run on movable tracks or have special broad wheels that enable them to move slowly over the surface of the bog. These plants need no housing, as they are built with removable iron or wooden sides and a stout roof. Increased output, where such plants are used, is obtained by adding new units. The possible output is from 1 to 10 tons of salable peat a day with one or two men, according to the power of the engine employed.

If the plant is designed to produce peat briquets, it must have strong and durable buildings, on account of the weight and size of the necessary driers, boilers, engines, and presses used in any form of the briquetting process, and the storage pockets must be thoroughly protected against the weather on account of the ease with which the product absorbs water.

The producer-gas plant for utilizing peat fuel needs about the same construction as a steam-boiler plant, but the buildings need not be so large for an equivalent development of horsepower.

LOCATION AND PLAN.

If the plant is to be a permanent and stationary one, its main buildings should be placed so that the raw, wet peat will have to be moved the shortest possible average distance to reach the machinery by which it is to be treated and the finished material after treatment can be quickly transported to and from the drying and storage grounds. At the same time, account must be taken of the means of getting the product to market easily and at small expense. It should be remembered in this connection that the dry, finished salable product is the cheapest to transport, because there is no waste to it; therefore the finished fuel can be moved a longer distance without loss than the fresh, water-laden raw peat. Still it is evident that the selection of the place where the building is to be located must be more or less affected by its nearness to a town or to favorable drying grounds, etc. The laying out of the plant, the location of machinery in the building, and the placing of drying grounds in relation to the buildings must all be carefully planned, so that the necessary processes of treatment may become, so far as possible, automatic, needing the smallest amount of attention and labor. In general, every place where machinery can be substituted for hand labor should be considered, and, if feasible, the machinery put in place.

MACHINERY.

The choice of machinery is of necessity governed by the kind of product sought. Except for the production of cut peat on a small scale, machinery of some kind is essential. Before buying machinery it is very desirable that the investor should thoroughly acquaint himself with the progress in making peat fuel that has been made in Europe during the last century. This can be done by carefully reading one or more of the excellent manuals of peat utilization noted in the list of publications at the end of this paper.

It is much better to take advantage of the experiments and experience of the practical men who have been at work on the problems of peat-fuel production for more than a century and who have embodied their experience in methods of production that have been fully worked out and proved on a practical basis than it is to attempt to devise new machinery and processes or to adopt untried methods or machines invented by men without experience. An advantage is gained by examining carefully German books on this important subject, because in these will be found records of many unsuccessful peat-fuel machines. The prospective inventor of similar devices may find that his very plan has been tried long ago by experienced men and found useless for commercial purposes. If new methods are to be tried, they should be understood to be such, and not made the basis of a commercial plant, from which immediate financial returns are expected.

PEAT FUEL.

INTRODUCTION.

Peat has never been used much as fuel in America, although for many years small amounts have been produced in Canada and in the northern and northeastern parts of the United States, either by experimental factories or by individuals who have prepared small quantities for their own use. Many of the more extensive developments have been conspicuous failures. A few have reached completion, but none have attained their theoretical output; that is, none have made and sold at a profit the amount of peat fuel which the promoters of the plan estimated for a season's production and which the investors had a right to expect.

In none of this experimental work has the cause of failure been directly traceable to the peculiar properties of the peat itself. In some plants too little capital was available to handle the enterprise properly; in others machinery was installed which had not been thoroughly tested before it was adopted; others were placed in charge of enthusiastic but inexperienced men; and still others were unable to obtain proper and cheap transportation for their products and hence could not market them.

Unlike coal and other fuels on the market, peat needs special treatment, including drying, before it can be used for fuel. As it is dug from the undrained deposit it contains from 85 to 95 per cent of water, and drainage rarely lowers the amount below 80 per cent. That is, a short ton of wet peat may have only 100 pounds of dry, burnable matter and rarely will contain more than 400 pounds. In the wet condition it is entirely unburnable and the various ways in which it is prepared for use or market consist principally in methods for ridding it of water quickly and cheaply and for increasing its fuel efficiency and transportability. The following brief discussion considers these methods in the order of simplicity and amount of capital required for equipment, as well as prospective usefulness under Alaskan conditions. In this discussion the matters of location, markets, means of transportation, and other factors which would be pertinent for regions of denser population and long-established trade in fuels, over well-developed routes, can be omitted, as it is assumed that any use made of peat in Alaska, for some time at least, will be local.

CUT PEAT.

The simplest and most ancient form of preparation of peat for fuel still in use in Ireland, Sweden, and many other parts of Europe where peat is used for domestic purposes, is to cut it from the bog in the form of blocks. This is done with some special form of spade, the type in use in many parts of Europe being made by welding a narrow, sharp lug at right angles to the point of the blade of a long, narrow spade; this is called in England a slane. As fast as cut, the blocks are laid on the cleared surface of the bog, near the opening, and after a few turnings become partly dry; they are then loosely stacked for further drying and storage.

This form of peat fuel is entirely dependent on the structure of the peat for its texture, compactness, and efficiency. As it can be cut only from the drained parts of peat beds, it is usually bulky, is easily broken and crumbled, and burns freely but with considerable waste. On the other hand, the cost of production is small, and little equipment is required besides sheds for storing and possibly for drying the finished product. The cost of making cut peat ready for the market in

Europe varies, according to a recent writer,[a] from about 50 cents to as much as $1.75 a ton of air-dried peat. These considerable differences are apparently caused by differences in the methods used and the efficiency and price of labor. The size of the bricks into which the peat is cut depends on the climate, the compactness and state of decomposition of the peat, and the uses to which the bricks are to be put. Allowance must be made for shrinkage of about one-quarter to one-half in the size of the bricks, in drying; bricks of fibrous, turfy, poorly decomposed material would need to be of larger size than those of more compact and well-rotted peat. If cut too small, the bricks are costly to handle, burn too quickly, and break too readily. If made too large, however, they do not dry out quickly or thoroughly and are burned with difficulty.

The bricks are sometimes cut vertically from the beds and sometimes horizontally, depending on the compactness of the peat. In general, the best results will be obtained by making horizontal cuts from a trench, as this brings the long axis of the bricks parallel with the bedding of the peat.

In northern Europe the top turf is removed from a space as wide as the length to be given the bricks, then vertical cuts are made the length of the spade at the proper distance from the working trench, and horizontal cuts are made with the slane to form the bricks and lift them from the bed. By using a broad spade, with properly spaced lugs, two or three bricks can be cut and lifted at a time.

