DEPARTMENT OF SCIENTIFIC AND
INDUSTRIAL RESEARCH

Report of the Fuel Research Board for the Years 1922, 1923

First Section:

THE PRODUCTION OF AIR-DRIED PEAT

LONDON: PUBLISHED UNDER THE AUTHORITY
OF HIS MAJESTY'S STATIONERY OFFICE, [illegible]

DEPARTMENT OF SCIENTIFIC AND
INDUSTRIAL RESEARCH

Report of the Fuel Research Board for the Years 1922, 1923

First Section:

THE PRODUCTION OF AIR-DRIED PEAT

LONDON: PUBLISHED UNDER THE AUTHORITY
OF HIS MAJESTY'S STATIONERY OFFICE, 1923

FUEL RESEARCH BOARD

SIR GEORGE BEILBY, F.R.S. (*Director*)

THE HON. SIR CHARLES A. PARSONS, K.C.B., F.R.S.

SIR RICHARD THRELFALL, K.B.E., F.R.S.

Assistant to the Director:
C. H. LANDER, D.Sc., M.I.Mech.E., Assoc. M.Inst.C.E.

Consultant to the Board:
THOS. GRAY, D.Sc., Ph.D., F.I.C.

Department of Scientific and Industrial Research,
16, Old Queen Street,
Westminster, S.W. 1.

TABLE OF CONTENTS

(8081) Wt. 19444/700/1010 1,000 6/23 Harrow G. 25.

IV.—EXPERIMENTS ON THE AIR-DRYING OF PEAT AT TURRAUN

V.—CONSIDERATION OF SCHEMES FOR MECHANICALLY WINNING 100,000 TONS OF PEAT PER ANNUM

LIST OF ILLUSTRATIONS

REPORT OF
THE FUEL RESEARCH BOARD
FOR THE YEARS 1922, 1923

FIRST SECTION: THE PRODUCTION OF AIR-DRIED PEAT

To the Lord President

MY LORD,

IN our report for the year 1918-1919 reference was made to the work of the Irish Peat Inquiry Committee and to the further work which the Board proposed to carry out on the subject of peat winning and utilisation. We also stated that Professor Pierce Purcell had been appointed Peat Investigation Officer to the Board, and that Mr. E. J. Duffy, B.Sc., had been appointed as Research Assistant to Professor Purcell. In our present report we deal with the investigations made since that time.

2. In 1921, the report of the Irish Peat Inquiry Committee* was published, together with our recommendations and other relevant documents showing why it was not found possible to carry out the large experimental scheme of peat winning recommended by the Committee.

3. Peat, as it occurs in an undrained Irish bog, contains from 92 to 95 per cent. of moisture, and by draining the bog the moisture content can be reduced to between 88 and 91 per cent. Peat cannot be usefully employed as a fuel until the moisture content is reduced to 25 to 30 per cent. No economic method of drying by artificially generated heat is yet available, and in every case where peat is used commercially at the present time, the peat has been air-dried. This report therefore deals only with air-dried peat.

---

* The Winning, Preparation and Use of Peat in Ireland: Reports and other Documents. Published by H.M. Stationery Office, 1921. Price 3*s*. (by post 3*s*. 2½*d*.

4. Mr. Duffy has carried out an investigation into the properties of air-dried peat and the factors which govern the rate of drying. Both hand-cut and machine-formed blocks were investigated. His report is given in Appendix I.

5. Some hundred tons of peat cut by hand, macerated by machine at Turraun, and air-dried on the bog, were sent to H.M. Fuel Research Station, East Greenwich, and experiments were made on the carbonisation of this material in vertical retorts, and on its use as a fuel for steam raising. Some of these results have been published as Technical Paper No. 4 of the Board.*

6. During 1920 Professor Purcell visited Canada in order to make himself fully acquainted with the work which the Canadian Peat Committee was carrying out for the Federal and Provincial Governments on the mechanical winning of peat, and in 1921 and 1922 he visited Germany and Sweden for the purpose of studying the latest practices in these countries. His reports are given in Appendices II. and III.

7. In Professor Purcell's main report the results of the above-mentioned investigations are summarised and discussed.

8. The winning of peat on a small scale has been successfully practised from time immemorial, but the problem of large scale production is far more difficult. The undrained bog contains over 90 per cent. water ; but taking this figure, then seven and a half feet depth of bog will produce the equivalent of one foot of air-dried peat containing 25 per cent. moisture, hence even a deep bog of say 20 ft. can only produce at the outside some 3,200 tons of air-dried peat per acre.

For this reason, and also because it is necessary to spread the peat on the ground in thin layers for purposes of drying, the operations involved in continuous large scale production must inevitably cover a very large area, and the problems of transportation over this area of both the undried raw peat and the air-dried product become increasingly important as the scale of production is enlarged.

9. Professor Purcell has dealt with these difficulties and has visualised possible schemes for peat winning on a scale of 100,000 tons per annum from one bog area over a period of years. He

---

* The Carbonisation of Peat in Vertical Gas Retorts. Published by H.M. Stationery Office, 1921. Price 6*d.* (by post 7*d.*)

has dealt with the imaginary case of a rectangular bog extending over some 8 square miles, and has shown very plainly and for the first time the vital importance of the initial lay-out of the bog for a definite scheme of development year by year over a sufficiently long period. Only in this way can trustworthy estimates of the amount of peat which can be economically won from a given bog, and the approximate cost of winning it, be made.

10. Since submitting his report, Professor Purcell has drawn our attention to the fact that power driven plants for peat winning are now being manufactured in this country.

GEORGE BEILBY,
Director of Fuel Research.

3*rd February*, 1923.

THE PRODUCTION OF AIR-DRIED PEAT

I.—INTRODUCTION

1.—The Problem of Winning Peat

THE use of peat as a domestic fuel is of very ancient origin and is probably coeval with that of coal. Notwithstanding the long period over which peat fuel has been used, progress in its preparation and utilization has been slow, and in many countries its production is still dependent upon the laborious hand-winning methods which, with the exception of minor differences, are the same in all countries.

During the past century many attempts have been made, chiefly in Germany, to apply mechanical methods to the excavation and spreading of the peat. While the use of elevators and macerators has led to the production of a denser and tougher fuel, the output of such plants is small and the number of workers so large that unless wages are kept at a very low level such processes can scarcely be held to produce a peat fuel capable of competing with hand-cut peat or coal. Within the past ten years strenuous efforts have been made to develop mechanical methods of excavation and to apply conveyor plant to the automatic distribution of the peat in the shape of blocks, or " sods," on the bog surface. The purpose of this report is to set out recent practice as observed during visits paid to Canada in 1920 and to Germany and Sweden in 1921. (See Appendices I to III.) It may be fairly stated that in the countries mentioned the most serious efforts have been made towards the solution of the problem of winning peat. The problem may be said to consist in the preparation of a fuel in the form of blocks or briquettes containing 15 per cent. to 30 per cent. of moisture from the raw peat in the bog, which, in its undrained condition, may contain 92 per cent. to 95 per cent. moisture and, when drained, 88 per cent. to 91 per cent.

There are only four possible methods of reducing the moisture content of the peat :—

(*a*) Air-drying in the open or under cover ;
(*b*) Evaporating the water by artificial heat (the heat used being partially recovered) ;
(*c*) Mechanically pressing the water from the peat ;
(*d*) Removing the water by electrical osmosis.

Attempts have been made and are still being made in almost every country in which peat exists, to dry the peat by the application of heat in different ways. Methods involving pressure and combinations of heat and pressure have also had extensive trials. But the fact remains that although experimental success has frequently been claimed, there is no process based on the application of pressure, or heat and pressure, producing peat and working on a commercial basis to-day.

The method of electrical osmosis depends on the fact that when a direct current of electricity is passed through peat, the water flows with the current to the negative pole. While it is true that water may be driven in any direction by an electrical current, yet, owing to the decreasing conductivity of the peat with reducing moisture content, the power required to dry the peat to a point where it may be used becomes so great that the process has not so far proved economic.

The preparation of pulverized peat has been attempted chiefly in Sweden (see pp. 27, 132-143). The peat is spread on the bog surface in the form of blocks, and air-dried in the ordinary way until its moisture content is less than 40 per cent. The air-dried peat is then collected and taken to the factory, where it is pulverized, sifted and passed through drying ovens until its moisture content is reduced to between 12 per cent. and 15 per cent. When the moisture content of raw peat is reduced from 91 per cent. to 33⅓ per cent. by air-drying, it follows that nineteen-twentieths of the original water has been removed by air-drying. Even this process, in which so large a proportion of the original water is removed by air-drying and on which considerable capital, including State subsidies, has been expended, cannot be said to have proved commercially successful, as only one factory out of three erected in Sweden is still working.

It has often been suggested that peat with a moisture content of 60 per cent. and even higher, could be used in gas producers for the production of a power gas, and particularly in connexion with the recovery of ammonia. Of the many large-scale plants constructed to work on these lines, apparently all, except one, have closed down, and only the Orentano plant in Italy is at work to-day. This plant, however, is now being supplied with peat containing not more than 25 per cent. to 30 per cent. moisture.

With the failure of these plants to give commercial results, there is no longer the same incentive to devise processes for the partial dehydration of peat, by which peat with, say, 60 per cent. moisture could be obtained all the year round and used in producers.

Since the only processes employed by firms selling peat fuel on a commercial basis are those solely dependent on air-drying, a critical consideration of the various methods may serve a useful purpose. It is therefore proposed to examine in detail the various steps involved and to set out the results of some experiments which were carried out at Turraun, King's Co., during the 1920 season, on the rate of drying machine-formed peat exposed under varying conditions of weather.

From the data secured at Turraun, and on the results considered possible with the mechanical winning of peat, an attempt will be made to visualize the working of a large scheme of peat-winning under the climatic and other conditions prevailing in the Bog of Allen area, so that the difficulties associated with the mechanical winning of peat on a large scale may be better understood.

To realize clearly the factors involved, two facts must be borne in mind at each stage : first, that for every separate ton of air-dried peat containing 25 per cent. moisture which is produced, 7½ tons of raw peat containing 90 per cent. moisture must be handled, even in the case of a drained bog ; second, that, even with the best qualities of peat, whose calorific value on an anhydrous basis is 10,000 B.Th.U. per lb., the 25 per cent. moist air-dried peat will have a net calorific value of not more than 7,220 B.Th.U. per lb. It will be safe to take the average net value of air-dried Irish peat at 6,900 B.Th.U. per lb., and taking industrial coal at 11,500 B.Th.U. per lb. net, as fired, it will be seen that 1·67 tons, or about 1⅔ tons, of air-dried peat contain the same number of therms as a ton of coal. A ton of coal in bunkers occupies about 45 cub. ft., whereas a ton of air-dried machine-formed peat occupies about 90 cub. ft. to 95 cub. ft. Hence, for equal thermal effect with coal, 1⅔ times as much peat by weight must be transported. This will have 3½ times as much volume as coal.

The result of these considerations must be that, if peat is to compete with coal on a calorific basis, only the minimum of labour and the minimum of capital must be expended per ton produced. Further, it will be obvious that if the peat has to be carried to any considerable distance from the bog, the transport charges per therm may prove so excessive as to render it difficult for the peat to compete with coal. In Germany peat enjoys a special tariff on the railways. The rebate granted in November 1921 on peat compared with coal is shown in Fig. 1. From the curve it will be seen that, as a matter of State policy, increasing preferential help in the matter of transport charges is given to peat to enable it to compete with coal up to a distance of 350 km., when the rebate amounts to almost 16 per cent. on the coal tariff. For greater distances the rebate is reduced, until at 600 km. the freight charges per ton on peat and coal are the same.

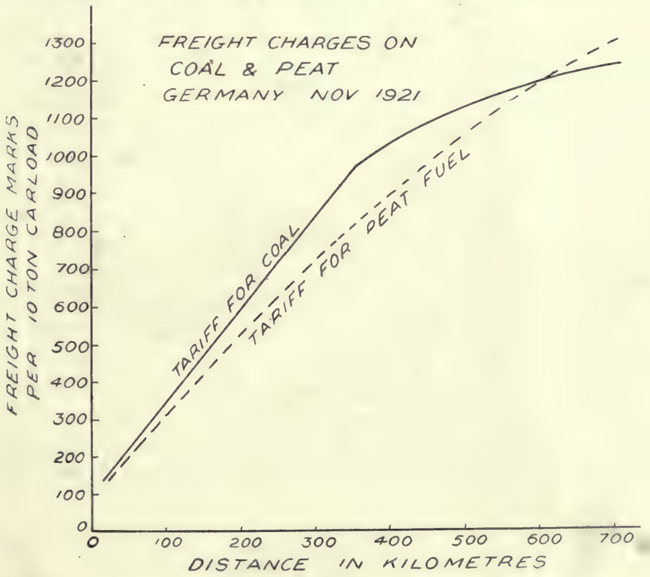


FIG. 1.

II.—CLASSIFICATION OF MECHANICAL METHODS OF PEAT-WINNING

2.—Types of Plant in Use

THE principal methods of excavating, transporting and spreading the raw macerated peat on the surface of the bog for air-drying are as follows :—

Excavation.—This may be effected by the following types of machines :—

(*a*) Elevator machines, in which the peat excavated by hand is cast on to an elevator, the excavated face being left either vertical or sloping.
(*b*) One or other of the many types of continuously rotating ladder dredgers with a chain of buckets.
(*c*) A grab or scoop whose action is intermittent.
(*d*) A machine in which a high-pressure jet of water washes down the peat to a sump, from which it is pumped as a very wet slurry. (Hydro-peat process).

These machines may work on the surface of the bog, on the subsoil under the bog, or on the cut-away bog ; and may be supported on rails, caterpillar bearing surfaces, or on floating pontoons.

Most of the existing peat machines are designed to work on the surface of the bog. When a bog has been drained for some time and its surface has settled, a growth of grass or heather, coupled with the partial air-drying of the surface peat during the summer, causes a kind of surface mattress to form, which will bear weights of $1\frac{1}{2}$ lb. to 4 lb. per square inch without serious settlement. Depending on the degree of drainage and the character and depth of the peat, heavy machinery may be supported on rails with a large proportion of sleepers, or alternatively, caterpillar bearing surfaces may be provided on which the concentration of the load will not exceed the above figures.

Where rails and sleepers are used the time of at least two men is taken up in preparing and moving the track and sleepers ahead of the machine. In addition, the machine itself is usually pulled forward by the tension on a cable fixed to an anchor ahead of the machine, and a certain amount of time is lost in preparing fresh anchorages. The advance and extended experience during recent years in the application of caterpillar bearing surfaces to all kinds of heavy tractors and machines moving over soft and uneven ground has become available for peat machines, and both in Canada and Germany examples of such machines are found. Mr. E. V. Moore has employed caterpillar bearing surfaces to support and move his excavating, conveying, spreading and harvesting plant. Dr. Wielandt has placed his transporter on caterpillars, and the Baumann-Schenck excavator and distributor are also so mounted. The adoption of caterpillar traction allows of the concentration of the controls at a central point on the plant, and as adjustments are possible, the whole plant, both excavator and conveyor, can be made to move uniformly and at will over the bog surface. The writer observed the work accomplished by the Moore plant in 1920 at Alfred Bog, Ontario, where the pressure due to a plant weighing 30 tons was distributed so as not to exceed 350 lb. per square foot. The plant was moved regularly and steered parallel to the face or around curves without difficulty.

Maceration.—The uniform mixing-up of the various layers of peat in a bog and thorough maceration is looked upon as an essential operation in the production of air-dried peat fuel. The majority of macerators do not effect anything beyond a purely mixing action, which is all that is necessary with some types of peat. With other types of peat and where roots and timber are met with, fixed and rotating knives are provided, and these cut up the fibre and timber. (For a discussion on macerators, see Hausding,* pp. 170–180).

Transport.—The excavated peat, after maceration, may be spread on the bog surface adjacent to the site from which it is excavated, or it may be sent by pipe-line, belt conveyor, plate conveyor, screw conveyor, rope conveyor (Persson's), or in tip waggons running on rails, to some distance, where spreading takes place on a suitable drying-ground.

Spreading.—The following methods of spreading the peat may be used :—

(1) The macerated peat pulp may be tipped in heaps on the bog surface and then levelled and spread by a field press of the Jakobsen, Anrep or Ekelund type into a layer of uniform thickness 4½ in. to 5 in. deep by 7 ft. wide, and cut into separate blocks by disc cutters (see pp. 74 and 138) ; or

(2) The peat pulp, extruded from the mouthpiece of a forming machine in a continuous band of 5 in. × 5 in. cross-section, may be dealt with as follows :—

(*a*) The extruded peat is caught on boards 4 ft. 6 in. long by 7 in. wide and cut to lengths by hand. The boards run by gravity down a roller table and are automatically placed on the two ropes of a Persson's conveyor (see pp. 26 and 127) and carried up to 200 metres from the peat machine until the boards are lifted off the conveyor and the peat spread by hand ; or the boards of peat may be placed by hand on a truck with shelves, from

---

* A handbook on "The Winning and Utilisation of Peat." By A. HAUSDING. Translated (1921) from the third German Edition. Published, H.M. Stationery Office. Price 30s. (by post 31s.).

which they are removed when the trucks have been pushed to the spreading-ground, where the peat is tipped off the boards; or

(*b*) The extruded peat is applied to a chain of tilting plates of the Dolberg, Strenge, Wielandt or Baumann-Schenck type (see pp. 95–125) and, by them, conveyed to a distance of 40 metres to 100 metres from the face, when it is automatically tipped on the surface and left to dry; or

(*c*) The extruded peat is caught on a belt conveyor (as in the Canadian Peat Committee's Moore No. 2 plant) (pp. 76–82), and carried out at a velocity of 200 ft. to 300 ft. per minute, until it is scraped off to a spreader which has a mouthpiece 4½ in. deep by 12 ft. wide. The layer of peat, 12 ft. wide, is cut longitudinally into strips 5 in. wide by disc cutters and cross-cut by special knives into lengths of 10 in. to 15 in. In the 1920 Moore plant at Alfred the belt conveyor was 159 ft. long, and from it 10 rows to 11 rows of peat, each 12 ft. wide by 4½ in. deep, are spread parallel to the working face (see pp. 76–80). The conveyor, which is supported on caterpillar elements, is at right angles to the excavated face, and moves along at a rate of 6 ft. to 8½ ft. per minute—the spreader, which is attached to the conveyor, following on at the same rate (see Fig. 37).

In the new plant used at Alfred last season (1922) a belt conveyor 860 ft. long, resting on eleven caterpillars, extends out at right angles to the excavated face. Peat is passed from the macerator of the excavating element to the belt conveyor by a system which allows the excavator to move forward continuously, while the conveyor remains in the one position. A spreader 12 ft. wide, mounted on caterpillars and driven by a 10-h.p. oil engine, moves parallel to the belt conveyor, from which it is fed with peat pulp. The peat is tipped off the belt conveyor by a scraper and tipping gear, which moves forward with the spreader, and a band of peat 860 ft. long by 12 ft. wide and 4½ in. deep is laid down at right angles to the working face (see pp. 87–90).