In those parts of Alaska where the peat beds are frozen and do not thaw out readily on being stripped of their overlying covering of moss, special methods of quarrying the frozen material by the use of saws and axes may be necessary. Thawing in the parts of the peat beds that are being worked may be hastened by cutting trenches near enough together so that the peat between them will be warmed by the air from the sides as well as from the top. It is probable also that the frozen peat may be removed in slabs of considerable size by separating it along the more fibrous layers formed by certain kinds of plant remains, and after these slabs are thawed they can be cut up into bricks. If the peat is to be macerated, it may be dug with pick and shovel and, after thawing, thrown into the peat machine, before it has dried very much.

For Alaskan conditions it is doubtful if the bricks, when cut, should exceed 12 by 6 by 3 inches, and it may be possible that in the moister and cooler parts of the Territory smaller bricks will give more satisfactory results, because drying will be more rapid and more thorough; experiment will determine the proper size for each locality.

[a] Nystrom, E., Peat and lignite, their manufacture and uses in Europe: Canada Dept. Mines, Ottawa, 1908.

It is clearly an advantage to cut as large bricks as it is possible to dry thoroughly, on account of the larger output thus obtained with the same number of cuts and the increased ease of handling during drying.

After cutting, the bricks are laid out on the edge of the cutting trench until they are dry enough to be handled, and are then piled up into small heaps by placing several together on end or cob fashion, or into small conical or pyramidal open piles, the bricks being so placed that the air can readily circulate between them. When well dried they are stacked loosely in large piles and protected from rain by some form of rough roof.

The work of preparing peat for fuel in this way should be begun as early as possible in the spring, so that advantage may be taken of the favorable drying conditions existing in spring and early summer.

So far as can be judged, this type of peat fuel is not adapted for large production in this country on account of the high cost of the necessary labor. It can be used by individuals or by small, isolated communities, such as trading and military posts, mission stations, or mines, where need arises, but especially in those districts away from the seacoast where wood is scarce or at seacoast localities that are remote from wood and coal supplies. The fact that a large part of the fuel used for heating and cooking by the people of Iceland, northern Russia, Finland, Sweden, Denmark, Ireland, and some other parts of Europe is peat which has no other preparation than that above described plainly indicates that climatic conditions need not prohibit its manufacture and use in Alaska.

MACHINE PEAT.

As the need arose for a fuel better than cut peat, in a more durable and transportable form, efforts were made to improve the texture and other qualities by treatment which rendered the material more compact. The earliest and the simplest process to be used consisted in adding water to the peat as dug, thoroughly kneading it by the trampling of men or animals, either in holes in the peat bed itself or in wooden or metal troughs sometimes 10 feet or more long. The resulting wet pulp is shoveled into molds, or, after being spread in a layer 5 to 8 inches thick over a portion of the bog that has been cleared for the purpose it is marked off into bricks, which separate from one another as contraction due to drying takes place. As soon as they are dry enough the bricks are turned, then piled and treated exactly like cut peat.

The name machine peat is given to all forms of the product made by grinding, mixing, or macerating the wet peat as it comes from the beds, so that it becomes less fibrous. In the process the included coarse material is broken up, and probably also some of the cellular structure of the peat is destroyed. Certain colloidal or gluelike substances released or developed during the grinding act to cement the material and, as they are insoluble in water when dry, render the whole mass more or less waterproof.

A distinction is sometimes made between the product obtained by grinding peat to which sufficient water has been added to reduce the whole to a watery pulp and drying the resulting slurry or semifluid mass in molds laid on the ground, and that made by macerating the peat about as it is dug, or with only a slight admixture of water, and forming it into bricks of any desired size by cutting up the long prism of thoroughly ground peat as it issues from the orifice of the grinding machine. The bricks resulting from the latter method are sufficiently firm to retain their form when they come from the machine and are dried by exposure to the air on covered racks, or on the ground without cover.

The crude process of macerating the peat by trampling it in troughs or openings in the bog is not adapted to any but the most primitive conditions, or to places where it is necessary to have the fuel and where better appliances, requiring the development of power, can not be obtained. The process is also open to the objection that a good deal of manual labor is needed in spreading the peat and handling it on the drying grounds.

In Europe this method of making peat fuel seems to be confined largely to small and isolated communities, and it is emphasized here only because it may be used in such places in Alaska where no other fuel can be had at equivalent cost. In European districts and plants where peat production is large such inefficient and simple methods have been abandoned for those depending on machines, the output of which is sometimes also called condensed, machine-formed, or pressed peat. The last name is something of a misnomer, however, for only enough pressure is exerted upon the peat by the machinery to force it from the outlet in a stiff, pasty condition. In the United States the term "wet process" has been applied to distinguish it from briquetting, in which the peat is dried artificially before shaping it by pressure.

So far as shown by many entirely trustworthy reports the machine process is the only successful method of making fuel for general purposes from peat now in use in Europe, and for that reason it merits a somewhat full discussion here, especially as it is generally applicable to all types of peat and requires but a relatively small outlay of capital to establish a well-equipped plant and but little experience and power to run it.

The essential part of such a plant is the peat machine, of which many patterns are now on the market. Some excellent models of these machines have been designed and are built to order in the United States. In its simplest form the peat machine is very similar to the clay pug mill of the brickmaker, and both brick and tile mills have been used in this country with peat of certain types for making peat fuel. The specially designed peat machine, however, consists of a vertical or horizontal cast-iron body, with a hopper attached above it, in which revolve one or two knife-armed shafts. These are provided also with spirally arranged flanges for moving the peat forward to the grinding knives and advancing it to the outlet after grinding. In some machines the edges of the screw flanges are sharp and work against knives set firmly in the cast-iron walls of the body of the machine. Others have both fixed and revolving knives combined with screw flanges.

The main object of the whole construction is to thoroughly cut up, crush, and grind all the constituents of all types of peat into a homogeneous, pasty mass, without clogging or breaking the machine. The machine that will make uniformly compact, tough bricks from any type of peat, but especially from fibrous material, rapidly and continuously, without excessive consumption of power, is the one best adapted to Alaska peats. The most successful peat machines are of very heavy construction and have adjustable knives, so that any kind of peat can be ground, and all parts subject to clogging and wear are easily accessible. The heavy construction is necessary because of the stumps and other woody matter, as well as stones, often found in peat beds.

Machines of foreign make may be had of all sizes and capacities, from those which can be run by a single horse and with the help of a few men have a capacity of 3 tons or more of air-dried fuel per working day up to those which require a considerable force of men, powerful engines, and auxiliary machinery for excavating and handling the product and have an estimated capacity of 50 tons or more of finished material per day of ten hours.

For detailed descriptions of the types of machines of this class made by many European manufacturers and for reports as to their efficiency the reader is referred to the excellent accounts by Nystrom[a] and to the catalogues of American and European manufacturers of peat machinery.

Besides the peat machine, the equipment for making pressed peat consists of small cars, trucks, and other machinery for moving the product to the drying grounds and storage sheds and, at most plants, for carrying the raw peat from the bog to the peat machine.

The larger peat machines are usually provided with some form of mechanical elevator, which takes the peat to the hopper from the car,

[a] Nystrom, E., Peat and lignite, their manufacture and uses in Europe: Canada Dept. Mines, Ottawa, 1908.

or from the top of the bog, or possibly from the bottom of the excavation, the arrangement being dependent on the location of the machine relative to the excavations.

The machine itself may be mounted directly on rails or on a movable platform by the side of the excavation, and follow the digging, thus saving the expense of moving the wet peat to some fixed point of grinding. In case this plan is adopted, the cleared part of the bog may be used for a drying ground, and only the dry material need be taken from the bog, a plan which saves the cost of transporting the large amount of water contained in the wet peat. To this equipment must generally be added, under the economic conditions found in America, some form of power digging machine suitable for getting out from the bog each day as much peat as the machine can properly grind. Failure to do this involves the necessity of having a large force of men digging peat, as it is estimated that practically ten times the weight of material produced must be dug—that is, 500 tons, or about 400 cubic yards, for an average daily production of 50 tons. The form of digging machinery is apparently immaterial, so long as it is efficient and adapted to the conditions under which it must be used. In Europe the chain-and-bucket digger has been used with success. The ordinary steam shovel, the bucket or dipper dredge, and similar forms of steam excavators have been tried, and recently the centrifugal pump has been used for digging very wet peat, which, after excavation, is forced or floated to the machine. As such devices as those mentioned are of doubtful utility under conditions known to exist in parts of Alaska, where it may be especially desirable to make machine peat, the conditions under which operations are to be carried on in a particular locality must be thoroughly studied before any of these digging devices is chosen. It is not unlikely that in many places none of them can be used, in which case special methods should be developed, as, if some provision is not made, the producing part of the plant is likely to be in operation only a part of the time. Sufficient drying ground and storage room must also be laid out and made ready for any contingency, or again the plant will be idle at times when everything else is favorable for production.

The requirements for making the ordinary machine type of fuel from peat are, therefore, (1) a deposit of good peat; (2) some form of peat machine; (3) machinery for digging the peat; (4) adequate ground space and pallets, or short wooden boards, on which to dry the peat, and enough room for storage; (5) tramways and cars, or mechanical carriers of some description, for transporting the peat to and from the grinding plant, the drying grounds, and the storage bins. The cost of this outfit, exclusive of the land, naturally will vary widely according to the estimated productive capacity of the plant, the number and quality of the buildings erected, and the amount and kind of accessory machinery provided. The cost for a 5-ton plant will be not far from $1,000; one which will produce from 50 to 60 tons of finished peat fuel a day will probably cost from $8,000 to $10,000, if economy is used in laying out and constructing the buildings. These prices are for the eastern part of the United States, and to them must be added the cost of transporting the machinery to the locality where it is to be used. This cost, with other items that must be taken into account, will mean an increase of at least 50 per cent for most parts of Alaska. The capital needed to run the plant during its first season must be added to this sum.

Small, compact, and efficient machines of simple and strong construction and with a capacity of 5 to 20 tons of finished fuel daily seem best adapted to the conditions existing in those parts of Alaska where peat is most likely to be used as fuel. This is especially true until more is learned about the chances of success of an entirely new type of fuel of which the prospective consumers know little of the heating value and other qualities of the raw material and nothing of the final product. The capacity of a small plant can be increased at any time by duplicating the essential machinery. It is far easier, in any case, to be successful with a small, thoroughly equipped plant, turning out a finished and attractive looking form of fuel, than with one only partly fitted out with a highly efficient peat machine, the rest of the equipment being inadequate to run it.

In this connection it may be said that in the last two years there have been brought out in both Europe and the United States small portable peat plants designed to move about on the surface of the peat bog by their own power, and, while moving, to dig, grind, and spread the peat, very little manual labor being required. One of these, designed and used in Germany, runs on a movable track placed beside the trench from which the peat is dug. The machine digs the peat on one side and elevates it to the pug mill, where it is ground and formed into bricks, which are spread on the bog surface in orderly fashion on the side of the track opposite the opening, the whole plant moving along the track as the work progresses. This machine is operated by a single man, the power for digging, grinding the peat, and spreading it, as well as moving it, being supplied by a gasoline engine, although steam could be used. The daily output is the equivalent of 10 tons of dry fuel.

A similar portable plant of about the same capacity, designed and built in this country, is independent of track, being mounted on broad wheels and a movable roller platform, which is a part of the plant. The digging is done from the rear end of the machine as it moves slowly forward, and the peat as it is dug is elevated to the grinding mill, from which it falls through a spout into a spreading and marking device that forms it into a sheet of uniform thickness on the surface of the bog and marks it with parallel cuts lengthwise, so that on cross-cutting it rectangular blocks or bricks will be formed. The machine is also designed to turn the blocks up into windrows as they dry. This plant is operated by a single man, or in larger sizes two may be required. The motive power is a gasoline or steam engine. The German plant has been thoroughly tested, and the American plant will be used during the summer of 1910 in a number of places.

The cost of production of machine peat is generally estimated in the United States, somewhat optimistically perhaps, at not over $1 a ton of air-dried fuel. This estimate is doubtless fair, if only the cost of labor is taken into account, as in Europe the labor cost generally falls below 75 cents a ton, but when loading, managerial, interest, maintenance, and amortization charges and the cost of the peat are properly apportioned the cost will be found to exceed $1.50, and unless unusual skill in management is shown will probably approximate $2 a ton. From this statement it may be possible to estimate the cost of the same material under the conditions existing in different localities in Alaska where it may be desirable to attempt the manufacture of machine peat.