(3) A further method of spreading is that used in connexion with the "Hydro-peat" process, by which the peat is pumped to the drying-ground through a 15 in. to 18 in. diameter pipeline as 95 per cent. moist pulp. At the drying-ground it is allowed to spread itself out between dam boards, over an area to a depth of 6 in. to 9 in. When it has drained, settled and dried out somewhat it is cut into separate blocks by disc cutters, or some other device. It is claimed that this process is well adapted for use in bogs containing much timber, and that, as maceration can be dispensed with, there is a saving in power required for this purpose, and that pumping forms a simple and efficient method of transport. A smooth and level drying-ground

is an essential for this process, which has been tried at the Store Vildmose, Jutland, Denmark, and also in Germany (pp. 143–146).

For a number of years Wetcarbonizing, Ltd., conveyed all the peat required at the Dumfries factory by pumping it through a pipe-line of large diameter.

3.—OPERATIONS REQUIRED FOR THE AIR-DRYING OF PEAT

After the peat pulp is spread on the bog it begins to lose water at a uniform rate, and in good weather will be sufficiently firm to stand handling in 10 to 14 days after spreading.

In the central districts of Ireland the peat is usually " footed " in piles of 9 to 11 sods (see pp. 49 and 53), and later on it is built into small clamps or stacks containing 100 to 200 sods, built up with a large proportion of voids, or, alternatively, the different footings may be built into " walls." When drying has progressed sufficiently to allow the sods to stand more weight, they are collected into stacks or large heaps and the drying operation is there completed. The bottom sods in the footings and clamps usually require a little further drying before they are fit for stacking. In the northern districts the peat has to be handled three times before it is fit for stacking. The harvesting operations in England are conducted on somewhat similar lines to those in Ireland.

In Germany and Sweden the partially dried peat sods are turned over and left to dry still further. They are then footed and subsequently collected into stacks.

In Canada the peat blocks are turned over once with a hand rake and, in the middle of the peat season, they get sufficiently dried in this way and may be collected and stacked directly without further handling.

The following figures represent the average output per person for harvesting operations :—

Turning peat (fairly wet), equivalent to 12 tons air-dried peat per day.
Footing or walling peat (women), equivalent to 9 tons air-dried peat per day.
Footing or walling peat (youths), equivalent to 6 tons air-dried peat per day.
Clamping or rickling, equivalent to 6 tons air-dried peat per day.
Collecting and stacking (by hand), equivalent to 4½ tons air-dried peat per day.
Collecting and stacking (with conveyors), equivalent to 12½ tons air-dried peat per day.

4.—COLLECTION OF THE AIR-DRIED PEAT

With ordinary hand-winning methods, as practised at Maghery and Turraun, in Ireland, the peat is filled into large wicker baskets borne by two men and carried a maximum distance of

50 yds. to large stacks, where it is left while further drying takes place. The peat is then transferred as required into tip waggons, running on a temporary field railway laid for the purpose. Two men working in this way collect and stack 9 to 10 tons per shift, the cost being about 1*s.* 3*d.* per ton of air-dried peat.

Where automatic excavating and transporting plant is used in Germany the peat is collected and carried in a similar manner some 30 to 70 metres from the place where it is spread and stacked clear of the drying-ground. At certain periods during the season, when the peat is sufficiently well dried on the ground, it is collected into waggons instead of being stacked and is hauled to the storage piles, to the bunkers close to the power station, to the railway siding, or to the canal for transport. For instance, at Wiesmoor much of the peat won during the summer is sent direct to the bunkers, thereby saving handling.

Mr. E. V. Moore has made two attempts to employ belt and scraper conveyors to collect the peat fuel clear of the drying-ground and to load it into waggons. In his 1920 plant the peat, picked up by hand or by large coke forks, was cast on to a small elevator which delivered the peat on to the belt conveyor used for spreading the raw peat. This conveyor delivered the peat on to a stack or into waggons running on rails just clear of the spreading-ground. Owing to certain objections (see pp. 83–84) this system has been abandoned.

The No. 3 Harvesting Plant (Fig. 2) has now been successfully used at Alfred Bog for the past two seasons and, attended by 7 to 9 men, is able to convey and stack or fill into waggons from 12 to 15 tons of peat per hour, including stops to change the track. The plant consists of a light steel channel 18 in. wide by 9 in. deep by 60 ft. long supported at each end on small caterpillar elements driven by an oil engine. The channel is about 12 in. above the surface of the bog, and a scraper, operated by the oil engine, conveys the peat as it is thrown into the channel by hand, and elevates it into a waggon or stack as required. The forward movement of the harvester can be regulated so that, according to the number of men employed, they may have just sufficient time to pick up all the peat from the ground and throw it on to the conveyor. The machine eliminates a good deal of the laborious work associated with carrying the peat, and renders this work suitable for youths or women. By the use of improved or extended conveying plant on caterpillar supports for the collection of the peat, it should be possible to raise the output per worker from 4 tons or 5 tons per shift with hand methods to 10 tons to 15 tons per shift.

Owing to the rough nature of the surface of the bog, it is unlikely that any apparatus can be designed to pick up the dried peat blocks mechanically and place them on the conveyor. It should be possible to design a harvesting plant of equal length to the transporter used for spreading the wet peat. If of sufficient length, it could have a capacity of 20 tons to 25 tons per hour, which is approximately the limit for the temporary field railways used on bogs. Such a conveyor would harvest the peat laid down by two to three excavators and make it possible to get the drying-ground clear in time for the second spreading of peat contemplated. With the wide spreading-grounds used by the Canadian 1921 plant, it will no doubt be more economical to use a shorter harvester and Fig. 3 shows diagrammatically how a harvester similar to the No. 3 machine at Alfred and 40 yds. long might be used to clear a drying-ground 200 yd. wide.

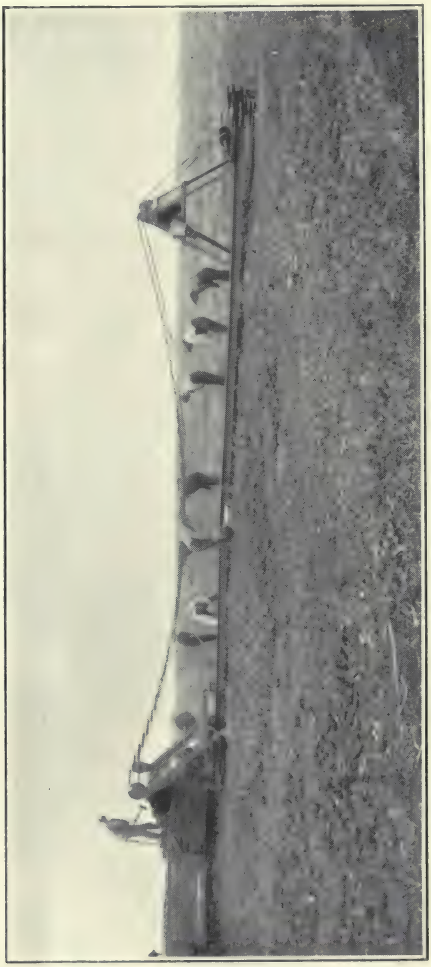


Fig. 2.—Collection of air-dried peat.
(No. 3 Harvesting plant, Alfred Bog.)

The peat is first cleared off an area " A," 40 yd. wide (Fig. 3), adjacent to the field railway already laid, the harvester filling the peat directly into waggons or else making it into a pile clear of the track. A 200-yd. length of portable track, 24-in. gauge, with rails weighing 12 lb. to 14 lb. per yard, is laid at right angles to the existing track. The harvester, moving out parallel to this track, fills the peat waggons and returns on the other side, so that strips 40 yds. wide—marked 1 to 6 in the figure—are cleared off in turn. Each length of portable track will serve for two 40-yd. strips, as shown, with a combined width of 80 yds. An area 160 yds. long by 80 yds. wide will yield 160 tons of air-dried peat, or as much as can be cleared by the harvester in one 10-hour shift.

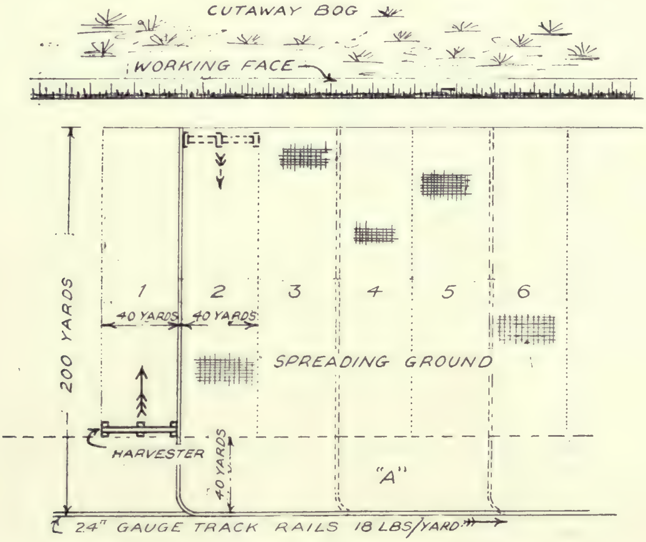


FIG. 3.

5.—THE ECONOMICAL SPREADING AND COLLECTION OF AIR-DRIED PEAT

It is clear that any large scheme of systematic peat-winning must involve the cutting of a slice of uniform section from the face under excavation, and the spreading of this in a layer of uniform thickness, not exceeding 5 in., with minimum transport. Thus, in Fig. 4 the section line XX cuts across an equal section of excavated and of spread peat.

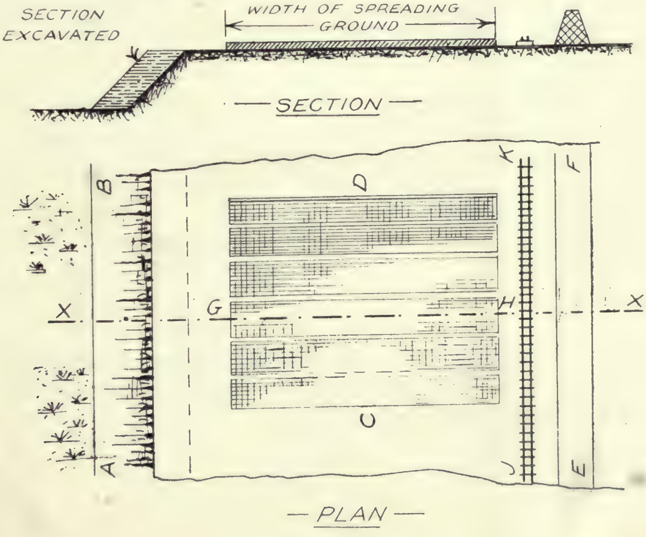


FIG. 4.

Some makers of peat machines claim that maceration causes reduction in volume or condensation of the raw peat, but there is no evidence to support such claims.

As the cross-section and hence the quantity of material excavated per linear yard of the face AB increases, so must the distance GH over which it is spread increase, and with it the cost of the conveyor and the charge under this head per ton of fuel spread.

On the other hand, all normal methods of collecting the peat fuel when dried include the collection of the fuel off the spreading-ground CD and its stacking along EF, from which it is removed along a narrow-gauge track JK. The cost of conveying the fuel when picked up to the stack along EF will increase with any increase in the width of GH, but the more fuel stacked per linear yard along EF the smaller will be the overhead charges to the fuel for this narrow-gauge line.

According to the system used, there will evidently be some width GH corresponding to minimum cost of production. There are mechanical limitations to the width over which it is possible to distribute the peat pulp, but the great area of drying-ground required for large production will suggest having this area as wide as possible, because the wider the spreading-ground, the less is the movement required in the excavating unit to produce a given quantity of fuel. Again, for a given production, the larger the slice removed from the working face of the bog, the shorter is the length of working face which must be developed, and less cutting-up and waste of bog will result.

The effective length of conveyor and width of spreading-ground as at present used with different systems is as follows :—

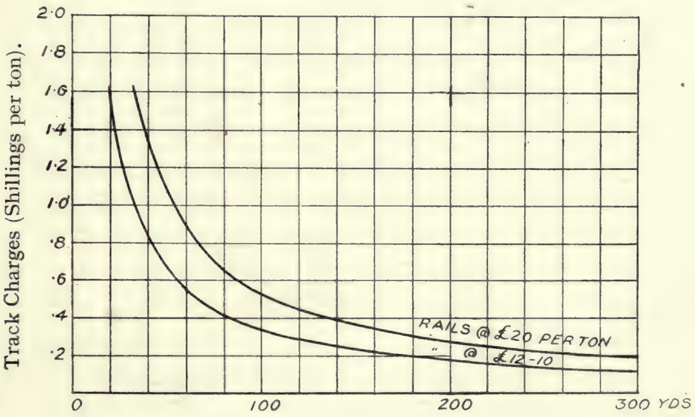
MACHINE.	EFFECTIVE LENGTH OF CONVEYOR.
Fully Automatic.	
Wielandt	42 to 52 metres.
A.H.W., Sweden (Wielandt system) ..	27 ,, 40 ,,
Strenge, large pattern	65 ,, 75 ,,
,, small pattern	35 ,, 40 ,,
Siemens Elektrische Betriebe	90 metres.
Dolberg	42 ,,
Baumann-Schenck	24 to 104 metres.
Moore, Canada, No. 2 (1920)	50 metres.
Canadian Peat Committee (1922) ..	262 ,,
Semi-Automatic.	
Korner	100 ,,
Persson's	100 to 200 metres.
Ekelund	300 ,, 400 ,,

In the following sections an attempt is made to analyse the bearing of the various factors mentioned above, on the peat-winning problem as a whole.

6.—Cost of Track for Collection and Transport

If 90 per cent. moist peat pulp is spread on the bog to an average depth, allowing for spaces, of 4½ in., and if the width of the drying-ground covered is 100 yd., then the yield per yard forward will be 1·25 tons per spreading, or if two spreadings are made on the same area, the yield will be 2·50 tons of air-dried peat containing 25 per cent. moisture. For estimate purposes, we will assume the track to be 24 in., or 60 cm., gauge throughout, the rails on the temporary roads parallel to the spreading-ground being 18 lb. per yard, and on the main roads 20 lb. to 24 lb. per yard. With rails and pressed steel sleepers at £12 10*s*. 0*d* per ton on bog, the temporary track will cost 5*s*. 4*d*. per yard, and, allowing 6½ per cent. interest and 8½ per cent. amortization, or 15 per cent. in all, the annual charges work out at 0·80 of a shilling per yard of track. Hence, if the spreading-ground is 100 yd. wide and two spreadings are made per season, the amount to be charged per ton of peat collected will be $\frac{0{\cdot}80}{2{\cdot}5} = 0{\cdot}32$ shilling or 4*d*. per ton. If the spreading ground is 50 yd. wide, the charge will be 8*d*. per ton and, for some of the short transporters used in Germany (38 yd.) and Sweden (30 yd.), the charges will be 10½*d*. and 1*s*. 1½*d*. respectively.

The curves in Fig. 5 show the variation in charges on track with increasing width of spreading-ground and for rails costing £12 10*s*. 0*d*. and £20 per ton. It will be seen that increasing the width from 30 yd. to 100 yd. reduces the cost from 1*s*. 1½*d*. to 4*d*., i.e., by 9½*d*. per ton, whereas increasing the width from 100 yd. to 200 yd. only gives a further reduction of 2*d*. per ton. If the width of the spreading ground is less than 70 yd. the charges will exceed 6*d*. per ton and, therefore, become appreciable.



Width of spreading ground.

Fig 5.

Other things being equal, little reduction in cost is to be looked for under this heading by extending the drying-ground beyond 100 yd. in width, so long as rails are procurable at £10 to £15 per ton. The charges discussed above relate solely to the cost of the temporary track laid along the back of each drying-ground and do not include charges on lines connecting to the main road or on the main road itself. At £12 10*s*. 0*d*. per ton, the portable track with 13 lb. rails will cost 3*s*. 9*d*. per yard, the temporary track with 18 lb. rails 5*s*. 4*d*. per yard, and the main road track with 22 lb. rails about 6*s*. 6*d*. per yard.

7.—Relation between Depth of Bog, Section Excavated and Width of Spreading-ground

When the peat is spread in a uniform layer of 4½ in. average thickness with a spreading-ground 100 yd. wide, the cross-section of the peat spread is 112·5 sq. ft., and if the depth of the bog is 10 ft., a layer 11 ft. 3 in. thick is removed each time. If a depth of 20 ft. is excavated, the thickness of the layer will be 5 ft. 7½ in.

With the Wielandt dredgers a width of over 5 ft. is removed, but the inventor does not consider it feasible to excavate to greater depths than 12 ft. Both the heavy and light pattern Strenge machines are designed to excavate a width of 4½ metres and 2 metres respectively with a vertical face, but as it is not possible to obtain a stable *vertical* face of over 8 ft. to 10 ft. in height, these machines need not be further considered.

The Anrep-Moore excavator in Canada and the new pattern Dolberg excavators can cut off any desired width up to 20 ft. or 30 ft. while leaving a sloping face, but here again they have not been used to greater depths than 10 ft. to 12 ft.

The Ekelund von Porat excavators, working on the bottom of the Vislanda (Hasthagen) and Vakö bogs in Sweden, take out a prism about 38 ft. wide and 10 ft. deep and spread it out on a drying-ground over 1,000 ft. wide.

The Canadian Peat Committee's 1922 plant at Alfred, Ontario, with a belt conveyor 860 ft. long, removes a prism of 300 sq. ft. to 320 sq. ft. section (9 feet deep by 33 feet wide) in slices 6 in. thick from a sloping face.

It is necessary to emphasize the fact that, with all the above methods of mechanical excavation, experience is limited to bogs with depths of 9 ft. to 16 ft., and that in no case which has come to the author's notice does he find mechanical excavation under the conditions which exist in the large bogs in the centre of Ireland, where the depth varies from 20 ft. to 40 ft., the average over large areas being 25 ft.

It has been stated that any attempt to expose a face, even at a slope of less than 45 deg. in a drained bog where the depth is over 20 ft., will result in the bottom peat flowing out, allowing the surface to settle and crack, and the peat machine to capsize. This suggests that for the bottom humified peat, even when drained, there is no " angle of repose." Whether this is the case or not, the possibility of working ladder dredgers of double the lengths at present employed can only be settled by actual experiment. To meet this difficulty the removal of the peat from a 25-ft. bog in two or three layers of from 8 ft. to 12 ft. in depth has been suggested. If this course were followed, machines as at present designed and perfected might be employed. There are, however, three serious objections to its adoption, viz. :—

(1) After the removal of the upper layer of surface peat, the surface left after excavation would be rough and uneven and would require considerable levelling to allow peat machines to work over it and to render it suitable as a spreading-ground.

(2) The surface mattress, formed by the roots and fibre of growing plants (heather, eriophorum and grasses), and partially air-dried peat on which the peat machines are supported, would be removed, and, until drainage, air-drying and natural growth had produced a new surface mattress, it would be unable to support heavy peat machines.