At present it is impossible to forecast the prices at which peat can be sold in Alaska. The little that has been produced in the United States has been eagerly bought at high prices for domestic use, and more has been demanded after it has been tried. Its theoretical fuel value is greater than that of good wood and from five-eighths to five-ninths that of good coal, hence its selling price should be intermediate between that of wood and coal in the communities where it is produced.

An objection often made to this method of preparing peat is that production must be confined to the season of no frosts, as freezing prevents the wet machine peat from properly compacting and drying hard; moreover, rainy or very humid weather checks operations entirely, because the peat will not dry out of doors in such weather. These conditions necessitate the suspension of work altogether during the winter and give irregular employment to the force and plant at all seasons; they also reduce the theoretical output. The same objections are valid, however, in many other successfully conducted industries, some of which require much larger capital for equipment. They therefore seem no certain bar to success in this new industry, which will, in Alaska, have a season of production quite as long as that in other regions where peat is the only fuel and where the fuel supply for the entire year is prepared and stored during short humid or even rainy summers. In Sweden the peat-gathering season ends about the 20th of August in most years.

Artificial drying by some simple and direct method after the bricks have been formed is the ideal sought by many inventors to replace the uncertainties and limitations which the present system of air drying imposes upon production, but no one has yet been able to overcome the fact that it takes more heat to dry a ton of wet peat as it comes from the bog or the peat machine than can be obtained from the fuel which the process yields. To this cost for fuel must be added all the charges for producing the material which is dried. Moreover, during the drying process the bricks crack and check, their value being thus seriously impaired. It seems possible, however, that by utilizing waste heat in very efficient driers peat from which a considerable amount of water has already escaped may be dried sufficiently by artificial treatment to be stored, and that the limit of the season of production may be thus extended. Aside from the peculiar properties of the peat, the cost of the additional treatment and handling, as well as of extra equipment, must be taken into account, as these must be paid for by the material recovered.

It is evident, therefore, that the problem is complicated and can be attacked only by trained and experienced men if it is to be brought to a successful issue. Successful artificial drying, in any event, will be accomplished only by utilizing what would otherwise be waste fuel and heat. It appears certain that no attempts should be made to dry machine peat artificially in Alaska until it is clearly shown that air drying can not be successfully used, and that there is in some locality a demand for this kind of fuel great enough to justify the costly installation that must be made to have the process even technically a success.

BRIQUETTED PEAT.

In Europe, where lignite and poor grades of coal have long been successfully briquetted and sold in large quantities, the attempt to briquet peat was made early in the development of the briquetting industry. In this form peat makes an efficient and easily transported fuel and commands a ready sale, at good prices, for domestic use, because of its cleanliness, ease of handling, and other good qualities. The briquets are of uniform size and of cylindrical, ovoid, prismatic, or other shape. Generally, although not invariably, they burn more slowly than peat prepared by the processes previously described.

In preparing the peat for briquetting, cut peat or pressed peat is air dried to about 40 or 50 per cent of moisture, then ground and screened and artificially dried to about 15 per cent of moisture; it is then conveyed to the briquetting press or stored. An improved method of air drying is in use near London, Ontario, where, instead of digging, grinding, and pulverizing the peat, as is generally done in Europe, the surface of the cleared bog is very lightly harrowed, and after an hour or more of exposure to the sun and wind the air-dried dust is collected by a special machine, constructed on the principle of the exhaust carpet cleaners and operated electrically from a track laid on the surface of the bog. As only the dry dust is picked up by the collector, the material reaches the storage bins with not more than 30 per cent of moisture. It is afterward pulverized still finer and dried to about 15 per cent of moisture in its passage to the briquetting press.

All forms of air drying out of doors are open to the objections that have already been stated, and more attempts have been made to produce driers for the production of peat briquets than can be recorded here. Nearly every principle applicable to the construction of machinery of this type has been tried, and as yet none has been found able to meet the need satisfactorily, so that the peat can be dug, ground, dried, pulverized, and briquetted without the intervention of a period of exposure to the air and the sun's heat. This has been the aim of all manufacturers of peat fuel, and especially of inventors, since the briquetting press was introduced, but whether they have tried driers alone or combinations of presses for squeezing out part of the water, with driers of almost every conceivable type, using direct heat, steam heat, or electric devices, all have been discarded after a time, because of the cost of maintenance as compared with the value of the output; in other words, they have failed to pay operating expenses and a profit. This failure may be attributed, beyond any doubt, to the small value of the product and the small quantity of salable material obtained as compared with the raw peat treated, as shown in the table below:

Weight of water removed at 10 per cent stages from 1 ton of peat as excavated from the bog (90 per cent water) in drying to 10 per cent of water.

Percentage of water in the peat.	Dry peat content.	Water content.	Weight of water removed for each 10 per cent reduction.	Weight of material obtained for each 10 per cent reduction.	Total weight of water evaporated.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
90	200	1,800	....	2,000	....
80	200	800	1,000	1,000	1,000
70	200	466.7	333.3	666.7	1,333.3
60	200	300	166.7	500	1,500
50	200	200	100	400	1,600
40	200	133.3	66.7	333.3	1,666.7
30	200	85.7	47.6	285.7	1,714.3
20	200	50	35.7	250	1,750
10	200	22.2	27.8	222.2	1,777.8

The most recently advertised artificial drying plant for preparing peat for briquetting has been developed in the United States. It is described as a series of large hollow rolls revolving at different rates of speed and heated by exhaust steam from the engine which runs them. The peat, in the form of a thin paste, is passed between the rolls and formed into a sheet of dry pulp, after which it is disintegrated and pressed into briquets, of any desired size and shape.

The cost of briquetting plants is six to ten times greater than that of plants of the types previously mentioned, probably involving a minimum expenditure of not less than $50,000 for the complete equipment, with buildings, necessary driers, engines, digging, and other appliances, and a single briquetting press with a capacity of about 50 tons in twenty-four hours. This unit is mentioned because it is apparently as small as has been considered practicable for commercial purposes. The estimate is based on the quotations of German manufacturers of tried machinery and is likely to be exceeded in actual construction; it certainly will be if untried processes are adopted and newly invented machinery is installed. The greatly increased cost of the plant over that required for the manufacture of machine peat is easily understood in view of the need for heavier and more complicated machinery and for a much greater amount of it, together with the larger and more powerful boilers and engines required, all of which entail heavier and more substantial construction of buildings.