(3) The removal of the upper 8 ft. to 12 ft. of surface peat would include a large proportion of sphagnum peat. This would not give a dense fuel. On the other hand, by its removal the lower layers might not contain sufficient fibre to produce by themselves a good fuel, the resulting fuel being too brittle to stand handling and transport. The ideal machine peat fuel will contain a mixture of all the layers from the top to the bottom.

8.—RELATION BETWEEN LENGTH OF WORKING FACE, WIDTH OF SPREADING GROUND AND OUTPUT

Let it be assumed that during the season two spreadings of 90 per cent. moist peat are laid out on the bog surface to an average depth of 4½ in. Then, with machines having outputs of 5 tons, 7½ tons and 10 tons of air-dried peat per hour for a working season of 2,000 hours (see pp. 33–37), Table I and Fig. 6 give the length of working face in yards which must be developed with spreading-grounds 50 yd. to 250 yd. wide, the limits practically covering all Continental and Canadian practice.

TABLE I

Output of Machine. Tons, Air-dried.		Width of Spreading ground in Yards.				
Per hour.	Per season of 2,000 hours.	50	100	150	200	250
		Length of working face required (yards).				
5	10,000	8,000	4,000	2,666	2,000	1,600
7½	15,000	12,000	6,000	4,000	3,000	2,400
10	20,000	16,000	8,000	5,333	4,000	3,200

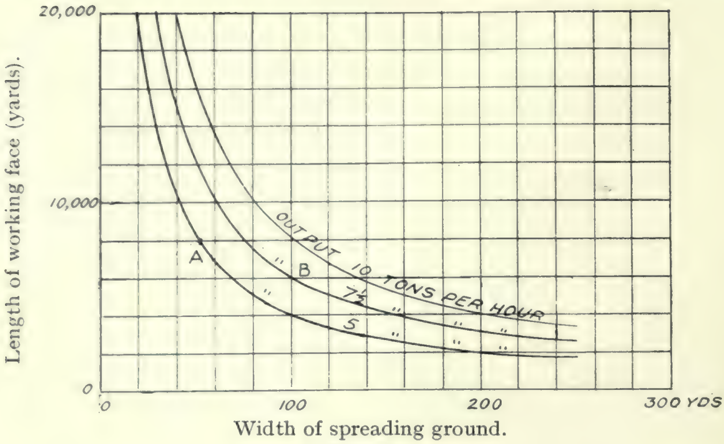


FIG. 6.

The output of the Wielandt machine and also of the Moore No. 2 plant is a little greater than 5 tons per hour, the spreading-grounds being respectively 46 yd. and 59 yd. wide. We may therefore consider the data in the above table in reference to the machine with an output of 5 tons per hour and a spreading-ground 50 yd. wide as approximating to the conditions of the two machines mentioned. For such machines a working face 8,000 yd. long (4·55 miles) must be developed over which the plant moves twice each season.

Similarly, the large Strenge machine at Wiesmoor, with an output of 10 tons per hour and a spreading-ground 77 yd. wide, would require a working face over 10,000 yd. (5·7 miles) long to lay out 20,000 tons per season. On pp. 33–37 details are given for the suggested lay-out of a large bog area, on which 120,000 tons of peat are prepared per annum, in the case of machines producing 7½ tons and 10 tons per hour, with spreading-grounds respectively 100 yd. and 250 yd. wide, the latter machine corresponding to the Canadian Peat Committee's 1922 plant.

If the drying-ground is only 50 yd. wide, 45½ miles of working face would be required for ten machines each with a seasonal output of 10,000 tons, to give a production of 100,000 tons per annum. Apart from considerations of cost, it would be difficult to develop 45½ miles of working face on any one bog area. If the machine has an output of 7½ tons per hour and a spreading-ground 100 yd. wide, seven machines requiring 24 miles of face will give a somewhat greater production. If the 1922 Canadian plant gives an output of 20,000 tons, only five such machines will be required, and with spreading-grounds 287 yd. wide, the total length of working face required will be about 8 miles. The importance of these facts will be recognized when the details for these schemes are examined.

These considerations would generally seem to involve the necessity of using a wide spreading-ground, but, owing to the number of factors involved, it is difficult to say what the optimum width should be. The economic width will vary with the particular system adopted, the size and distribution of the bog area, and the dimensions of the scheme, but for large schemes it should lie between 100 yd. and 250 yd.

9.—THE CHOICE OF POWER FOR THE OPERATION OF PEAT-WINNING PLANTS

Both steam boilers and electrical motors have been used for driving peat-winning plants. For instance, in Germany, at Elisabethfehn, Dr. Wielandt generates 3,000-volt, 3-phase, 50-cycle current at his coke-works and transmits this on copper and aluminium overhead lines supported on larch poles driven into the bog along the back of the drying-ground. A portable transformer station is used to transform the current down to 500 volts and this current is led to the peat machine by a flexible cable, the current used in a 37-k.w. motor averaging about 25 k.w. per hour. At Wiesmoor all the machines are driven by electrical motors, the high-tension current from the central station being transformed down at permanent transformer stations placed at various points on the bog. At Scharrel Brick Works the peat machines are also driven by electrical motors.

On the other hand, at Fintlandsmoor Peat Works near Ocholt, the three Strenge light pattern machines are driven by small horizontal peat-fired steam boilers, and at Heiderfeld bog in Holstein apparently all the peat-winning plants are operated by steam engines. In practically all districts in Germany where small isolated peat-winning plants are at work steam engines are employed to operate them.

In Sweden almost all peat-winning plants are operated electrically by power obtained from the hydro-electric supply, as at Svedala, Sjöholmen, Vakö and Falköping, or by power produced at their own stations, as at Vislanda and formerly at Vakö. Generally speaking, the 1,600-volt 3-phase current of the local hydro supply is transmitted along overhead lines suspended on larch poles driven into the cut-away bog adjoining the working face, current being taken to the machine on a flexible cable. In some cases the operation of the machine by 1,600-volt 3-phase current has been attended by fatalities, but in other cases such accidents have been avoided. At Vislanda, 440-volt 2-phase current generated at the Peat Powder Factory is used. As in Germany, some of the small isolated plants are operated by steam boilers.

In the earlier work carried out by the Canadian Department of Mines at Alfred bog, Ontario, 550 volt 3-phase current was used, but owing to the sale and breaking up of the station in 1916, due to war conditions, the Canadian Peat Committee, when work was resumed at Alfred in 1919, adopted steam engines for operating the plant. Each of the units operating at Alfred bog in 1920 contained an 80 h.p. Worthington water-tube boiler weighing about 11 tons, out of a total weight for the plant of 29 tons. On each of the machines there are a number of twin and single cylinder vertical steam engines for operating the plant. These boilers used 3 tons to 4 tons of air-dried peat per 10-hour shift and the provision of a water supply for the boilers occasionally gave rise to difficulty.

While the use of steam plant may be justifiable in the case of small isolated machines, there is no doubt that for the larger machines, and particularly where two or more of these machines are operated on the one area, an electrical drive will result in considerable economy and will also avoid many difficulties associated with the working of steam boilers under the conditions obtaining on the bog.

In the first place, for a steam plant, the time of one or two men is wholly occupied in providing fuel and water and looking after the boilers. Secondly, the provision of separate rails for the steam boiler, the attending to belts and the moving forward of the plant wastes an amount of time. But an even more important consideration is the effect of the additional weight of steam boilers and steam engines over that required for electrical motors on the stability of the working face and on the extra bearing surface which must be provided to distribute this weight. For instance, at the Alfred plant, at least 50 per cent. more bearing capacity has to be provided in the caterpillars for carrying the steam boilers than would be required if electrical motors were installed.

When the question of the working of bogs 20 ft. to 25 ft. deep is to be considered, instead of a depth of 9 ft., as in the case of Alfred and some of the Continental bogs, this reduction in weight, due to the substitution of electrical for steam plant, may be of almost vital importance. The additional flexibility secured by electrical operation and the advantage of concentrating the control of the whole plant in the hands of one operator, coupled with the advantages due to the reduction in weight, would alone warrant some extra cost for the electrical over the steam plant. However, the introduction of electrical drives should, in practice, have the effect of reducing the capital charges on the plants, and it should also reduce the operating costs where three plants or more are being operated.

The capital charges on the power plant and overhead lines, as well as the operating costs and loss in transmission, must be taken into account, but when allowance is made for the more efficient use of the fuel at the power station and for the distribution of the station costs over a number of plants, it is safe to conclude that considering the convenience of electrical operation, the arguments are all in its favour.

It is possible that the safety resulting from the substitution of 330 volt 3-phase current for the higher voltage used on the Continental plants would warrant the extra expense involved by the provision of motors of the lower voltage.

III.—PRODUCTION OF PEAT FUEL IN VARIOUS COUNTRIES

10.—Statistics of Production

THE figures for the output of peat fuel given in the accompanying Table II have been collected from the best sources available (see footnote). Owing to the conditions under which the peat industry is conducted, it is difficult to obtain exact figures for production, even for a single area, so that the outputs given in the table must be accepted with reserve.

(*a*) *Sweden*.—The Swedish peat deposits are estimated to cover an area of over 19,000 sq. miles, of which about 2,000 sq. miles contain peat suitable for fuel. A rather limited quantity of coal is found only in the southern parts of Sweden, occurring in thin seams containing high percentages of ash, and water power has been developed on a very large scale, so that there are now few districts which have not been reached by the hydro-electric power lines. In 1912 water power supplied 55 per cent. of the total power employed for the whole of the Swedish industries, including mining.

A very large peat litter industry has been in existence for many years, and peat fuel is also produced by both mechanical and ordinary hand-winning methods. Owing to the shortage of coal, and its high price during the war period, measures were taken to increase the output of machine peat fuel, with what result will be seen from the accompanying table. No reliable figures are in existence as to the production of hand-cut peat fuel, but Captain Wallgren, Chief Peat Engineer to the Swedish Government, considers that the output under this heading might equal in amount that tabulated for machine peat (see Table II).

It is impossible to overlook the serious decline in the output of machine peat fuel since the armistice in 1918. This is apparently due to the very high cost of living in Sweden and the correspondingly increased rate of wages paid during the war period, which raised the cost of production of peat fuel to a figure scarcely permitting it to compete with imported coal when this became available. Wages were still high during the 1921 peat-winning season, except on a few areas where drastic cuts had been made.

During 1921 the following railways were using ordinary air-dried peat fuel for locomotive firing :—

1. Västergötland–Göteborg.
2. Elmhult–Sölvesborg.
3. Kalmar–Berga.
4. Falköping–Ulricehamn–Halmstadt
5. Nässjö–Halmstadt.

Nos. 1 and 2 have factories for the production of air-dried peat, but Nos. 3, 4 and 5 buy peat in the open market. In addition the State Railways use pulverized peat over many of their lines.

(*b*) *Russia.*—It is difficult to obtain reliable figures for the consumption of peat fuel in Russia. The late Mr. A. Anrep, of Sweden, stated that in 1902 over 4,000,000 tons of peat fuel were made, but owing to the reduction in the price of crude oil, peat production diminished for some time after that date. Wallgren, in his 1913 report, estimates that 7,000,000 tons of peat fuel were made in Russia (5,000,000 tons in the seven central Governments), and that 36 out of the 37 firms making peat used their whole output in industry. Wallgren stated that the large output of peat was probably due to the " pass " system in Russia, by which no workman could travel without a pass, so that it could hardly be regarded as free labour.

Mr. A. Naumann, writing in March, 1914, from Petrograd, reports a revived interest in peat fuel, this taking second place in respect of fuel consumption. In 1909 the consumption of fuels was as follows :—

	Per cent.
Russian crude oil	44
Air-dried peat	33
Donetz coal	23

Since then the production of peat has increased owing to increasing cost of coal and crude oil.

The " American Peat Society Journal," Vol. II, 2, pp. 50–53, 1918, states that, " stimulated by the war and the consequent shortage and high price of coal, the output of peat fuel in Russia in 1918 was approximately 10,000,000 metric tons, or almost double the quantity produced in years preceding the war. Of this quantity, about 7,000,000 metric tons was manufactured in the central provinces."

(*c*) *Germany.*—Notwithstanding the long-continued efforts of the makers of peat machines in Germany, the total output of peat fuel is small. This is due, no doubt, to the low pre-war price of coal, but the efforts now being made have raised the output to 3,000,000 tons per annum, and practically all the peat fuel produced is machine-formed peat (see Appendix III).

(*d*) *Italy.*—There was an increase of 47,000 tons of peat fuel produced in Italy during 1920, compared with 1919, and this was largely due to the increased output in Venetia and Codigoro. Six peat works produce about 85,000 tons out of the total production of 147,000 tons. There are 3,000 men and 1,100 women and youths employed in the industry.

While it is difficult to collect reliable statistics of peat production, it appears that in Sweden, Holland and Denmark the production of peat fuel has fallen off since the Armistice in 1918, while during the same period the output has been increased in Germany and Italy.

11.—RECENT PRACTICE IN PEAT-WINNING IN CANADA AND ON THE CONTINENT

Detailed descriptions are given in Appendix III. of the Wielandt, Strenge, Siemens-Strenge, Dolberg, Baumann-Schenck, A.H.W. and Ekelund-von Porat machines used in Germany and Sweden, but, as pointed out, none of these machines have operated to depths greater than 4 metres. The Canadian Peat Committee's 1922 plant, which promises to achieve success under Canadian conditions, is only designed to excavate to a depth of 9 ft. However, a great advance has undeniably been made in Germany in the application of plate conveyors to the automatic distribution of the formed peat blocks on the bog up to a distance of 70 metres (75·5 yd.) from the face. A like statement applies to the new spreading system in Canada, which allows a drying area 860 ft. or 287 yd. wide. (See Appendix II).

The main difficulties to be surmounted seem to be in connexion with the excavation from deep bogs, and until machines are built which will work up to depths of 18 ft. to 20 ft., and are practically tested, it is not safe to attempt to predict the results. At present, 50 metres to 70 metres seems to be recognized as the useful limiting length of the plate conveyors used in Germany, but no doubt with further experience the methods of excavation and design of the conveyors will be improved so as to allow the length to be increased to 100 metres and the output to exceed 7½ tons per hour. If this should prove to be the case, then the grave objections which have been indicated elsewhere (p. 20) to the use of machines with short conveyors, requiring great lengths of working faces to be developed, will be considerably modified.

In Germany there are five more or less distinct designs of automatic peat machines, in which the peat is mechanically excavated and, after maceration, spread on the surface to dry. All these machines have conveyors formed of an endless chain of plates for automatically tipping the peat on the bog. The heavy pattern Siemens-Strenge used at Wiesmoor, with an output of 10 tons air-dried peat per hour, is the largest, but the system of excavation is such that it could not be applied to deeper bogs, or bogs in which the conditions were less favourable than at Wiesmoor. The transporter is 70 metres in length, and this part of the plant works most efficiently (pp. 121-2). The dredger of the light pattern Strenge excavates from a vertical face to a depth of 2 metres to 2½ metres (including the top half-metre of surface peat cut off and thrown into the trench for reclamation purposes, in accordance with the State regulations), and it is only suitable for work under favourable conditions. These machines are operated either electrically or by steam engines and, with 35-metre conveyors, have an output of 4½ tons air-dried peat per hour (p. 106).

The Wielandt machines, of which many are used in various parts of Germany, and also in Sweden, excavate from a face sloping at 60 deg. with the horizontal and to a depth of 3 metres.

With a 42-metre conveyor the output is about 5 tons per hour. The machine has some interesting features, but it is doubtful if it could be built to work to a greater depth than 4 metres, especially if the slope were reduced to 45 deg. to allow for the stability of the working face with more humified peat.

The Dolberg automatic plant has one of the best-designed plate conveyors. Although the overhead girder suspending the dredger is rather top-heavy, the machine has many novel points and, as it is a recent design, there is scope for further improvement in details. This machine can be built to excavate to depths of 5 metres and can cope with a moderate quantity of small roots or partly decayed timber. The conveyor has an effective length of 50 metres and an output of 4 tons per hour (p. 116).

The writer was unable to visit the Baumann-Schenck plant in Bavaria, but it is a business-like plant and has been considerably improved from the original designs (p. 125).

The majority of the Swedish peat-winning plants are semi-automatic, the peat being excavated by hand and cast on to an elevator. After maceration, the peat is transported to the spreading-ground on a Persson's rope conveyor and spread by hand. These machines are generally spoken of as most reliable under all conditions, and are adapted for use where it would not be possible to use other plants (p. 127).

The Ekelund-von Porat machines used at Vakö and Vislanda work on the sandy bottom of the bog, from which the peat has been removed. They require a considerable amount of power, and the system of transport and field-pressing has many disadvantages. Considering the weight and power of the machine, the output is small, amounting to not more than 120 tons to 130 tons in three 8-hour shifts (p. 137).

The new plant of the Canadian Peat Committee, with 860-ft. movable belt conveyor, which was tried for the first time at the end of the 1921 season, has an output estimated to average 10 tons per hour over the whole season (p. 93). The weight of this plant is over 120 tons and the cost, including power station, rails, cars and harvesting equipment for one unit, comes to about £20,000. The Committee estimate, on the basis of the results secured during 1922, that with a new and remodelled plant the production and other costs will be 21*s*. per metric ton of finished peat (30 per cent. moisture) loaded in railway trucks at peat works. They report, however, that night operation is perfectly feasible, and, working 20 hours per day for a 100-day season, the output will be 18,000 metric tons, and the cost in railway cars 16*s*. per ton.

Owing to fluctuations in the cost of plant, rate of exchange, rates of pay and conditions of labour, it is difficult to state the costs of producing peat fuel by many of the above systems. On the basis of the estimated cost and outputs of the various German plants visited, and taking labour at 1*s*. per hour and power at 1*d*. per kw.-hour, the cost for plant, labour and power, but excluding rent of bog, supervision and establishment charges, for excavating, macerating and spreading the peat with automatic peat machines would lie between 2*s*. and 3*s*. per ton of air-dried peat. To arrive at the total cost of air-dried peat, allowance must be made for drainage, harvesting and transport charges, in addition to those mentioned, and as these will vary with local conditions, it is impossible to give a figure which will be generally applicable.

12.—Occurrence of Timber in Bogs

The bogs in the Duchy of Oldenburg, Germany, vary in depth from 3 metres to 5 metres and timber is very rarely met with.

In Sweden the majority of the bogs contain timber in one or more layers, although there are bogs such as Rogestorps, near Falköping, which are free from it. The Alfred bog in Canada, as stated elsewhere, contains a large proportion of undecayed pine and tamarac roots, and this creates much difficulty both for the excavator element and the macerator.

With the exception of the Ekelund-von Porat excavators at Hökön and Vislanda, and, to a lesser extent, the Dolberg excavator at Heiderfeld, and the Anrep Moore excavator in Canada, none of the excavators are designed to work in a bog in which even a small proportion of undecayed timber occurs. The problem of dealing with these roots is not easy of solution. If timber is present in a large proportion, the difficulty can only be overcome by hand excavation combined with elevators, or by washing out and pumping the peat, as in the hydro-peat process (p. 143) which appears to be much used in Russia.