In 1903 F. H. Mason,[a] then United States consul-general in Berlin, published the following estimate of the cost of a peat-briquetting plant, equipped with European machinery, for artificial drying, with an estimated output of 50 tons of briquets a day:

Estimated cost of 50-ton peat-briquetting plant.

Buildings	$14, 280
Machinery	17, 850
Steam engine and fixtures	3, 570
Tramways	3, 570
	39, 270

Later estimates increase rather than diminish this sum, and it is doubtful if, when duties, higher price of labor, and other necessary charges are added, such a plant could be constructed in Alaska within the estimate first given ($50,000).

If, however, the system of drying the peat on the bog is adopted, a certain undetermined deduction may be made, as a part of the drying machinery will not be needed. It may be said also that by increasing the surface from which air-dried material is collected and the number of collectors, a sufficient amount of peat dust may be gathered and stored to supply the briquetting press during unfavorable weather and even through the winter. If this is done, weatherproof storage houses of large capacity and of durable construction will have to be added to the equipment.

It is apparent also that if the price of production given for machine peat is a just approximation, that for briquetted peat must be increased at least by the interest charges on the greater investment required

[a] Spec. Cons. Repts., vol. 26, 1903, p. 81.

and by the maintenance and other expenses of running the more complicated and powerful machinery. Besides this, the added cost of artificial drying and of grinding and briquetting must be taken into account. It will hardly be possible, therefore, to make peat briquets with any machinery now on the European market for less than $3 a ton, and even this is scarcely feasible, except under very favorable conditions. What can be done with American machinery now in the process of development remains to be seen. The Canadian processes mentioned above have not yet reached the stage where their inventors consider them fully perfected, although they are in operation on a factory scale; no figures relative to them can be quoted.

The fuel efficiency of briquetted peat should be at least one-third greater than that of machine peat of the same origin to warrant the added cost of production given above. Actually the increase in efficiency, as given by Nystrom, is only about 15 per cent. It is therefore apparent from business considerations that the increased cost of the plant and the more complicated machinery and processes necessary to make peat briquets are not justified, especially as the cost of production is more likely to be 50 per cent greater than it is to be 33 per cent. Peat is somewhat more transportable in the form of briquets than in any other form because it is less bulky, and it might have a somewhat greater sale on this account, but not in proportion to the increase in cost of manufacture. The present state of the attempts at commercial production of peat briquets is such that the installation of a plant for this purpose in Alaska should be undertaken only after the most careful examination of European and American developments in this direction to find out whether they could be used as desired. In any case only the densest and purest deposits of peat, and those of large extent, should be considered suitable for briquetting operations.

Electric processes of preparing peat for briquetting have been announced at various times and extensively advertised. They have been based on the supposition that the cell structure of the plant remains in the peat would be destroyed by the passage of electric currents, after which the water could be removed by pressure. None of these processes has yet been commercially successful, and the theory on which they are based is of very doubtful value, as there is no evidence that the cellular structure will be in any way affected by the passage of the electric currents used.

PEAT POWDER.

Peat in the form of fine powder, burned under a blast in a specially constructed burner, makes a very efficient fuel. The process of preparation is simple. The peat is cut or dug from the bog and, after being left on the surface through the winter to disintegrate, is gathered in a partly air-dried condition, dried artificially, and then pulverized. The resulting powder is dark colored, nonabsorbent, and very nearly as heavy as coal.

In firing with peat powder no smoke is developed, because the supply of air can be adjusted so that combustion is complete and rapid. The firing can be so regulated and controlled by the engine, after proper connections are made, that it becomes almost or quite automatic. In fact, peat used in this way burns and yields results like a gas. This is especially illustrated by the ease with which the temperature of the flame is regulated and by the possibility of getting oxidizing and reducing flames at will by changing the quantity of air supplied to the flame.

The temperatures obtained and held by properly built peat-powder burners are sufficient to melt glass, iron, steel, and other metals, and the use of peat fuel of this type for burning brick and lime could be widely extended in regions where peat is abundant. The vacuum collector, already mentioned, which takes the peat from the bog in the form of air-dried powder, should have special application to this product for fuel purposes, if it has sufficient capacity to warrant its use. With it the cost of gathering, completing the drying, and pulverizing should not exceed $2 a ton for the product ready for the market under conditions as they exist over most of the United States, and the cost of a well-equipped plant will be much less than for one intended for any type of briquetting.

PEAT COKE AND CHARCOAL.

A step further in the process of increasing the fuel value of peat and of rendering it more transportable is to convert it into coke or charcoal. The present method of coking peat is to make bricks of the peat to be converted into charcoal, using any of the types of peat machines developed for making machine peat and, after drying these bricks as thoroughly as possible by exposure to the air, inclose them in gastight retorts heated from the outside. The gases driven off from the peat when heated in such retorts are, so far as possible, condensed and redistilled, and in this way a number of valuable by-products are recovered. These substances are practically identical with those obtained from the destructive distillation of wood in charcoal making by modern methods. They consist of (*a*) methyl or wood alcohol, ammonia or ammonium sulphate, and acetic acid or acetate of lime, which are obtained by treating the tar water or lighter distillates; and (*b*) illuminating oils, lubricating oils, paraffin wax, phenol (creosote oil and carbolic acid), and asphalt, which are obtained from the tar. The noncondensable gases are combustible and may be used in heating the retorts and in running the engines which furnish the motive power of the plant.

The most fully developed and most successful of the processes of coking peat, and apparently the only one which has reached the commercial stage, is that devised by Martin Ziegler and represented in Europe by three large and successful plants, two in Germany and one in Russia. By this method the peat is dug and formed into bricks by peat machines and air dried exactly as if it were to be sold as machine peat. The peat bricks are then stacked in vertical cast-iron retorts with fire-brick lining, provided with air-tight openings for removing the finished coke and recharging with peat, and with flues for the escape of the gases formed. The retorts are surrounded by a double fire-brick wall with flue spaces between, through which the combustion gases pass. These gases are further used by conducting them to driers, where the peat is dried before introducing it into the ovens.

At the beginning of the process fires are started in fire boxes at the base of the retorts, but when the coking is well under way the lighter and uncondensable gases are conducted to the fire boxes and furnish all the heat needed. The condensable gases are drawn by fans to the special recovery plant and there redistilled, a part of the necessary heat coming from that of the combustion gases and a part being waste heat from the coking retorts. As fast as a charge is sufficiently coked it is drawn off at the bottom into air-tight receivers in which the coke cools. At about the same time a fresh quantity of peat is put into the top of the retort, through box openings provided for the purpose, thus making the process continuous.

The products of this treatment are peat coke and peat half coke, the latter not so thoroughly coked as the former, so that not all the heavy volatile constituents are driven off. The peat coke is black, heavy, and hard, gives a metallic note when struck, is as strong as good charcoal, and is adapted to all the uses of charcoal, especially to the smelting and refining of metals. The half coke is less dense and burns with a long, clear flame, making excellent fuel for use under boilers and for steam production generally.

For making peat coke of good quality the peat should be thoroughly ground and dried and should be low in ash and other impurities. For the half coke poorer grades of peat with considerable ash may be used.

The amount of coke obtainable from peat of good quality—that is, peat which contains less than 8 per cent of ash, which is free from coarse fibrous or woody material, and which, when machined, dries into hard, tough blocks by the Ziegler process—is from 30 to 33 per cent, and of peat half coke (or peat coke No. 2) from 45 to 50 per cent of the weight of the dry peat used. A considerable portion of the remainder is recoverable as by-products, which are, it is claimed, sufficiently valuable to pay a considerable part, if not all, of the cost of production, leaving the peat coke as profit.

The coking plants are built on the unit system, a single retort or, better, two retorts, with the accessory mechanism and recovery plant, constituting a unit. The cost of a unit with two retorts is about $50,000, and in it about 50 tons of air-dried peat could be coked daily, with a resulting product of 16½ tons of coke or nearly 23 tons of half coke. The cost of production and of the recovery of by-products for the unit with one or two retorts is high compared with that for a larger number, as about the same general equipment, supervision, and number of men are necessary in either plant.

The cost of producing peat coke, including digging, machining, and drying the peat, expenses of maintenance, etc., under conditions existing in America is estimated to be from $3 to $3.50 a ton for small plants and considerably less for large ones, if the by-products are recovered and sold at current market prices. For Alaska these prices would be considerably increased, as labor costs so much more and there would be no market for the chemical by-products. Without the sale of such materials it is doubtful if the coke could be made at a profit, except on a very small scale for use in metallurgical operations requiring charcoal, as peat coke can replace charcoal in all its uses, including the making of charcoal iron and steel and the refining of other metals. Powdered peat charcoal is also used in hardening steel and in the manufacture of calcium carbide. As a fuel it is reported to be, and in all respects should be, equal to hard-wood charcoal.

As yet no attempt to manufacture peat coke by the Ziegler process has been made in the United States. A few small ovens have been erected for making peat charcoal on an experimental scale, but so far as has appeared these ovens have not been sufficiently well equipped to get beyond an early stage of experimentation, and it can not be foretold whether peat coke and charcoal can be profitably made here or not. The matter is still more uncertain for Alaska, for it is not even known that peat of the right sort for making peat coke can be found there in large enough deposits to justify the erection of a suitable plant for making it.

GAS FROM PEAT.

When peat is heated in a closed retort or away from the air, large volumes of gas are given off. This gas is inflammable, burning with a bright flame, which develops much heat. In fact, its production gives the long, bright flames which characterize a peat fire when the fuel is thoroughly air dried.

The gas from any fuel—charcoal, coal, coke, wood, or peat—is generated on a commercial scale in some form of gas producer, commonly a vertical hollow furnace, with a grate at the bottom and an air-tight device for supplying fuel at the top, so that it may be operated continuously. Gas producers for the development of illuminating gas are not here considered, as those in which "power gas," for use in internal-combustion gas engines, and fuel gas are made are of more special interest in this discussion.

An old type of power gas producer still in general use is known as the "suction producer" and supplies gas directly to the engine, which develops its charge and draws it from the producer, as needed, by the suction of its own piston stroke. Producers of this kind are restricted to the use of anthracite, charcoal, and other fuels without bituminous matter, unless some very efficient form of tar extractor is used, as the tars and similar substances from bituminous fuels would be carried over into the engine as gases and, condensing there, would clog up the valves and other working parts.

A second type is the pressure producer, which is so constructed that steam and air blasts cause the gas to be produced from the fuel under slight pressure. It can thus be stored under pressure in a suitable container until used, and as its production does not depend on the suction stroke of the engine, it can be cleansed on its way to the container before it is supplied to the engine. Gas producers of this kind, therefore, are adapted to the use of bituminous coal, lignite, and peat, and when used with such materials are provided with special attachments for cleansing the gas of ash and the condensable volatile matter, the gas being forced through these attachments as it is sent to the container. This type of producer was designed for large plants and until recently was run chiefly on anthracite.

A third form of power gas producer is the down-draft type, in which the tarry products of distillation of the fuel are converted into permanent gases. This type seems to have been most satisfactory for use with peat abroad. The hot gases containing the volatilized tars and similar materials are drawn by exhaust fans from the top of the producer through the fuel bed, where the hydrocarbons are decomposed in contact with the hot carbon into simple, permanent gases, which are then cleansed and supplied to the engines.

Gas producers for using peat as a source of power gas have been made by several European manufacturers of gas engines. They have been for several years in successful operation in Sweden and Germany, and new plants are yearly added to the list.

The producer gas obtained from peat is large in quantity, as much as 48,000 cubic feet per ton of water-free peat substance, having a heat value of 152 British thermal units per cubic foot, being reported.[a]

The calorific value of producer gas from peat varies considerably, like that of producer gas from coal and other fuels, the variations depending on the quality of the peat, the amount of air and steam

[a] Nystrom, E., Peat and lignite: their manufacture in Europe, Canada Dept. Mines, Ottawa, 1908, p. 227.

introduced into the producer, and the type of producer. Nystrom gives the results of carefully conducted European tests to determine the calorific value of producer gas from peat as follows:

Calorific value of producer gas from peat.

[British thermal unit per cubic foot.]