13.—Peat Powder

Experimental work on the production of peat powder was commenced at Bäck, in Sweden, by Lieutenant Ekelund in 1907. Owing to the good results obtained in firing locomotives on the Swedish State railways with pulverized peat, two large peat powder factories were set up during the war period at Vislanda and Vakö. The Vakö factory has been shut down since 1919, but the Vislanda factory, which is run in connexion with the State railways, is still in operation. It would appear that, notwithstanding the high efficiency with which peat powder may be burnt in a locomotive boiler, there are many difficulties in the way of its production on an economic basis. For instance, a considerable amount of power and heat are used, and a large proportion of the fibre and wood in the peat has to be rejected during the process, owing to the difficulty in fine grinding.

Definite figures showing the result obtained at either Vislanda or Vakö factories are not available, but owing to the fact that these factories were erected under the inflated prices ruling during the war, the capital expenditure has been so great as to constitute a very serious burden under post-war conditions.

IV.—EXPERIMENTS ON THE AIR-DRYING OF PEAT AT TURRAUN

14.—Work during 1920 Season

AS experience in the manufacture of machine peat in Ireland had been confined to a few unsuccessful attempts by the Department of Agriculture and Technical Instruction for Ireland, the Fuel Research Board decided to undertake some experiments to determine the effect of maceration on peat, the rate of air-drying for macerated peat, and the length of the peat-winning season possible in Ireland. Facilities were granted by the Leinster Carbonising Coy., for the carrying out of these experiments at Turraun, King's Co., and a full report on the work is given in Appendix I by Mr. E. J. Duffy, B.Sc., M.E., the research assistant in charge. The 1920 peat-winning season was wetter than the average experienced in Ireland, with the result that over large areas there was a failure to secure the ordinary supply of hand-cut domestic fuel. At Turraun, notwithstanding the bad weather conditions, the macerated peat was dried down to 25 per cent. moisture content at the end of the season, and over the major portion of the area used three separate spreadings of peat were made and dried on the same area.

Peat cut by hand and macerated peat were spread at the same time and under identical weather conditions. The machine peat dried more regularly and in less time than the cut peat. An examination of the drying curves will show that isolated wet days have little effect on the rate of drying of machine peat, and even when some rain fell on every day during certain weeks the peat still continued to lose moisture. The reasons for this are fully discussed in Mr. Duffy's report. The density of the air-dried machine peat averaged 0·942, as compared with an average of 0·5 for hand-cut peat of similar type. The volume occupied by a ton of this air-dried machine peat of 25 per cent. moisture content varies between 90 cub. ft. and 95 cub. ft., as compared with 140 cub. ft. to 160 cub. ft. in the case of hand-cut peat.

15.—Length of Peat-winning Season

Owing to the absence of severe frosts in Ireland, it is considered that peat might be spread in an average year from early in February up to the end of August, that is, during a period of almost seven months, or over 200 days. Allowing for bad weather, Sundays and holidays, this should leave a peat-winning season of 160 working days. The following table gives the peat-winning season on some bog areas in Germany and Sweden :—

	Total days, inclusive.
Germany	
Elisabethfehn.—March 25th to September 20th	179
Wiesmoor.—March 1st to July 21st	143
Other places in Oldenburg.—March 1st until July 15th	137
Fintlandsmoor.—April 15th to August 1st ...	108
Heiderfeld Moor.—May 1st to August 1st ...	92
Sweden	
Vislanda and Vakö Myr.—April 1st to August 1st	121
Sjöholmen.—April 1st to July 20th	111
Rogestorps.—April 15th to July 20th	96

The period worked at Elisabethfehn is rather unusually extended, and the peat spread towards the end of the season, while not completely dried, is sufficiently dry to be used for the manufacture of peat coke. Of course, the number of effective working days during which peat is won is considerably less than the figures given in the table.

The advantage of spreading the peat blocks with clear air-spaces between each, rather than by packing them close together, was clearly proved by the experiments at Turraun. In designing the latest form of spreader adopted by the Canadian Peat Committee this fact has been recognized, and the peat blocks are so formed that evaporation takes place from five sides of the block instead of from one side only (namely, the top). In this way drying is considerably accelerated.

30✓

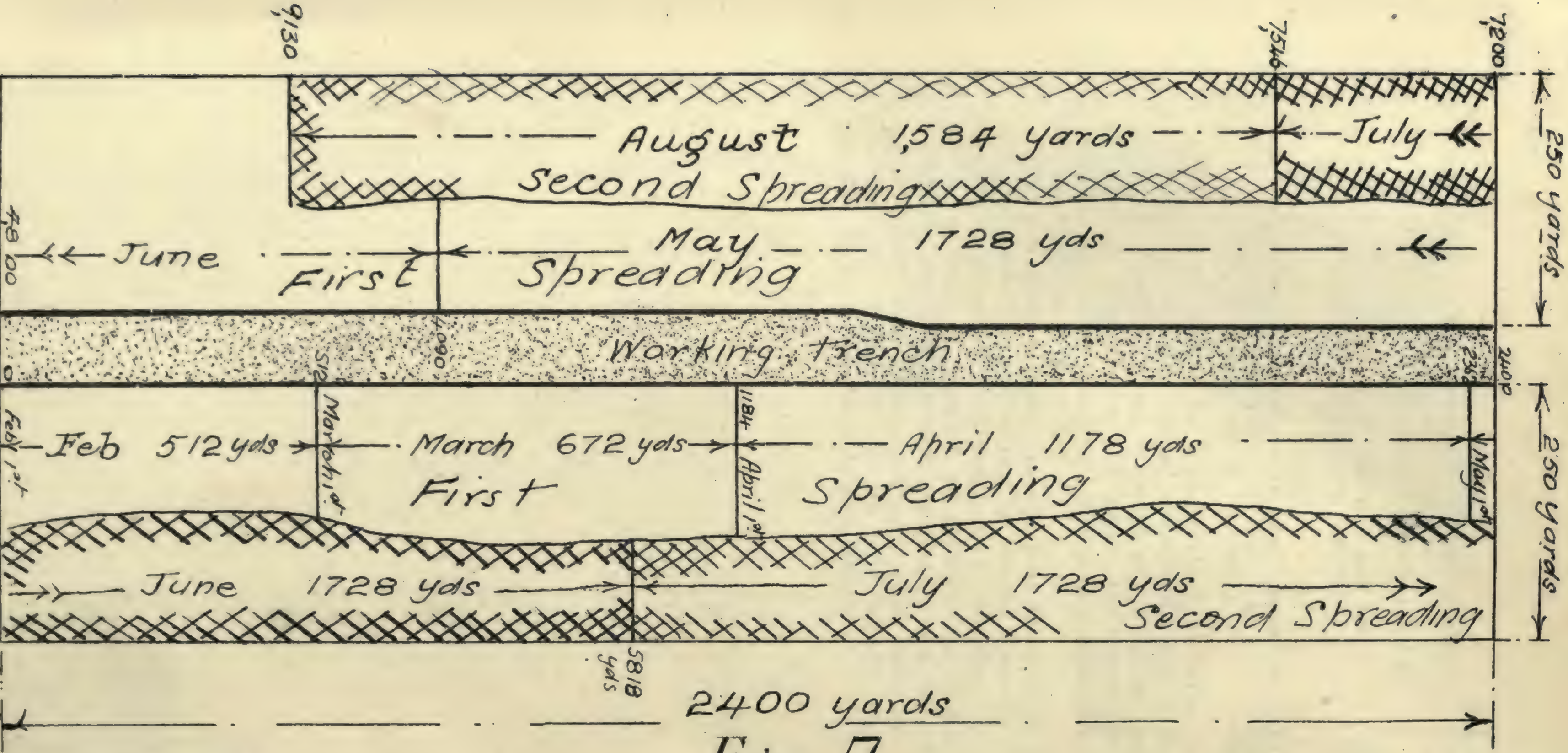


Fig. 7.

PS.36331/19444/700/1010/1000. 523.

C&R Ltd 934.

V.—CONSIDERATION OF SCHEMES FOR MECHANICALLY WINNING 100,000 TONS OF PEAT PER ANNUM

16.—Progress Schedule for Peat-winning Plants

THE *possible* length of the peat-winning season in Ireland may be taken as February 1st to August 31st, giving a net working season of about 2,850 hours, after deductions are made for Sundays, holidays and bad weather. If peat pulp is spread to an average depth of 4½ in., 80 sq. yds. covered with peat will yield 1 ton of air-dried peat per spreading. Table III gives a schedule of the number of hours worked and the output and length of working face required during each month for plant "A," having an output of 10 tons per hour and a spreading-ground 250 yd. wide.

In preparing the schedule of hours worked per month, three 8-hour shifts per day have been allowed for during the period May to August. On the German and Swedish bogs the working of three 8-hour shifts is quite common. In some cases two 10-hour shifts or two 11-hour shifts are preferred, and in Canada two 10-hour shifts are more general. When allowance is made for meal-times during three 8-hour shifts, the actual hours worked will be little in excess of that possible from two shifts of 10 working hours. In the countries mentioned a large proportion of migrant labour is employed on the bogs, the men being housed in barracks or in specially built huts. Provision is also made for men with families.

Where a colony is to be planted, and a housing scheme is involved, it will clearly be advantageous to reduce the number of persons to be settled, especially in view of the difficulty of providing alternative employment when the peat works are practically closed down from October to February or March.* For this reason it would be preferable to work two 8-hour shifts with two hours overtime on each shift, giving 20 hours actual work per day. If electric light is available, automatic peat machines may be worked at night with almost the same facility as by day.

To avoid unnecessary moving, the peat machine works up one side of a trench 2,400 yd. long, as shown in Fig. 7, and then returns on the other side of the trench. The length of 2,400 yd. for the working trench is selected so that by covering both drying-grounds twice in the season, the total length covered would be 9,600 lin. yd., or somewhat more than is possible for the plant in accordance with the schedule in Table III. Figure 7 gives the

---

* See report of the Irish Peat Inquiry Committee.

TABLE III

ESTIMATED HOURS WORKED AND PROGRESS DURING PEAT SEASON—PLANT "A"

Month.	No. of days.	Deductions.		Net working days.	No. of shifts worked.	Length of shift: hours.	Actual hours of work per day.	Total working hours per month.	Plant "A." Spreading-ground 250 yd. wide. Output 10 tons/hour.	
		Sundays and holidays.	Wet days.						Output: tons per month.	Length of working face covered (yards).
February ...	28	4	4	20	1	8	8	160	1,600	512
March	31	6	4	21	1	10	10	210	2,100	672
April	30	4	3	23	2	8	16	368	3,680	1,178
May	31	5	2	24	3	8	22½	540	5,400	1,728
June	30	4	2	24	3	8	22½	540	5,400	1,728
July	31	4	3	24	3	8	22½	540	5,400	1,728
August ...	31	6	3	22	3	8	22½	495	4,950	1,584
Total ...	212	33	21	158				2,853	28,530	9,130

detail of the progress made in spreading as per schedule. The peat machine, starting at the lower end of the right-hand drying-ground on February 1st, works along the right-hand side of the trench, covering a length of 512 yd. of drying-ground, 250 yd. wide, during February, 672 yd. in March, and 1,178 yd. in April, so that the top end of the 2,400 yd. trench is reached on May 1st. The machine then swings through 180 deg. and returns down the left side of the trench, arriving at the lower end during the second week in June, when it is again swung into position at the lower end of the right-hand ground.

The work at Turraun has proved that, even in an unfavourable year, peat spread in February and March will be air-dried and ready to clear off the drying-ground into stacks before June 1st. The plant can, therefore, move forward again and lay down a second spreading over the same area. The progress of the second spreading is shown by the cross-hatched area, and at the end of the peat season the machine has stopped some 400 yd. short of completing the second covering of the entire area. From this diagram it will be seen that, even for the extended peat season assumed, it is possible at every stage of the operations to air-dry and clear off the first spreading of the peat before the time comes for laying down the second layer. In assuming the commencement of spreading as February 1st, provision is made for the most difficult case, so that for the modified season to be presently considered it may be accepted that no difficulty will arise in clearing the drying-ground before the second spreading is laid down.

17.—OPERATION OF PLANTS "A," "B" AND "C," WITH OUTPUT OF 10 TONS, 7½ TONS AND 5 TONS PER HOUR

Although Table III gives the *possible* length of the working season as about 2,850 hours, a much shorter season will be assumed for the purpose of the diagrammatic representation of the progress of plants " A," " B " and " C," whose outputs are 10 tons, 7½ tons and 5 tons per hour on spreading-grounds 250 yd., 100 yd. and 50 yd. wide, respectively. Plant " C " corresponds roughly with the present Wielandt machine, plant " B " with the anticipated increased capacity of automatic peat machines with plate conveyors (see p. 25), and plant " A " approximates to the latest Canadian plant.

Table IV is prepared for a peat season of 2,000 hours, extending from March 1st to end of July, in which due allowance is made for lost time from all causes. This figure may be considered a very conservative estimate of the length of season possible.

According to the following schedule, the actual lengths of working face required for plants "A," " B" and " C" are 3,200 yd., 6,000 yd. and 8,000 yd., if two spreadings are made per season over the whole area (p. 19). For the purpose of our diagrams it is assumed that the work is carried out on a drained bog 20 ft.

TABLE IV

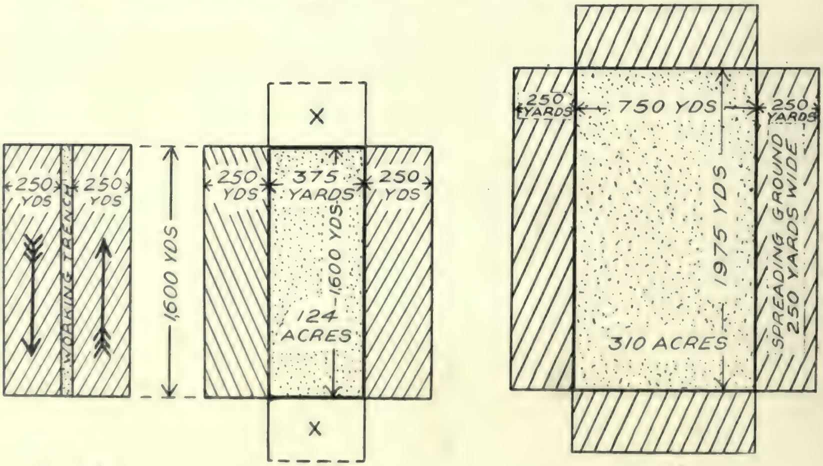
Month.	Total working hours.	Plant "A." (10 tons/hour.) Spreading-ground 250 yd. wide.		Plant "B." (7½ tons/hour.) Spreading-ground 100 yd. wide.		Plant "C." (5 tons/hour.) Spreading-ground 50 yd. wide.	
		Output: tons.	Length covered: yards.	Output: tons.	Length covered: yards.	Output: tons.	Length covered: yards.
March	200	2,000	640	1,500	1,200	1,000	1,600
April	300	3,000	960	2,250	1,800	1,500	2,400
May	500	5,000	1,600	3,750	3,000	2,500	4,000
June	500	5,000	1,600	3,750	3,000	2,500	4,000
July	500	5,000	1,600	3,750	3,000	2,500	4,000
Total	2,000	20,000	6,400	15,000	12,000	10,000	16,000

deep with an average moisture content of 90 per cent. The width of the slice removed from the working face at each cutting will be 14·06 ft. for " A," 5·62 ft. for " B," and 2·81 ft. for " C," so that with two spreadings per year the working trench will be increased in width by 56¼ ft., 22½ ft., and 11¼ ft., respectively.

Each acre of the 20 ft. bog assumed will produce about 3,225 tons of air-dried peat (25 per cent. moisture), and the area of bog cut away each season will be with plant " A," 6·20 acres; with plant " B," 4·65 acres; and with plant " C," 3·10 acres.

Plant "A."—Each Unit spreading 10 *Tons per Hour on a Spreading-ground* 250 *yds. wide*

Three stages in the operation of plant " A " are represented in Fig. 8, namely, at the end of 1 year, 20 years and 50 years.



(*a*) First Year.

(*b*) Twentieth Year.

(*c*) Fiftieth Year.

FIG. 8.

Commencing in the first year with a working trench 1,600 yd. long, two spreadings on each side will yield 20,000 tons, and at the end of the season the trench will be 18·7 yd. wide. Working in a similar manner for 20 years, the portion cut away will be 375 yd. wide, forming an area of 124 acres which may be reclaimed. Since the ends now allow 375 yd. of working face, the machine is assumed to excavate along these faces instead of moving idle over them, and the spreading-grounds " X X " are utilized. At the end of 50 years an area of 310 acres is cut away and the working face developed measures 5,450 yd., so that, if necessary, a second machine could work on this site for a great portion of the season.

A rectangular area of 6,400 yd. × 4,250 yd., containing 5,625 acres, is laid out as shown on Fig. 9, so that six machines of type " A," with 250-yd. spreading-grounds and each with an output of 10 tons per hour, may work for 50 years without the working area of one plant interfering with that of another. The annual output of these six plants would be 120,000 tons, or a 20 per cent. margin over the 100,000 tons previously mentioned. The working trench for each plant must act as the drainage trench for the area commanded by that plant, and appropriate outlets for the drainage from the trenches must be provided. For such a scheme as this it is essential that a large area of bog should be available, and that an area which has not previously been worked over, or cut up, should be selected. The lay-out of the drainage system may then be devised in relation to the whole scheme, without restrictions imposed by existing conditions.

To simplify the diagrams a strictly symmetrical lay-out is adopted, which, naturally, would have to be modified to suit the particular conditions of the area worked upon, and the drainage system is omitted. The dotted lines show the position of the temporary track for collecting the peat, which is moved every year, the full lines representing the permanent track.

After 20 years the ends of the trench are used as working faces, and the track system is altered to that shown in Fig. 9*b*, which shows the approximate position in the twenty-first year.

Fig. 9*c* shows the position in the fiftieth year, when each plant will have cut away 310 acres, and, in accordance with the original lay-out, the spreading-grounds of No. 1 and No. 2 are in contact, also the No. 2 and No. 3, and likewise for the No. 4, No. 5 and No. 6 plants. At this stage the No. 1 and No. 4 plants have each developed working faces of 5,450 yd., or a total of 10,900 lin. yd., there is, consequently, sufficient working face to accommodate the No. 1, No. 2 and No. 4 plants on the No. 1 and No. 4 areas, the No. 2 being left unoccupied, and the rail connexions are arranged as shown. In a similar manner the No. 3, No. 5 and No. 6 plants can be employed on areas No. 3 and No. 6. If this procedure be adopted, Fig. 9*c* shows the position in the eighty-fifth year, when the method of excavation must be again altered. At this stage 57 per cent. of the original area is cut away, but with a change of method the peat can be cut away till not more than 20 per cent. of the original area remains uncut.