From a Koerting gas producer at Skabersjo, Sweden, specially constructed for using peat. Average of ten analyses made by testing commission. Peat used had 32 per cent moisture	132
From a Luther gas producer, built for using peat at Ofenfabrik Koefner, Nymphenburg	114
From a Mond producer of the type used for bituminous coal at Stockton, England (Caro's report)	145
From a Mond producer at Winnington, England (Caro's report)	152

In this country very few records of experiments with peat in gas producers have been published. Of these experiments, the two made in 1905 and 1906 at the fuel-testing plant of the United States Geological Survey[a] at St. Louis, Mo., are of importance chiefly because they were made in a large pressure producer constructed for anthracite coal and not for bituminous fuels. As in one of these experiments the amount of peat used was too small for a full-test run, they must be considered as incomplete. In the first test the gas obtained was made from air-dried machine peat from a point near Halifax, Mass., and its average calorific value was 166 British thermal units per cubic foot. The second test was one of fifty hours' duration, using air-dried machine peat obtained near Orlando, Fla., the average calorific value of the gas being 175 British thermal units per cubic foot. These values are about the same as those of the producer gas obtained from bituminous coal in tests made at the St. Louis testing plant during the same year, in the same gas producer, and by the same corps of testing engineers.

Calorific value of producer gas from bituminous coal.

[British thermal units per cubic foot.]

Indiana coal (average)	147
Kentucky coal (average)	164
Illinois coal (average)	143
Ohio coal	157
Pennsylvania coal	142
Virginia coal	157
North Dakota lignite	161

In the 50 tests from which the foregoing figures were obtained the gas in only five showed a greater calorific value than that of the Massachusetts peat; and the value of the Florida peat was surpassed in but one test on coal, and that only by a single British thermal unit.

[a] Bull. U. S. Geol. Survey Nos. 290, 376, 416.

These comparisons show that the two samples of American peat and the foreign peats referred to above were as good fuel for the gas producer, so far as quality of the gas is concerned, as the coals used in the tests cited. It should also be noted that while air-dried machine peat was used in the producer tests at the fuel-testing plant, it is quite possible to use peat with 30 to 40 per cent of moisture and in lumps of any size or shape, as dug from the bog, for manufacturing producer gas.

Another significant feature of the tests cited above is the fact that the single full-test run made with peat as fuel in the gas producer gave a greater horsepower than that obtained from the best of the coal used in the boiler tests. The same result was obtained in the shorter run on Massachusetts peat and more recently has been confirmed by tests made by the United States Geological Survey at Pittsburg, Pa., with a down-draft gas producer designed for bituminous coal. In one of these more recent tests the peat used was from North Carolina and contained nearly 29 per cent of ash, yet gas was obtained of good quality and in sufficient quantity to run the gas engine that formed a part of the testing plant with its full load in a satisfactory manner. The energy of the fuel was converted into electric current and a commercial electric horsepower per hour was developed from about 4 pounds of the peat as fired—that is, with more than 28 per cent ash and 15 per cent of moisture.

Too much stress must not be placed on these few test runs, but it seems safe to conclude that the value of peat as a fuel is greatly increased when it is converted into power gas in a gas producer, and that, in the tests cited, under rigid conditions, the peat, with a fuel ratio to bituminous coal of 1:1.8, gave more power when gasified and used in a gas engine than an equal weight of coal used as fuel under a steam boiler. Apparently, therefore, the ideal way in which to use peat fuel for power purposes is to convert it into producer gas and use it in the gas engine, and that this can be successfully done has been demonstrated by a number of commercial operations abroad.

The cost of installing a plant with gas producers and gas engines is as yet somewhat greater than that of equipping with steam boilers and engines of the same horsepower, but these differences are decreasing. On the other hand, the cost of operating and maintaining the producer plant is about one-half that of the steam plant,[a] because a smaller amount of fuel, of much poorer quality, and a smaller firing force are required.

The weight of dry peat required per electric horsepower per hour, as shown by the available records of experiments, averages from 2 to 3 pounds, and the gas obtained from the producer may be somewhat

[a] Bull. U. S. Geol. Survey No. 316, 1907, p. 457; Bull. 416, 1909, pp. 31-33.

richer in hydrogen and lower in nitrogen than that from coal, although the hydrogen content would naturally depend on the degree to which the free hydrogen developed was consumed in the producer.

The principle governing the use of peat in gas producers as a source of power gas for use in gas engines may be applied to the production of fuel gas,[a] and in that form the energy of the peat may be economically and satisfactorily converted into heat units for firing steam boilers, ceramic kilns (brick, tile, pottery, etc.), lime and cement kilns, metallurgical furnaces, forges, foundries, and steel, muffle, glass, ore-roasting, and similar furnaces.[b] It is probable also that producer gas generated from peat could be used for fuel to thaw gravels in placer mining in those parts of Alaska where thawing is necessary. The gas could be generated for this purpose in pressure producers built without the more complicated scrubbing devices necessary to purify the gas for gas engines, and stored in simple gas holders, from which it could be piped to the places where it is to be used and burned in blast burners attached to suitable lengths of flexible hose. As producer gas is rich in carbon monoxide, a colorless, odorless, and very poisonous gas, care to prevent leakage would be necessary in all confined places, like pits and tunnels.

Illuminating, retort, or bench gas made by heating peat in closed retorts or ovens heated from the outside until all the gaseous matter is driven off could be used for the same purposes as producer gas. It is also possible to develop both kinds of gas at one operation by using the waste heat from gas producers to coke peat in closed chambers or retorts placed in such relation to the gas producers that the hot producer gas can be forced through them. This process has been used in the Ziegler coking plants before mentioned and is practicable at least in large operations.

The chief difficulties in utilizing peat for gas production in Alaska are those attendant upon the production of the peat in sufficient quantities for fuel and the transportation of the necessary materials for construction to the places where they are to be erected. These difficulties, however, are no greater than some that have been overcome in other lines of construction in mining operations. The first step in such development should probably be to test thoroughly the feasibility of producing the peat fuel. It now seems probable that, if it is found that this can be done, the product, even though very crude, can be very economically used in gas producers either for fuel or for the production of power.

Peat fuel, in proper form, is especially valuable for metallurgical work, being as a rule much lower in sulphur than coal or coke. Peat

[a] Nagel, O., Producer-gas fired furnaces, New York, 1909.
[b] Wyer, S. E., Producer gas and gas producers, New York, 1907.

that has been subjected to salt or brackish water, however, seems to be an exception to this rule and may contain considerable sulphur, some of which appears in the gases produced from it.

The producer in which peat is to be converted into producer gas for any of the purposes indicated above must be designed to meet the peculiar requirements of the fuel and to care for the considerable amounts of tar and other condensable matter that will be liberated as the gasification proceeds. The form of the kilns or furnaces in which the gas is to be burned and the method of firing them will also have to conform to the requirements of a gaseous fuel, and men will doubtless have to be specially trained to get the best practical results. In general, the attempt to develop plants for utilizing gas as fuel should be left to trained experts in gas firing and to concerns with large capital, because much experimental work usually needs to be done before such processes and the plants using them attain anything like their theoretical efficiency in actual practice. It may be said, however, that in individual plants nearly all the uses suggested as possible for producer gas as fuel have been tried on a commercial scale, either in Europe or in the United States, in some cases with marked success, and there seems no doubt that peat gas can be produced for any of these purposes very cheaply with a properly designed and well-constructed producer.

USE OF PEAT FOR FUEL IN ALASKA.

At Nome and along the tundra in that region the coarse, fibrous turfy peat is sometimes used for fuel under boilers, and occasionally for heating, by those who, being natives of northern Europe, are familiar with its use. At St. Michael for two seasons some peat has been prepared under direction of the quartermaster, Lieut. Philip Remington, by cutting it out in blocks and drying in the air. The first season, apparently because of insufficient drying, the material that was gathered burned very slowly and without the evolution of much heat, but by making the blocks smaller and drying more thoroughly this difficulty was obviated and a peat fuel of good quality prepared.

The following is a fuel analysis of this material on the moisture-free basis:

Analysis of peat fuel prepared at St. Michael.

Volatile combustible	53.88
Ash	29.23
Fixed carbon	16.89
	100.00
Sulphur	0.57
British thermal units per pound	7,092
Calories	3,940

The peat from which the analysis was made consisted largely of the poorly decomposed remains of grasslike plants and mosses and was light in weight. The high percentage of ash reduces the fuel value, but it still is somewhat more than one-half that of the best coal. These facts plainly indicate that, with thorough drying, the peat can be used at least as an emergency fuel in lieu of something better.

CONCLUSIONS.

But little has been said in this discussion relative to the value of peat as compared with coal and wood. Peat has a theoretical heating value ranging from five-ninths to five-eighths or more of that of good bituminous coal. It may be said, however, that the range of British thermal units in any considerable number of coal samples from different fields, or from different mines in the same field, is rather large. Thus in the tests made at the fuel-testing plant at St. Louis [a] the thermal value in a variety of bituminous coals from the eastern and central coal fields of the United States ranged from 9,360 British thermal units per pound for the poorest reported to 14,674 British thermal units for the best, while the few samples of lignite tested had a range from 6,739 to 7,603 British thermal units per pound.

The average calorific or heating value of 36 samples of coal from various parts of Alaska, collected and analyzed by the United States Geological Survey, is 12,800 British thermal units per pound, the highest giving 15,200 and the lowest 8,894 British thermal units, all calculated on the moisture-free basis. The lignites and subbituminous coals of the Yukon, the lignites of Chicago Creek and Seward Peninsula, and the subbituminous coals and lignites of northern Alaska would all lie below the average given above in heating value, as most of the 36 samples included in the list mentioned were pure bituminous coals. The heating values of such coals generally lie between 6,000 and 11,500 British thermal units. On the same basis peat ranges from less than 6,000 to 10,865 British thermal units, the higher figure being obtained from a peat sample from Florida. Turfy peat from the tundra at St. Michael gave 7,092 British thermal units per pound.

Under test conditions in Europe, in comparison with steam coal of good quality, peat when fired under boilers has been found to have about the ratio stated above—namely, a ton of good peat is worth about five-ninths of a ton of good coal. Under the usual methods of firing, however, there is likely to be a greater loss of heat units from the coal than from the peat, especially if the latter is in the form of air-dried machine peat. The peat does not clinker or give off any

[a] Bull. U. S. Geol. Survey No. 316, 1907, pp. 443-445.

volatile matter in the form of black smoke; it burns up completely, leaving only a powdery, light ash, which is small in bulk compared with the original fuel; it makes a good fuel bed in the furnace and burns with a long, bright, clear flame, without smoke or sulphurous gases, so that neither flues, grates, nor boiler plates are corroded or clogged. In burning peat it is of advantage not to stir the fire, which causes the fuel to break up and drop through the grate, or to give it too much draft, for then it burns with too great intensity. If, however, the attempt is made to burn cut peat in too large pieces before the material is thoroughly dry, very little flame or heat will be obtained and a smoldering smoky fire is the result, even with good draft. The water in the fuel absorbs the heat as fast as generated, and the fuel mass is kept at too low a temperature to maintain active combustion until the greater part of the moisture is converted into steam. The remedy for such a condition is to cut the peat into smaller pieces and dry these as much as possible before putting them into the furnace. When the interior of the peat mass is moist to the touch, the percentage of moisture is too high to give a brisk fire. In a horizontal furnace the fresh fuel can be dried by throwing it well back of the fire and subjecting for a time to the heat of the outgoing gases, after which it may be spread over the grate. In Europe the step grate is often used where peat is fired under large boilers.

As domestic fuel, machine peat is clean, can be made to burn slowly or rapidly, as desired, by regulating the drafts, is very easily handled, and is so efficient that it commands a ready sale at good prices to all who have had opportunity to try it. The poorer grades, those that are very fibrous and full of ash, are not so good but have their value where other fuel is scarce and high in price.

It would seem, therefore, that there is a good field for the preparation and use of peat in many parts of Alaska, where it is to be found in abundance and of fair or good quality. A small peat deposit will furnish fuel to a community of some size for a long time, if proper methods are taken to develop it. The principal points to be borne in mind in such exploitation are that the simplest equipment which is well designed to produce the desired quantity of a salable form of fuel is the one most likely to be successful, and that every added process of handling adds many times to the first cost of equipment and to the difficulties of producing an article which can be sold at a price sufficient to pay the cost of preparation.

It also seems probable, from present knowledge, that large peat deposits will be most efficiently and satisfactorily utilized by converting the peat into producer gas and using the gas for power to run gas engines, which, in turn, may be employed for manufacturing or for the generation of electricity. The production of gas may have added value where the form of the producer is such that at least the ammonia generated by gasifying the peat may be saved and sold as a by-product. This process, however, may not be feasible in small plants, for the installation and cost of maintenance are higher in proportion for small than for large units. For all plants requiring the use of more than 150 horsepower the use of producer gas to be furnished from peat fuel should be taken under serious consideration where peat beds are available.

Peat fuel is well adapted for burning bricks, lime, and cement, either as machine peat, peat powder, or as a source of producer gas, and for general power purposes and various metallurgical operations, when fired in the form of gas or coke. A very important use is for heating and cooking purposes in small and isolated communities.

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