The average length of single-line track required will be, roughly, 7,500 lin. yd. of permanent track and 25,000 lin. yd. of temporary track, the capital cost of the track work on the bog varying from £8,000 to £10,000. The total length of working face developed and worked over in the first year will be 19,200 yd. and in the fiftieth year 32,700 yd. The handling of 120,000 tons of air-dried peat over lines laid on the surface of the bog constitutes a serious undertaking in itself. Assuming the peat to be drawn off during a period of eight months, eight hours being worked per day, and in trains of 15 waggons, each containing 1½ tons of peat, the average tonnage to be moved would be 600 per day, or 75 per hour. Hence, 50 waggons would have to be tipped and despatched per hour, which means that a properly organized system of transport with time schedule must be adhered to.

Should the symmetrical lay-out adopted in the diagrams be possible in practice, no difficulty will arise in the working of the three plants on the two spreading-grounds (No. 1 and No. 4). Each plant may spread its peat according to schedule without interference with another.

Owing to the topographical conditions ruling on bog areas, however, it is unlikely that a symmetrical lay-out could be arranged for six plants similar to those under discussion, each requiring so much working area. Hence, as a rule, it will be more advantageous to space out the plants farther apart, so that operations may be continued without interference for a period of years, and then to arrange for reserve working areas to which some of the plants may be transferred and the interference discontinued. The objection to placing the plants farther apart is the increased haul on the air-dried peat at an early stage in the working of the scheme.

Plant "B."—Each Unit spreading 7½ *Tons per Hour on a Spreading-ground* 100 *yd. wide*

Fig. 10 shows eight units of this plant working at three different stages on a rectangular area 4,250 yd. wide by 6,400 yd. long. Working faces 3,000 yd. in length are laid out at 950 yd. centres, so that the eight plants work without interference until the hundredth year, when the drying-grounds of adjacent plants touch each other. With this lay-out, even in the hundredth year, the automatic peat machine has to travel idle only 750 yd. after covering a 3,000 yd. length of drying-ground. When travelling idle the machine may be speeded up and the lost time is not serious. With the plant "A" however, owing to the working trench increasing in width at two and a half times the rate for plant " B," the time lost in moving idle would become important at an earlier period. For instance, in the fiftieth year plant "A" would travel 750 yd. idle for every 1,600 yd. of drying-ground covered, unless the face exposed at the end of the working trench is utilized.

When plants have no longer the necessary width of drying-ground left, some different scheme of working must be adopted. The strips of bog left at the end of the hundred-year period are, roughly, 3,000 yd. long by 200 yd. wide, and as each of these contains about 400,000 tons of air-dried peat, they are too large to leave for the colonists to work out by hand-cutting. Four of the plants could be used for some years to spread the peat on the residual strips left, or the peat might be mechanically excavated and spread on the cut-away bog.

Plant " C."—Each Unit spreading sufficient Raw Peat to yield 5 *Tons of Air-dried Peat per Hour on a Drying-ground* 50 *yd. wide*

To obtain an output of 120,000 tons per season, as in the case of plants "A" and " B," would require 12 plants of type " C." The increased difficulty of providing on any one area the 55 miles of working face required by twelve plants of type " C " will be readily appreciated.

In conclusion, to spread a given number of tons of peat per season requires a given number of square yards of spreading area, and, at the end of the operation, when the bog is cut out, an area sufficient to carry one season's spreading must be left uncut. Hence, for a given production, the area of uncut bog left will be independent of the width of spreading-ground used, but the narrower the drying-ground, the greater will be the length and number of working faces employed, and hence, the greater the number of uncut strips left, and the more difficult the problem of their utilization. From this it is clear that it is desirable to have the spreading-ground as wide as possible. In all cases, the farther apart the working trenches are placed, the longer will it take before adjacent plants interfere with each other, and the less bog will be wasted. On the other hand, such a proceeding leads to long hauls on the air-dried product and necessitates a very large area. It is most unlikely that a plant with such a limited width of drying-ground as 50 yd. can be used in connexion with schemes involving large production, and the foregoing considerations show the difficulties which are involved even with drying-grounds 100 yd. and 250 yd. wide. A width of 100 yd. may be looked upon as a useful limit to which the present type of sod-spreader used in Germany may be developed. The 280-yd. conveyor used in Canada during the 1922 peat-winning season appears to have proved a success but the final Report of the Canadian Peat Committee is not yet available

Section of bog at Ticknevin, Co Kildare, showing percentage of water present at various points.

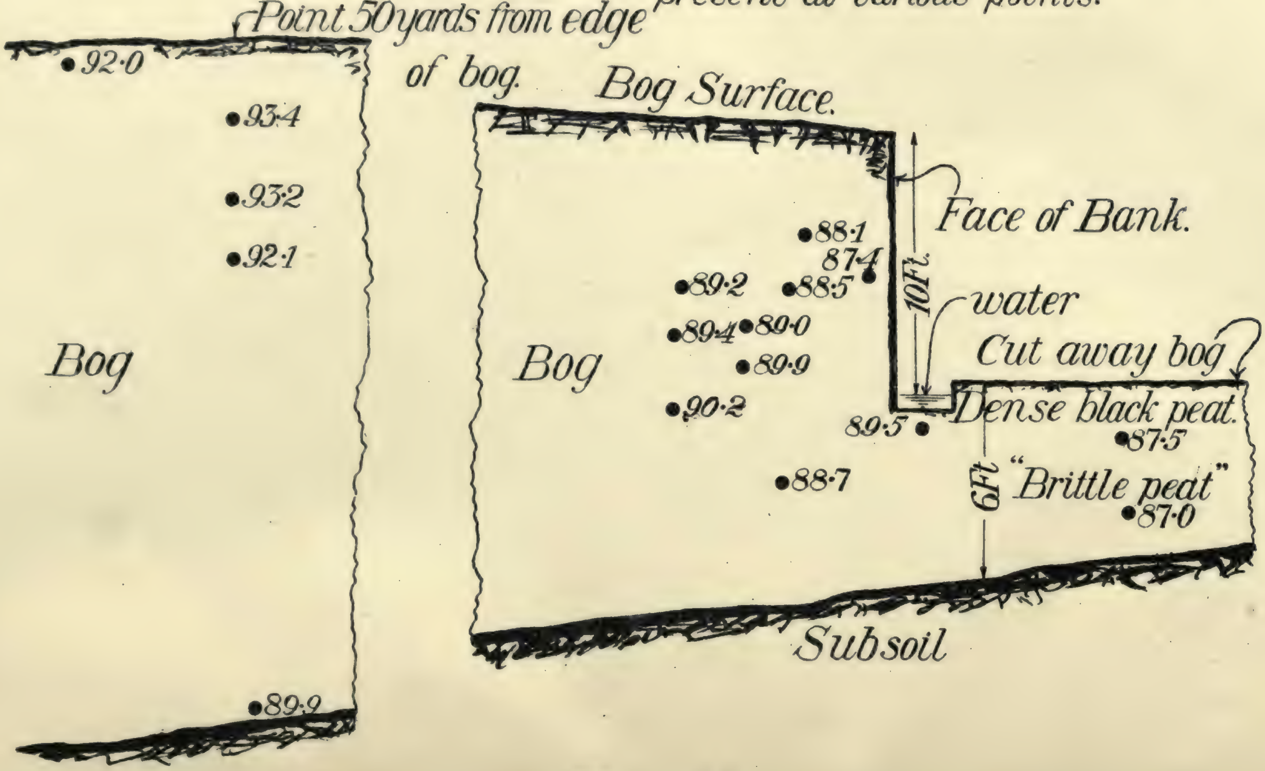


Fig. 11.

[illegible] 10444/700. 1000. 5'22.

C & R. Ltd 934.

APPENDIX I

THE AIR-DRYING OF PEAT

REPORT BY E. J. DUFFY, B.SC., M.E.

(1) *Introduction.*—In December 1917 the Irish Peat Inquiry Committee asked the Fuel Research Board for permission to carry out some experimental work in connexion with the air-drying of peat fuel. For this purpose, the Fuel Research Board in July 1918, appointed the author Research Assistant, and the work has been carried out under the direction of Professor P. F. Purcell, M.Inst.C.E., Peat Investigation Officer.

The rate at which peat can be air-dried and the limits of the working season are elements of the utmost importance in the economics of a commercial peat-winning scheme.

During the summer of 1919, observations were made on the air-drying of cut peat at Ticknevin, Co. Kildare, and continued from the autumn of that year up to October, 1920, at Turraun, King's Co. The manufacture and air-drying of machine-formed peat, of which little is known in this country, were made the subjects of investigation, facilities to carry out this work being afforded by the Leinster Carbonising Coy. on their bog at Turraun. The outstanding results of these investigations are set out in the following report.

(2) *Water Content of Raw Peat.*—The amount of solid or valuable substance in a bog is very small when compared with the quantity of water associated with it. From a large number of determinations made on raw peat taken from widely different sources, very few samples were found containing less than 87 per cent. of water. The actual water content of raw peat depends on its position in the bog and the drainage conditions which surround it. Thus, close to the outside of an exposed vertical face or " bank " of peat, the water content is usually about 88 per cent., but an inch or two of crust will, of course, be found at the face where the water content will be much lower, the crust being in many places nearly air-dried. At Ticknevin some of the bottom layers of well-humified marsh peat contained only 87 per cent. water, although situated well below the water level in an adjoining drain.

In those parts of a bog where the surface is quite firm and which may be regarded as well drained the water content varies from 88 per cent. to 91 per cent. Fig. 11 shows the percentage of water at various points in a vertical section of the drained Lullymore bog at Ticknevin.

Samples of raw peat as at present cut by farmers and others under normal conditions were usually found to contain between 88 per cent. and 90 per cent. water. The practice of removing a strip from 6 ft. to 8 ft. wide along the bank for each year's cutting allows the drainage to develop slowly from the cutting face inwards. From observations it would appear that for the conditions under which peat is cut by hand in Ireland at present, it will be safe to take the average moisture content of raw peat as 90 per cent.

At this stage it may be explained that it has been found more useful in certain cases to express water contents in terms of "water ratio" instead of the usual percentage method. The "water ratio" of any sample may be defined as the number of units of water associated with one unit of dry peat substance in the sample. Fig. 12 shows to scale the relative proportion of the water in raw peat to the anhydrous peat contained. On the one side is marked the water ratio, and on the other the corresponding percentage of water present.

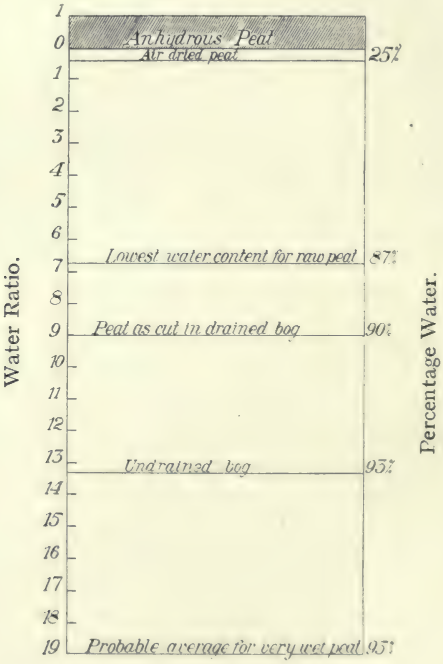
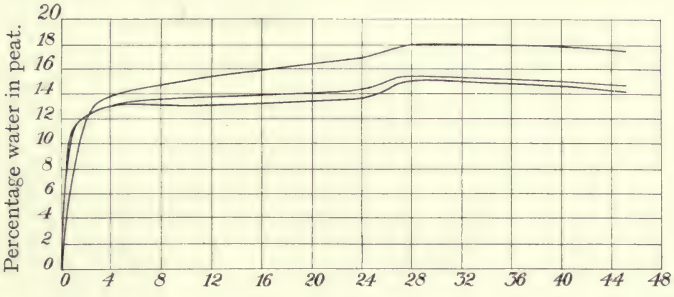


FIG. 12.

(3) *Water Content of Air-dried Peat.*—Peat reduced to an anhydrous state by total evaporation of the contained water is found to reabsorb moisture rapidly from the air until a certain condition is reached. This condition is important as it represents the practical limit of air-drying.

Several observations made on peat rendered anhydrous by evaporation at 105° C. and afterwards exposed in the open air, showed that water is reabsorbed hygroscopically until a stable condition is reached when the peat contains from 13 per cent. to 18 per cent. water. The actual amount of hygroscopic moisture in peat varies slightly with the relative humidity of the surrounding air.

Fig. 13 shows the percentage of water absorbed by anhydrous peat powder in different times. Three different kinds of peat were taken and the effect of the humidity of air is shown by the rise in the curves after 23 hours' exposure. At this stage the samples were placed immediately over a large vessel of water, being removed to a drier atmosphere eight hours later.



Time in hours.

FIG. 13.

Even under the very best conditions, the water content of air-dried peat is seldom below 20 per cent. It is only after a long period of drying that the inner parts of a peat block reach the lower limit of dryness. Under ordinary conditions in a good season, air-dried peat contains from 20 per cent. to 25 per cent. water, but it is considered sufficiently dry for use as a domestic fuel when the moisture content does not exceed 30 per cent. to 35 per cent.

A line has been drawn on Fig. 12 to show the condition of peat with 25 per cent. moisture (water ratio 0·33), and a glance will show the large quantity of water to be evaporated in producing peat fuel from raw peat.

(4) *Air-drying Cut Peat in Ireland.*—Air-dried peat, cut and spread by hand, is the principal domestic fuel in Ireland. The methods of cutting and spreading the peat have been described in the " Report of the Irish Peat Inquiry Committee " and need not be further dealt with here.

(5) *Peat Machines.*—Before giving detailed results of observations on air-drying, it will be necessary to describe briefly the construction and action of the Dolberg peat machine, which was used for these experiments. The object of the machine is to convert the raw peat (which is more or less stratified in the bog) into a pulp in which the fibres are uniformly distributed throughout the mass in all directions, and for this purpose there are two shafts rotating against each other and provided with helical blades made up in quadrants, the whole working within an oval-shaped body. The blades on one shaft pass between those on the other shaft, so that the peat, which is fed through a hopper on the top of the machine, is mixed and pushed forward to a converging neck and forming mouthpiece at the end. The

action of the screws on the peat is purely a mixing action, as there are no cutting or crushing contrivances inserted, as in other peat machines, such as the Anrep. The peat emerges from the machine in a continuous band partially divided by a knife inserted in the centre of the mouthpiece. This band is cut by hand with a knife into lengths of 15 in., after passing on to boards which move on a roller table placed under the mouthpiece. The loaded boards are taken off at the end of the roller table and the peat blocks tipped flat on the spreading ground for air-drying.

A second peat machine made by Abjorn Andersson (Sweden) proved unsuitable, as the mouthpiece supplied with this machine was not designed for forming peat blocks.

The original mouthpiece was designed for producing peat pulp only, and a second mouthpiece which was obtained was not long enough for the formation of a satisfactory block.

It may be stated that for the peat met with at Ticknevin and Turraun, which may be taken as representative of Irish peat, little maceration, in the strict sense of the word, is necessary. The mixing action of the Dolberg machine, when not fed too rapidly, was found sufficient to produce, on air-drying, a dense peat block of high quality. As the twin section (4 in. × 8 in.) of the block moulded by this machine was more suited to rapid drying under our climatic conditions than the 5 in. × 5 in. section of the Abjorn Andersson machine, the former was employed to produce the 100 tons of peat fuel required for experiments at H.M. Fuel Research Station at Greenwich.

(6) *Methods of Investigation.*—The following general method of procedure was adopted in making observations on air-drying : When peat blocks were first exposed for observation, samples of the raw peat were taken from the same place, and their water contents determined by evaporation to dryness at 105° C. to 107° C. The original weights of the blocks were determined and the weight of anhydrous substance in them calculated from the moisture contents of the samples. As drying progressed, weighings were made, usually at intervals of a day or two, and a simple calculation gave the water ratios at each stage. Curves representing the decrease in water ratio with time were plotted, until the peat reached the stage at which its weight became practically constant. The moisture content at this stage was occasionally determined as a check on the original determination.

(7) *Process of Air-drying.*—As the air-drying of peat is effected by natural evaporation of the contained water, it follows that the state of the atmosphere is the chief factor in the process. Evaporation goes on most rapidly when the air is warm and dry, and when it is in motion, so as to bring a continuous current of unsaturated air in contact with the peat. Evaporation takes place only at the surface of a peat block, the water being transferred by capillary action from the inner parts of the block to the outer fibres. Observations show that water passes from wetter to drier peat when they are in capillary continuity at a

rate which increases with the difference between the water contents of contiguous particles or fibres. As drying proceeds the water ratio becomes gradually lower from the centre to the outside surface of each block and, up to the stage when the peat is thoroughly air-dried, we find that samples taken at different points in the same block have different water ratios. The results of some determinations of water contents at different parts of partially air-dried peat blocks are shown on Fig. 14. The distribution of water depends largely on the position in which the peat block is exposed. Breast-slane peat blocks standing in a drill can only dry from the top surfaces at the commencement, and the curves in Fig. 14 (*a*) show the distribution of water in one of these blocks at two different stages. Fig. 14, curve (*b*), shows how water is distributed in the centre vertical section of a peat block placed flat on the bog for about a week. Fig. 14 (*c*) shows the actual water contents at various points in the centre cross-section of a peat block left flat on the bog for four days. This peat originally contained 88 per cent. water and had dried to an average of about 84 per cent. The curves drawn on the section should represent, approximately, lines of equal moisture content.

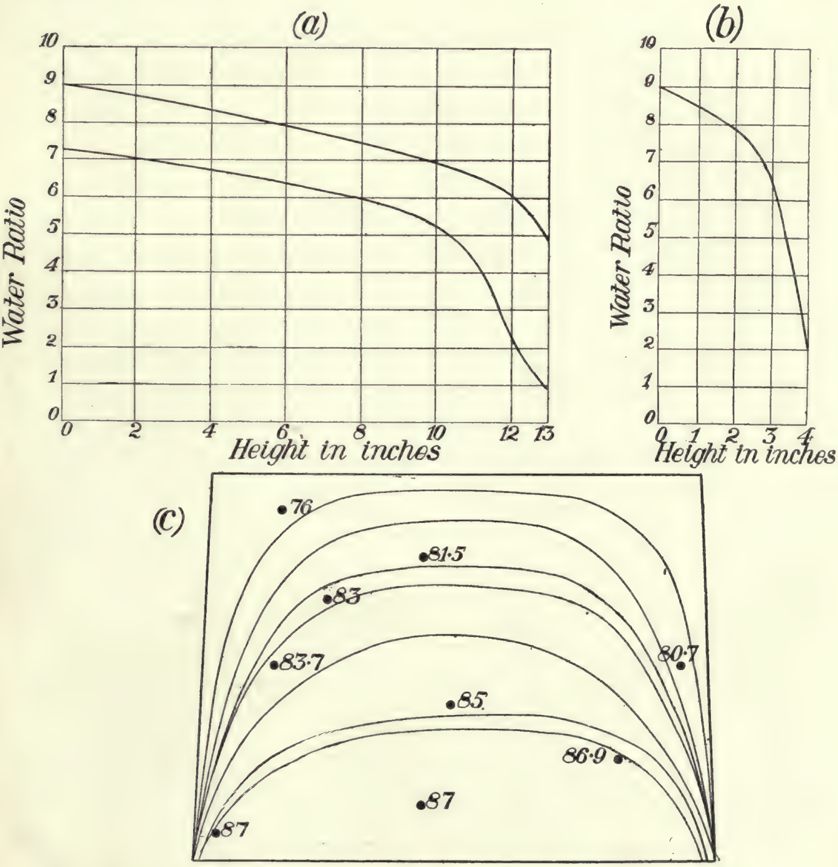


FIG. 14.

(8) *Factors which control Rate of Drying of Peat.*—The rate of drying of peat is governed by the following factors :—

(1) Weather conditions.
(2) Conditions of exposure of peat.
(3) Size and shape of peat blocks.
(4) Whether the peat has been macerated or not.

Under the heading of weather conditions we have to consider the influence of temperature, humidity, wind velocity and rain. The variety of factors operating in the process of air-drying under practical working conditions renders it difficult to fix the relationship of each to the general result, and the irregular variation of atmospheric conditions makes the problem still more complicated. Further, the change in the length of day during the different months must be considered.

It would be difficult to fix a definite relation between temperature, humidity, wind velocity and the rate of drying of peat, but a record of these has been constantly kept at the Turraun Peat Works where observations were carried out in 1920. The mean temperature and the rainfall have been plotted on some of the curves which follow.

(9) *Effects of Rain.*—The effect of rain in retarding or reversing the course of drying calls for special consideration. A study of the drying curves which have been constructed, together with the rainfall records, shows that the effect of rain depends on

(*a*) The quantity of rain which falls.
(*b*) The time during which it lasts.
(*c*) The size of the peat block.
(*d*) The quality of the peat.
(*e*) The manner in which it is exposed.
(*f*) The stage in drying which the peat has reached.
(*g*) Whether the peat is " macerated " or simply " cut."

From the many curves which follow, it will be observed that the absorption of rain decreases as the peat becomes more air-dried, but that recovery from its effects is more rapid in the case of wet peat. In summer weather, occasional rainfalls do not retard the course of drying to any considerable extent as the water, being mostly concentrated around the exposed surfaces of the blocks, is rapidly evaporated when the drying forces subsequently operate. As peat approaches the air-dried state, the effect of showers is scarcely more than superficial, as the firm surface throws off the drops. If, however, the rain continues to such an extent that the surface of the block is softened, absorption takes place so as to retard the course of drying more seriously.

Heavy rains destroy the form of very wet freshly macerated machine peat blocks, so that when drying subsequently proceeds the blocks do not separate uniformly. The finer material at the surface is washed into the trough-shaped division made between each block by the knife in the mouthpiece of the machine and this fine material, which has strong cementing properties, prevents the separation of each pair of blocks.

Slower drying results when the spaces between the blocks are not opened so as to increase the evaporating surface. If machine peat is allowed to dry for a few days so that a slight crust forms on the outside the mechanical action of rain will be greatly reduced.

On account of its dense, compact and uniform texture, machine peat when partially or fully air-dried is more impervious to rain than cut peat. The stratified nature of the latter allows water to enter along planes, and certain unhumified varieties rich in fibre and sphagnum moss absorb water readily.

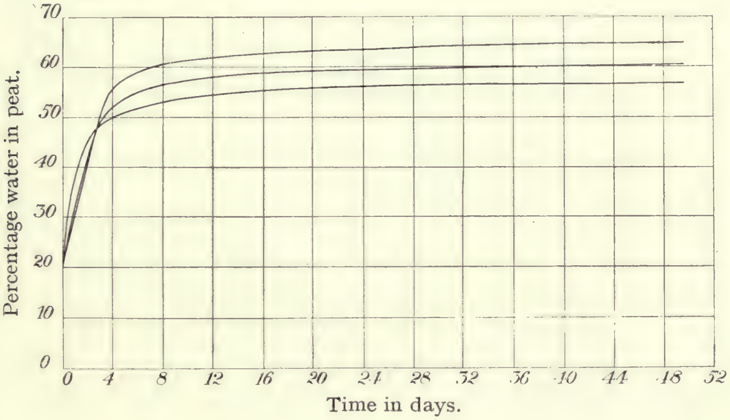


FIG. 15.

(10) *Absorption of Water by Air-dried Peat.*—Experiments were made to determine the absorption of water by air-dried peat blocks when fully immersed in a tank of water. Fig. 15 shows the percentage of water contained at different stages in peat blocks kept under water for 50 days. The blocks originally contained 20 per cent. water and by weighing at intervals the data for the curves were derived. It will be noticed that the absorption of water proceeded rapidly for the first four or five days and then continued at a diminishing rate. The following figures were calculated from the results :—

		Increase in weight per cent. per day.		
Sample.		1st 4 days.	2nd 4 days.	Last 42 days.
A	...	12·25	2·50	·405
B	...	21·00	4·75	·714
C	...	17·00	4·25	·476
D	...	15·50	2·50	·428
Mean	...	17·2	3·5	·50

The blocks increased in weight at a mean rate of a half per cent. per day for the last 42 days. Water absorption at this rate would take four years to reach 90 per cent. The rate of absorption, however, diminishes with time and the peat blocks show an increasing tendency to disintegrate. In the 50 days the moisture content had increased from 20 per cent. up to about

60 per cent. The absorbed water, which was not uniformly distributed through the blocks, seemed to enter slowly through openings and lines of weakness. It was shown (see Part II) that the moisture content of peat cannot be reduced by the application of mechanical pressure below about 68 per cent., but in one of the blocks used in the above experiment, the water content was reduced by pressure from 60 per cent. down to 41 per cent., that is, two-thirds of the water was removed. It would appear, therefore, that the absorbed water is only held mechanically in a condition quite different from that of the water originally present in the peat.

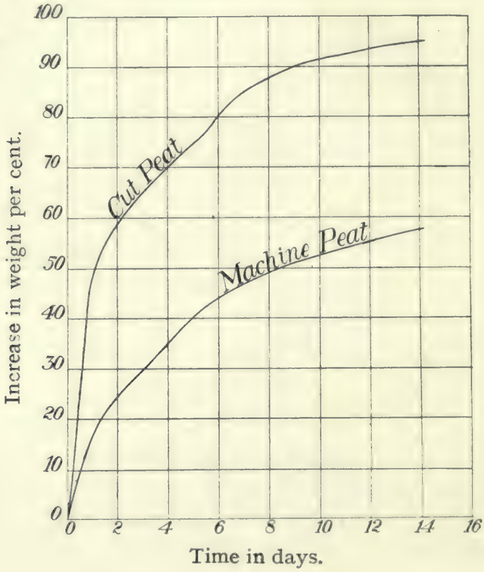


FIG. 16.

Fig. 16 shows the absorption of water by air-dried cut peat compared with machine peat. While cut peat increased in weight by 50 per cent. in one day, machine peat increased by only 17·5 per cent. in the same time. After 37 days' immersion the former had increased by 103 per cent. and the latter by 65 per cent. Assuming that the water ratio of each was 0·4 originally the results may be stated as follows :—

	Increase in water ratio.	
	After 1 day.	After 37 days.
Cut peat	0·70	1·44
Machine peat	0·245	0·91

The machine peat absorbed water more slowly than cut peat during the first day but afterwards the difference became less notable, no doubt owing to the softening of the outside crust of the machine peat block.

(11) *The Conditions of Exposure of Peat.*—The conditions under which peat is exposed have a very important influence on

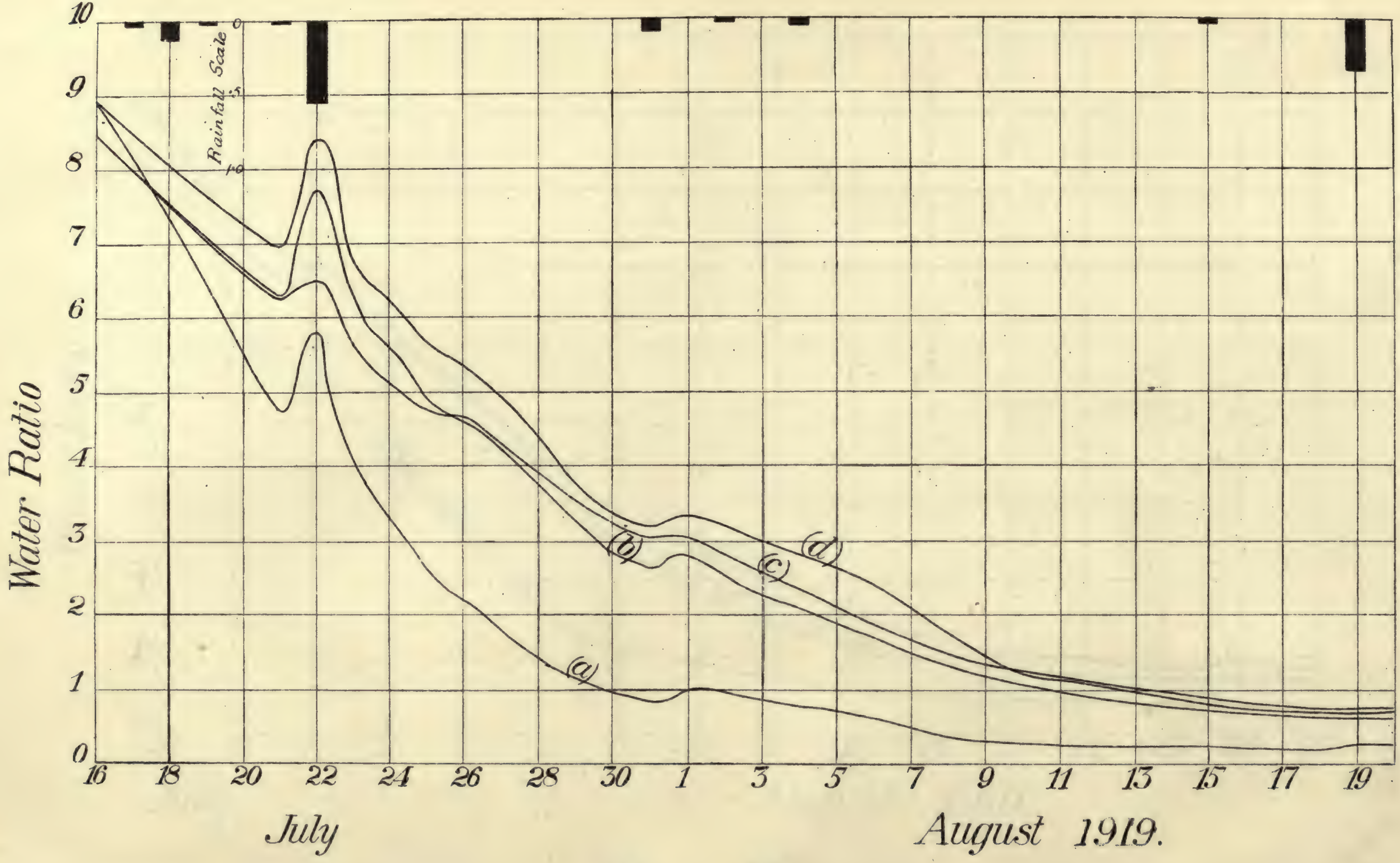


Fig. 17.

PS 26831 / 19444/700/1010. 1000.8/23.
C&R Ltd 934.

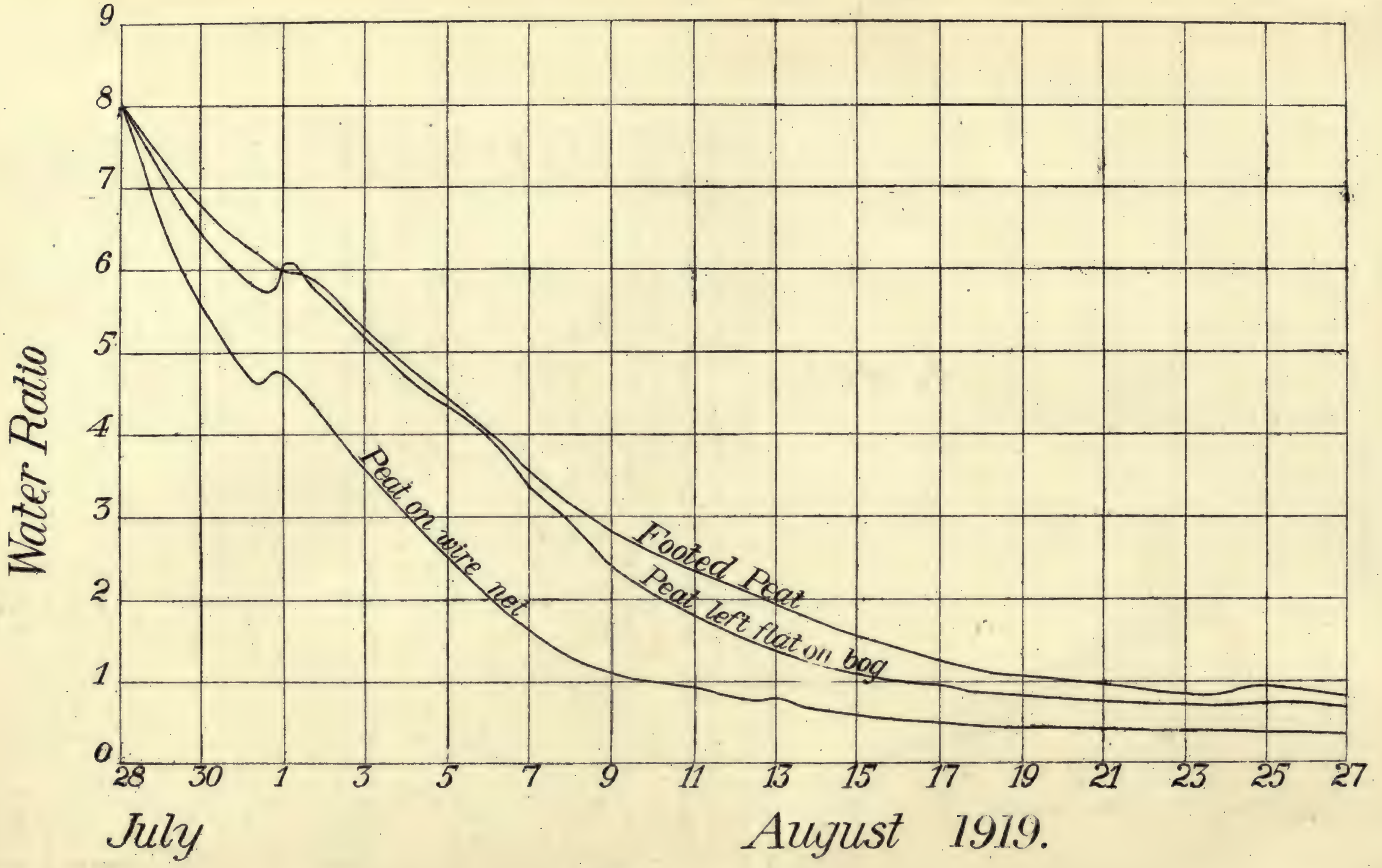


Fig. 18.

PS.36331/19444/700/1010. 1000.5/23.
C&R. Ltd 934

9h

its rate of drying. In practice, freshly cut or freshly formed peat must be left in contact with the bog surface until it reaches a condition sufficiently firm to allow it to be built into small heaps or footings. From the nature of the problem it follows that the rate at which air-drying takes place depends on the provision made for the circulation of dry air. Clearly the ideal condition would be to elevate the peat so as to bring it out of capillary continuity with the bog and out of contact with the more humid air near the surface while allowing of free evaporation from all its faces. This condition would be secured by placing the peat blocks on a wire net some distance above the bog.

(12) *Ideal Conditions for Air-drying.*—To compare the rate of drying under such ideal conditions with that obtaining under practical working conditions, the following experiments were carried out. A piece of wire netting was suspended horizontally at a height of about 2 ft. by poles fixed in the bog. Cut peat blocks were placed on the wire net out of contact with each other and similar blocks were placed flat on the bog surface and some others in a footing. In Fig. 17 the curves (*a*), (*b*) and (*c*) show, respectively, the rates of drying of peat under these different conditions. It will be seen that the peat on the wire net dried nearly twice as fast as that left flat on the bog. Two other experiments of the same kind showed that peat exposed on a wire net reached a given stage of dryness in about two-thirds the time required by peat left on the bog surface (see Fig. 18).

Experiments were made with a view to determining how far the rate of drying of peat may be accelerated by elevating it to different heights above the bog so that some indication might

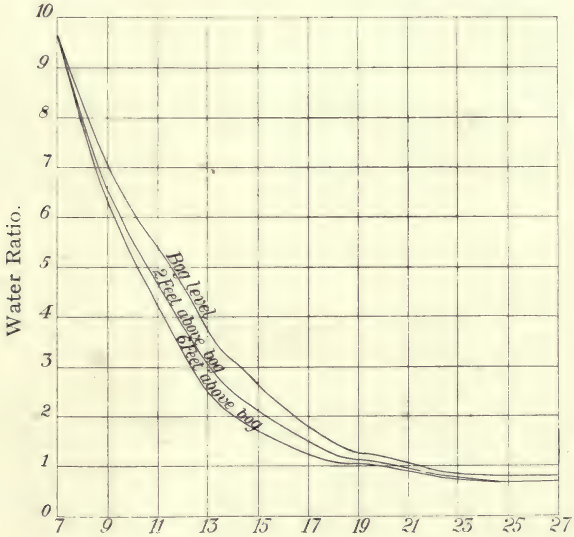


FIG. 19.

be given of the penalty incurred by drying in the humid air close to the bog compared with ideal but impracticable conditions. Similar peat blocks (both hand-moulded and cut) were placed at intervals of 1 ft. up to 6 ft. above the bog. These tests showed that there was little to be gained by raising the peat more than 2 ft. above the bog (see Fig. 19). The effect of placing peat blocks on a board or on a low trestle is as a rule to reduce the drying period by about a week in good summer weather. This difference emphasizes the importance of a dry bog surface for spreading ground as a wet surface acts as a reservoir for continuously supplying by capillary action more water to the peat blocks as air-drying progresses. Partly on this account it is found that in practice *footing* is almost an essential operation in the harvesting of peat fuel in Ireland.

It may be pointed out that the extent by which the drying period is shortened, whether by special methods of exposure or by turning and footing operations, depends on the exact weather conditions which obtain during the drying period. For example, the peat on the wire net which was referred to above (Fig. 17) had dried down to 25 per cent. water on August 11th, 1919, whereas this was never possible with the peat left flat on the bog or in footings owing to the less favourable weather conditions in the latter half of August. Thus, what might be only a matter of a few days' difference in the drying period in good weather might be much greater in wet or broken weather.

(13) *Size and Shape of Peat Block.*—A series of observations was made in order to discover how far the rate of drying of a peat block is governed by its size. Four peat blocks were made similar in shape but of different sizes and their rates of drying studied under similar conditions of exposure. The blocks were made of square cross-section, the length being two and a half times the breadth. The weights varied from 12 oz. up to 11 lb. when freshly cut. The drying curves for these blocks are shown on Fig. 20. Table I shows the time taken by the different blocks to dry down to 60 per cent. and to 33⅓ per cent. water

TABLE I

Dimensions of block.	Water ratio 1·5 (60 per cent. water) reached in	Water ratio 0·5 (33⅓ per cent. water) reached in
2 in. × 2 in. × 5 in.	6 days	10 days
3 in. × 3 in. × 7½ in.	10 ,,	16 ,,
4 in. × 4 in. × 10 in.	12 ,,	30 ,,
5 in. × 5 in. × 12½ in.	17 ,,	41 ,,

The final drying of large peat blocks is slow as the water has to pass through a greater distance before reaching the surface for evaporation.

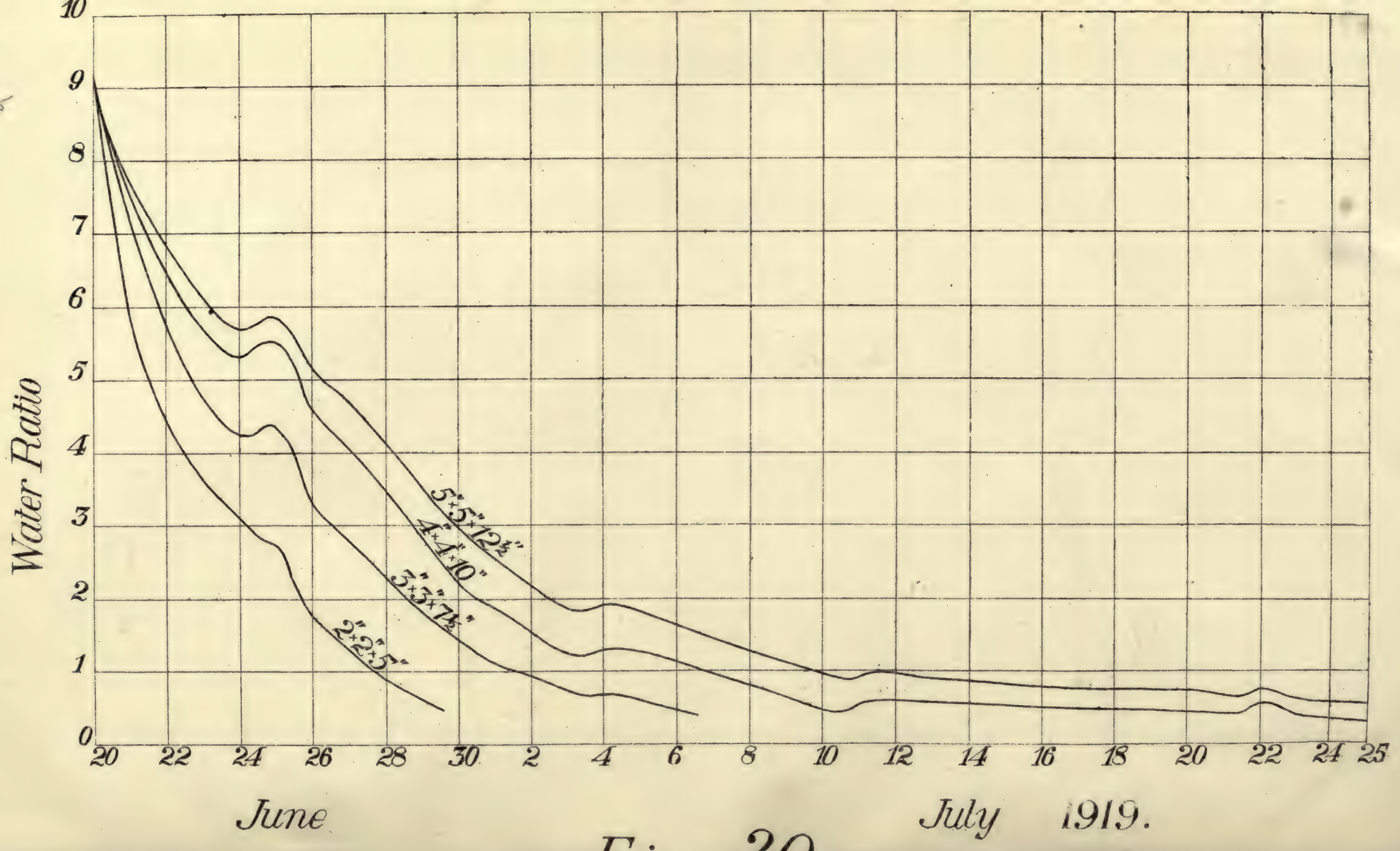


Fig. 20.

P.S. 38331. 19444 / 700/1010. 1000. 5/23.
C & R Ltd 8394.

Four blocks were moulded of equal cross-section (4 in. × 4 in.) but of different lengths and these were exposed to dry under similar conditions. As might be expected, the shortest blocks dried fastest, but for those more than 4 in. long (cube) the effect of the length was not so important. For blocks of the length used in practice, the rate of drying is practically independent of the length as the end effects are relatively less important.

It has been found that *within practical limits* the rate of drying of peat blocks is not much influenced by their shapes. Seven blocks were cut out as nearly as possible of equal volumes and of various shapes. Their rates of drying did not notably differ and did not seem to follow any definite law. In any case, for a given volume the *exposed* surface of a block will not vary much with changes in shape if the form is kept of practical dimensions.

(14) *Drying under Practical Conditions.*—Peat blocks cut according to present practice in Ireland weigh from 7 lb. to 12 lb. A study of the drying of 8-lb. peat blocks illustrated by the curves on Fig. 17 will reveal some points of interest.

Curve (c) shows the rates of drying of 11 blocks placed in a footing, and curve (b) shows the rates of drying of blocks placed flat on the bog surface. It will be seen that for the first five days there was no appreciable difference between the rates of drying of the different groups, the water ratio falling about 0·43 per day in each case. A heavy rainfall of 0·565 in. on July 22nd altered the positions of the curves. The peat left flat on the bog increased in water ratio by 1·4 and the footed peat by only 0·18. However, on the following day it will be noticed that each group had recovered from the effects of rain. After this the footing began to dry at a slower rate, so that the peat spread flat on the surface of the bog reached the 50 per cent. water stage in 25 days and the footing did not reach the same stage until 28 days had elapsed. The difference would be greater were it not for the rain which fell on July 31st, but, on the other hand, if more heavy rain had fallen the footed peat would be in a more advantageous position on account of the mutual protection which the peat blocks afforded each other.

Fig. 21 shows the rates of drying of peat blocks exposed under ordinary conditions at different times from June 18th to September 11th, 1919. The rainfall and mean temperature for each day are also plotted on the diagram up to August 26th.

The peat blocks which were used in making these observations had the advantage of being out of contact with each other from the time they were first spread. In actual practice the blocks are more often spread closely together, as for example in the case of machine peat, where the vertical sides of adjacent blocks are in contact at the beginning. Fig. 22 shows the rates of drying of an isolated hand-moulded block compared with eight cut and eight hand-moulded blocks which were placed in contiguous positions at the commencement. In the case of the latter until a certain amount of contraction had taken place no evaporation was possible from the vertical faces and hence, up to a point, the drying was slower than in the case of the isolated block. The difference, it will be noted, amounts to five or six days' drying in the case of hand-moulded peat blocks.

(15) *Drying in "Drills."*—Sometimes, as at Ticknevin, the blocks cut with a breast-slane are carefully tipped off a barrow and left standing close together with the longer sides vertical in a *drill*. Fig. 23 gives a comparison of the rate of drying of peat left in a drill with that of peat exposed under more favourable conditions. During a period of eleven days the peat in the drill had reduced in water ratio by only 1·35 (89 per cent. to 87·3 per cent. water), while in the peat left flat on the bog the water ratio had reduced by 3·35 (89 per cent. to 83 per cent. water). The latter was by no means under good conditions, being surrounded by long grass for a considerable time. The accelerating effect of footing the peat from the drills is clearly shown by the change in slope of the curve on July 30th. It is clear that estimates as to the time required for air-drying peat based on figures derived from sources where the drill system is practised are not applicable to other systems or to peat won by mechanical means.

Investigations on the rates of drying of some hand-moulded peat blocks were made at Ticknevin. These blocks were made by mixing the raw peat as thoroughly as possible and afterwards

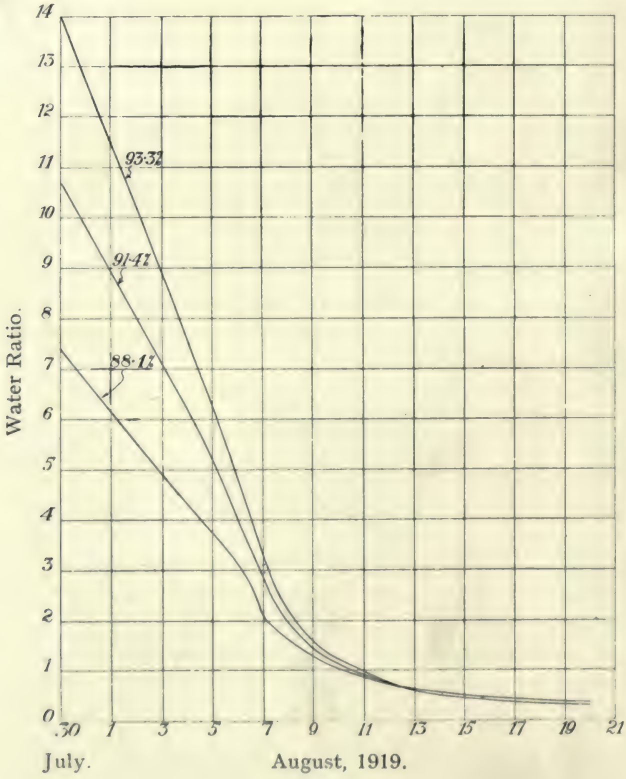


FIG. 24.

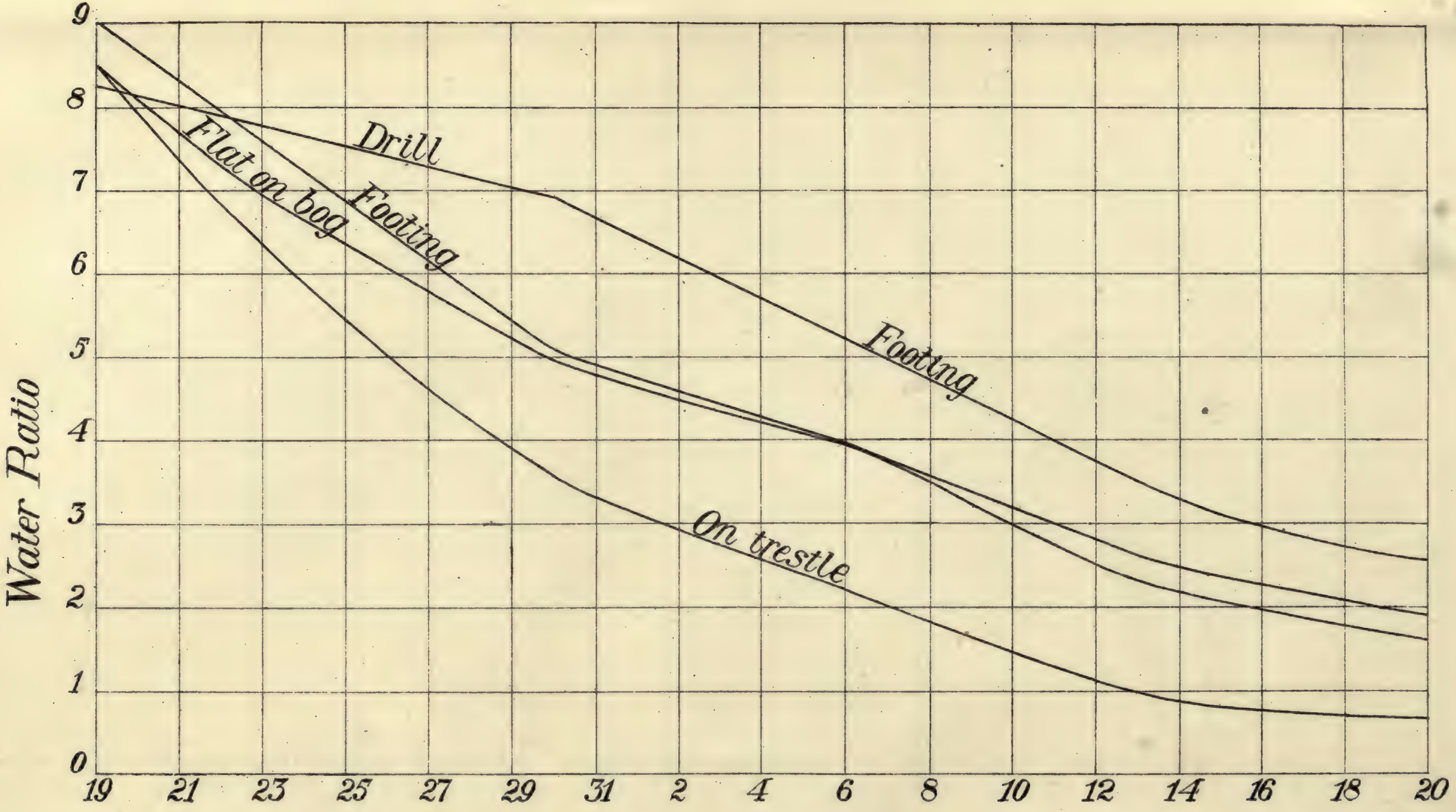


Fig. 23.

PS.36331/19444/700/1010. 1000.5'23.

C & R Ltd 934

filling the pulp into a moulding box measuring 4 in. × 4 in. × 9 in. These blocks weighed about 5¼ lb. when first formed and their rates of drying were studied as in the case of cut peat. As a rule, the hand-moulded dried much more rapidly than the cut peat.

The influence of the original water content on the time required to air-dry peat was investigated by moulding peat blocks with different proportions of water. In a certain experiment three groups of blocks containing 88·1 per cent., 91·4 per cent. and 93·3 per cent. water, respectively, were moulded and exposed to dry under similar conditions. The curves in Fig. 24 show the rates of drying of the different groups. It is remarkable that each group had become air-dried in about the same time notwithstanding the great difference in original water contents.

Peat which is moulded or formed in a very wet condition contracts more as drying proceeds and on this account loses water at a more rapid rate than peat containing less moisture originally. All these blocks when air-dried were found to have practically the same density (0·7), so that their final volumes were in the ratio 8 : 10 : 13·5. The greater contraction in the case of the wetter blocks is only in proportion to the smaller quantity of anhydrous matter they originally contained. In hardness, compactness and uniformity of texture, the air-dried blocks seemed best when produced from raw peat which was worked very wet, but experience showed that if the peat as moulded contains more than 91 per cent. water, it will not retain its shape.

(16) *Drying of Machine Peat.*—A study of the air-drying of machine peat was begun on August 26th, 1919. Spreadings were made at intervals from that date up to October 11th in the same year. The work was resumed on February 5th, 1920, and continued up to October.

1919 *Peat Season.*—Fig. 25 shows the rates of drying of machine peat during the first of these periods. The curves show that a considerable amount of drying took place during the months of September and October. It will be noticed that the first curve develops into three branches denoted (*a*), (*b*) and (*c*) after September 13th, these branches referring to peat left on a small trestle, peat footed and peat left flat on the bog surface, respectively. The footed peat dried faster than the peat left in contact with the bog and this has been observed to be of general application in the case of machine peat. Referring to curves (*b*) and (*c*), it will be noticed that the footed peat had dried from water ratio 5·0 down to 2·0 in about 18 days, while the peat lying flat on the bog required 26 days to dry the same amount. From the 19th to September 30th inclusive there were seven wet days with a total rainfall of 1·81 in. In this interval the water ratio of the footed peat had reduced 0·75 as compared with 0·2 in the case of the peat left in contact with the bog.

The effect of rain on the drying of machine peat may be observed from the plotted curves in the periods 20th to 25th

September and October 22nd to 23rd, 1919. Machine peat absorbs rain more rapidly when drying has not progressed sufficiently to form a firm crust on the outside of each block. In the case of very wet peat, freshly formed, the action of rain is principally mechanical, as explained on p. 44. It will be observed that the effects of the rain which fell in the latter half of November and subsequently is cumulative even in the case of peat nearly air-dried.

Rain, therefore, has quite a different effect in the winter months when compared with the summer or autumn. In summer weather the effect of rain is quickly neutralized by the more powerful forces of evaporation which exist at that time, the rain absorbed penetrating little beyond the surface, from which it is readily evaporated. On the other hand, in winter the drying forces of the atmosphere are able to evaporate only a small quantity of the rain which falls. Even in winter, however, a certain amount of drying takes place in peat if it is built into a large clamp or stack.

1920 *Peat Season.*—The drying of machine peat during the period from February to October, 1920, is shown by the curves on Fig. 26. It will be seen that the drying effected during the months of February, March and April was only slight. The peat, however, was spread ready to take advantage of the drying period immediately it commenced in May. The best drying periods were from the middle of May to the end of June. From early spring up to the end of summer the year 1920 was an exceptionally wet one. Table II shows the rainfall at Turraun for each of the first eight months of the year compared with the average rainfall for the same months during the five previous years.

TABLE II

	Inches of rain per month.		No. of days with over ·01 in.	
Month.	1920.	Average of 5 years.	1920.	Average of 5 years.
January ...	4·75	2·45	26	20
February ...	3·25	2·93	19	19
March ...	2·60	1·77	19	15
April ...	2·63	1·71	23	15
May ...	2·74	2·29	21	14
June ...	1·28	2·54	15	15
July ...	3·88	3·02	23	17
August ...	2·01	4·49*	17	17
Total ...	23·14	21·20	163	132

*August, 1917 = 10·62 in.

Under average conditions we should expect more drying to take place in March, April, and May than has been the case in this year. Nevertheless it is worthy of note that three spreadings of machine peat were made and air-dried on the same ground, the spreadings being made on April 29th, June 19th and July 27th, respectively.

Machine peat dries more rapidly than cut peat. On Figs. 25 and 26 curves have been plotted to show the rates of drying of cut peat blocks compared with machine peat. These curves show that the advantage was held invariably by the machine peat. This can partially be accounted for by the fact that (1) cut peat blocks are larger than machine peat blocks when first spread, and (2) machine peat contracts relatively more in drying than cut peat.

It was found that machine peat can be dried under conditions less favourable than is necessary in the case of cut peat. In the district where these experiments were carried out, farmers who were unable to cut their household turf before the end of May this year (1920) have had considerable difficulty in getting it dry before the end of the season, whereas under similar weather conditions little difficulty was experienced in drying machine peat to from 24 per cent. to 27 per cent. water. As soon as machine peat can be raised off the bog and built into small footings drying proceeds rapidly even under somewhat adverse conditions.

(17) *Harvesting Machine Peat.*—On account of the action of the macerator, machine peat when freshly formed cannot be handled. It must be left flat on the bog until it has dried down to about 75 per cent. water (water ratio 3·0), when it is built into footings of from 9 to 15 blocks each. In this position the drying of the blocks proceeds until they have reached 60 per cent. to 40 per cent. water, at which stage they are ready to be built into walls or clamps for final drying.

Except in very dry weather it is essential that machine peat be footed in order to bring it to the firm condition which must be reached before clamping takes place. If the bog is not well drained or if the season be wet certain parts of the bog surface contain a large proportion of water, so that the drying of peat with which it is in contact is greatly retarded. Under certain favourable conditions—that is to say, on a well-drained bog surface during May and June—it might be possible simply to turn over the blocks when they had dried sufficiently on the upper sides, and subsequently to build them into clamps without the operation of footing. We have found, however, that machine peat which has dried down to, say, 40 per cent. water by open exposure sometimes shows a tendency to disintegrate on account of the action of sun and rain. For this reason it is not desirable to leave machine peat too long in footings, and the best results are obtained when the final drying is brought about slowly in large clamps.

(18) *Time required to Dry Peat.*—From experience gained in observing the progress of drying this year we would say that in good summer weather machine peat may be footed in about a fortnight after spreading, and in another fortnight it may be collected and built into large clamps. In bad weather these periods might be nearly doubled. Obviously the time required

for drying will be longer in the spring and autumn than in the summer months, when the days are longer and the mean temperature higher. The early part of this year (1920) being so wet, there was little advantage in spreading peat before the end of April. It is important to note, however, that only slight damage was caused by rain and frost to peat spread at intervals from February 5th onwards. It should be stated that no heavy frosts were experienced during this season.

(19) *Effects of Winter.*—The general effect of winter conditions on machine peat was made the subject of observation during the season 1919–20. Local expansion, which is brought about by frost in the water-retaining cells of very wet peat, renders it friable when afterwards air-dried, so that the affected parts disintegrate in the form of fine dust. When peat attains a certain degree of dryness it is practically unaffected by frost. Thus the heavy frosts which occurred from the end of October to the end of November, 1919, appeared to cause very little injury to peat containing less than 70 per cent. water. Frost which occurred on October 15th and 16th of that year (2° and 3° of frost respectively) appeared to have no injurious effects; but 11° of frost on October 29th injured peat containing over 80 per cent. of water. Cut peat containing 81 per cent. water was obviously affected. Machine peat with 84 per cent. water exposed to this frost was afterwards dried down and found to lose 3·7 per cent. of its weight when brushed lightly on the surface.

In February, 1920, an examination was made of the condition of peat exposed under different conditions during the previous winter. It was found that the rain and frost had affected more or less adversely all peat openly exposed to the atmosphere. The effect was most noticeable in the case of peat blocks spread flat on the bog surface. As a general rule the drier peat was more immune from winter conditions, but even peat which was nearly air-dried in November and left flat on the bog had increased considerably in water content and had become brittle and friable in February. For example, from November 5th to February 24th the water ratio of peat blocks was found to have increased from 0·95 to 1·66. The original hard surfaces had broken up into scaly patches, which readily chipped off, and a large number of cracks or openings had developed on the exposed faces. The alternate action of rain and frost tends to disintegrate partially air-dried peat blocks. The rain washes off the particles set loose by the frost, and this process, repeating itself, breaks up a greater or lesser fraction of the peat blocks.

Peat which remained in footings during the winter suffered less damage. Machine peat was spread on October 11th and left flat on the bog until November 20th. Some of this was then built into small footings, from which a typical sample taken on February 3rd, 1920, was found to have a water ratio of 1·66, while peat spread at the same time and left flat on the bog through the winter had a water ratio of 3·90 on February 3rd.

The conditions which render partially air-dried peat immune from the effects of rain and frost would seem to be governed more by the manner in which the peat is exposed than by the degree of dryness actually attained before the frost sets in. It has been stated that even air-dried peat when openly exposed on the bog surface is injured by the alternate action of rain and frost. The rain gradually and continuously soaks through the hard surface of a machine peat block, and in addition the wet bog yields an unlimited supply of moisture. Peat blocks in footings, being fairly well protected from rain, would appear to be comparatively safe from frost as well. The surfaces of the blocks which are in contact with each other are altogether unaffected by frost, and the upper or more exposed blocks obviously suffer the most serious damage.

Certain qualities of peat are less able to resist the action of frost than others. Thus, the brittle marsh peat from the lower layers seems to be damaged more than the upper and less humified varieties ; but even under good weather conditions the former lacks cohesion and forms a brittle product when air-dried.

(20) *Length of Peat-winning Season.*—From these considerations it will be seen that in defining the limits of the peat-winning season, due regard will have to be paid to the possible occurrence of heavy frosts. During the 1920 season the frosts which occurred after work was begun on February 5th were comparatively light, so that although the season was abnormally wet, the damage caused to peat spread in February was less than would be the case if a long-continued frost had occurred while the peat was still very wet. Heavy frosts may occur during the months of February and March, and even in April. On account of the uncertainty as to whether and to what extent frosts will occur in these months, it is impossible to state definitely the time at which peat-winning operations should begin in any particular year in order to obtain the best results. As the injurious effects of frost on peat are roughly in proportion to the duration and intensity of the frost and produce serious effects only in the case of peat containing over 60 per cent. or 70 per cent. moisture, it is reasonable to expect that in an average season a beginning may be made in the spreading of peat early in February. Although peat spread at that time may not always result in quite as good a product as that spread during the months of May and June, it is of the utmost importance in a commercial scheme for peat-winning that operations should be commenced as early as possible so as to extend the working season.

It was found that in the years 1919 and 1920 machine peat spread before the beginning of September could be fairly well air-dried before the end of the season. Whether this would be true in general depends on the state of the weather during the months of September and October. Should these months prove unfavourable, peat which has been freshly spread towards, say, the end of August, will not have dried sufficiently to be clamped before winter.

The following figures have been abstracted from our results to show the rate of drying of machine peat towards the end of the season.

1919.

Date of spreading.	Water ratios at subsequent dates.					
	Sept. 6th	Sept. 16th	Sept. 27th	Sept. 30th	Oct. 27th	Nov. 4th
Aug. 26th	6·0	3·85	2·20	1·95	0·55	0·40
Sept. 4th	8·30	5·85	5·75	5·60	1·95	1·45
,, 19th	—	—	—	6·80	3·35	2·65

1920.

Date of spreading.	Water ratios at subsequent dates.					
	Sept. 6th	Sept. 16th	Sept. 27th	Sept. 30th	Oct. 2nd	Oct. 27th
Aug. 3rd	0·80	Air-dried	—	—	—	—
,, 13th	1·45	0·80	0·50	0·40	0·40	Air-dried
,, 21st	2·95	1·75	1·00	0·85	0·85	0·60
Sept. 3rd	7·20	3·90	2·00	1·85	1·85	0·61

From the above tables it will be seen that peat spread on August 3rd and 13th, 1920, had dried to less than 30 per cent. moisture by October 2nd, and that in 1919 peat spread on August 26th had dried down to less than 30 per cent. water by November 4th, and consequently might be considered satisfactorily air-dried. In 1920 the peat spread on August 21st and on September 3rd had dried down to water ratio 0·6, or a moisture content of 37·5 per cent., on October 27th, and was therefore in a condition in which it could be clamped and rendered immune from the action of frost during the winter. Peat spread on September 4th, 1919, however, had only dried to about 60 per cent. moisture on November 4th, and could hardly be considered in a fit condition to clamp.

While it is not safe to base general rules on the results of two seasons' working, from the evidence obtained in the seasons 1919 and 1920, it would appear that in the majority of seasons machine peat might be cut and spread as late as August 14th without incurring serious risk. Even adopting a conservative view of the possibilities of peat-winning, it is fairly certain that peat spread up to August 1st will be air-dried before the end of the season, and if this view is correct, peat may be won over a period of six months. From February 1st to August 1st covers a period of 181 days, which, allowing for Sundays and holidays, leaves 152 working days. Making a reasonable deduction for bad weather, the actual peat-winning season should not be less than 125 to 130 working days.

The conclusions which we have put forward above with regard to the air-drying of peat were based on observations carried out during two seasons which fairly well represent opposite extremes. The season 1919 was exceptionally dry, and that of 1920 extremely wet. The great variability in the physical character of peat, the drainage conditions on the surface, and many complex factors, must receive special consideration in any particular case. In order to fix the limits of the working season more reliably a greater amount of data obtained over a long period would be required.

(21) *Notes on the Working of Peat Machines.*—Up to the end of April, 1920, the work carried out with the peat machines was confined to periodical tests, which were not continued for more than a couple of hours on any occasion. From April 17th the work was taken in hand of producing 100 tons of air-dried machine peat for experiments at H.M. Fuel Research Station, Greenwich. Through the courtesy of the Leinster Carbonising Coy. the services of their men at Turraun were placed at our disposal, and under this arrangement the equivalent of 110 tons of 25 per cent moisture peat was spread before June 20th and well air-dried before the end of the season.

Hand methods had to be employed for excavating, feeding and spreading the peat, and owing to the lack of a mechanical excavator or dredger the bog was not worked to a depth of more than 6 ft. Three men excavated simultaneously from different levels or shelves, so that a fairly uniform mixture of the different layers was fed to the macerator. A paraffin engine supplied the necessary power.

The average moisture content of the raw peat was from 89 per cent. to 90 per cent. Measurements showed that the equivalent of 43 tons of 25 per cent. moisture peat could be spread on one acre of ground. Owing to the crude hand methods of working which were necessarily employed, it was found impossible to operate the machine at its full capacity, and the usual output was not more than 0·6 ton of 25 per cent. moisture peat per hour.

In the Dolberg machine it was noticed that hard unbroken lumps of peat taken from points near the surface of the bog occasionally found their way through the mouthpiece. Apparently this did not occur in the Andersson machine, owing to the rotating and fixed knives at the end of the macerator. The pulp from the latter was of a more uniform texture and more plastic consistency than in the case of the Dolberg ; but notwithstanding the speed of these knives and the powerful cutting action which they exert a considerable proportion of fibre (chiefly the remains of eriophorum or cotton grass) gets through untouched. As the Andersson machine was designed for the production of peat pulp which requires some special contrivance for spreading, the work with this machine was not prosecuted beyond a few trials.

Attention was paid to the effect of maceration on the different qualities of peat as found at different depths. With the bottom layers of marsh peat (locally called *tea peat,* and which, on account of the brittle product which it forms when cut with a spade or slane, is usually left behind by turf cutters) the results were unsatisfactory, as the pulp in the formed blocks lacked the necessary cohesive properties to hold together when tipped off the boards. When the upper layers (chiefly sphagnum) were worked alone the result was unsatisfactory, and the shrinkage on drying was comparatively small. Machine peat forms well and holds its shape when produced from the intermediate layers, which have been recognized as producing the better qualities of cut peat. The best results are undoubtedly obtained by mixing the different strata together in the proportions in which they are present in the bog.

The power of the paraffin engine (5·5 b.h.p.) was insufficient for working with the very dry top layers in a well-drained part of the bog, but excellent results were obtained by using raw peat with about 88 per cent. water. Experience showed that peat containing over 90 per cent. water was too soft to be formed into blocks after maceration, but on the whole the air-dried peat seemed tougher and better when worked very wet. This advantage is small, however, when compared with the greater output by having the raw peat as dry as possible.

(22) *Density of Peat.*—The density of raw peat is 1·00, as several determinations showed that the weights of equal volumes of water and of raw peat are equal within 1 per cent. The density of freshly macerated peat was also found to be 1·00, so that no condensation takes place as a result of the mixing action in the peat machines. This conclusion, formed on the results of a number of separate determinations, is contrary to the opinions expressed in Hausding's " Torfgewinnung and Torfverwertung," where it is frequently stated that the condensation produced by maceration amounts to 25 per cent. to 60 per cent.—figures which are manifestly impossible.

The density of air-dried cut peat is less than 1·00, so that the shrinkage in volume is proportionally less than the reduction in weight due to water evaporated. Several measurements were made of the density of air-dried cut peat containing from 20 per cent. to 30 per cent. water. The density of a light sphagnum peat was found to be 0·196, while a block of well-humified cut peat was found to have a density of 0·65, and no doubt denser qualities of cut peat will be found in other districts. It will be seen, therefore, that the density of cut peat varies greatly with the quality or age of the raw peat from which it was produced. The average value would be about 0·5.

The shrinkage in the case of hand-moulded peat was greater than in the case of cut peat, so that the average density of the former when air-dried was about 0·6.

The density of air-dried machine peat varied from 0·80 to 1·00. Table III gives the results of some determinations on the density of air-dried peat.

These results show that the density of machine peat is nearly double that of cut peat. From considerations of handling,

TABLE III

Kind of Peat.	Air-dried blocks.	
	Density.	Per cent. water.
A.—Cut Peat (Ticknevin, Co. Kildare).		
Light sphagnum moss	0·196	26·9
Fibrous peat	0·446	20·3
Peat of average quality taken from depth of 5 ft. to 8 ft.	0·445	—
	0·485	28·5
	0·54	30·0
	0·51	23·8
	0·46	22·0
Dense black peat..	0·65	25·0
B.—Hand-moulded Blocks (Ticknevin, Co. Kildare).		
Same as cut peat above taken from depth of 5 ft. to 8 ft.	0·57	23·0
	0·69	28·2
	0·707	29·3
	0·695	28·2
Mixture of different layers	0·53	33·3
Very fibrous peat..	0·44	20·0
	0·446	20·0
	0·58	22·0
	0·59	22·0
C.—Machine Peat (Turraun, King's Co.).		
Various blocks formed by Dolberg machine ..	0·86	33·1
	0·985	32·3
	1·00	35·9
	0·941	33·3
	1·00	24·0
	0·825	26·3
	1·02	—
	0·95	28·5
	0·87	25·6
	0·97	—

transport and storage this property of machine peat is of far-reaching importance. In addition, machine peat is practically uniform in quality, and the proportion lost in the form of fine dust through repeated handling is comparatively negligible.

(23) *Elimination of Water from Raw Peat by Mechanical Pressure.*—It was noticed that a considerable amount of water could be expelled from raw peat by subjecting it to small pressure. In a particular observation it was found that by squeezing some raw peat between the hands the water content was reduced from 91 per cent. to 89 per cent., that is, about 20 per cent. of the contained water was removed. The more important results of some experiments carried out by the author in the Engineering Laboratory, University College, Dublin, are given below. The principal difficulty in designing a suitable apparatus was to provide

a medium through which the expelled water could escape as easily and as rapidly as possible, while retaining the peat substance.

Among the factors which control the amount of water removed from peat by mechanical pressure are :—

(1) The length of time during which the pressure is applied.
(2) The rate at which the pressure is increased.
(3) The proportion of water originally present in the peat.
(4) The provision made for the escape of expelled water.
(5) The size of the sample pressed.
(6) The quality of the peat.
(7) The treatment which the peat has received before pressing.

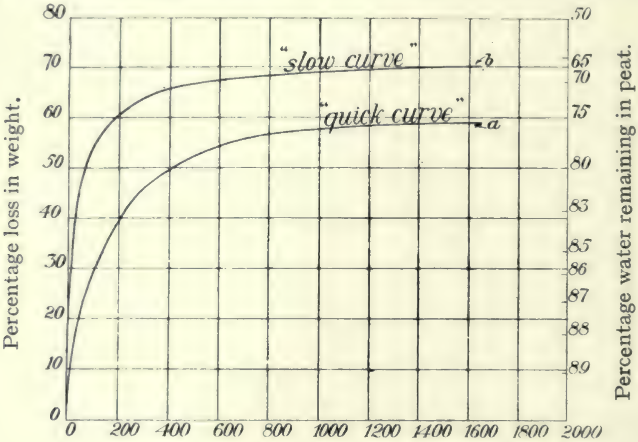


FIG. 27.

Curves (a) and (b), Fig. 27, show the effect of various pressures on small samples of raw peat containing 90 per cent. of water. In the first curve (a) the pressure was applied up to gradually increasing limits and allowed to drop off automatically as the volume of the sample was reduced, owing to loss of water. In the second case (b) the pressures were kept steady at different stages

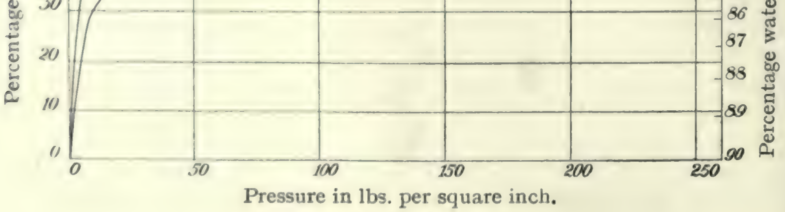


FIG. 28.

until no more water was expelled. This curve shows that the bulk of the water is removed at comparatively low pressures, and emphasizes the importance of allowing sufficient time for the water to escape.

The curves in Fig. 28 show the effect of comparatively small pressures on two different qualities of peat. It will be seen that water can be separated by pressure more readily from sphagnum peat than from the older and more humified peat.

The effect of the size of the peat sample pressed is shown by the curves in Fig. 29. Three different quantities of raw peat, weighing 1,836 grm., 942 grm. and 298 grm., respectively, were pressed under similar conditions in the same cylinder up to a maximum of 1,600 lb. per square inch and the percentage losses *in weight* were 42·2, 51·8 and 57·5, respectively.

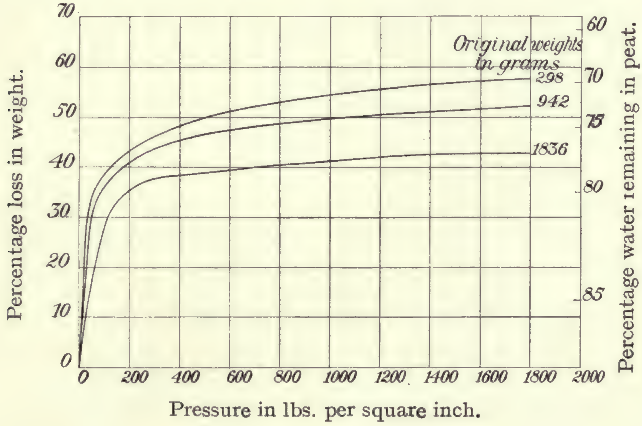


FIG. 29.

It may be assumed that it is possible to reduce the percentage moisture in peat from, say, 90 per cent. to 70 per cent. ; that is to say, to get rid of about two-thirds of the water originally contained by the application of high pressure sustained for some time. It would appear, however, that mechanical difficulties render this method unsatisfactory for removing the water even to this extent.

(24) *Proximate Analyses and Calorific Values of various Samples of Peat.*—Volatile matter was estimated by heating the anhydrous sample in a platinum crucible for seven minutes over the full flame of a Bunsen burner, screened from draughts by a cylindrical asbestos chimney. The quantity of anhydrous peat was taken in the proportion of 1 grm. per 30 c.c. capacity of platinum crucible. The loss in weight after thus heating represented the quantity of volatiles in the sample.

The residue, which contained " fixed carbon " and ash, was incinerated by heating strongly with free access of air for a considerable time. When further heating led to no further loss in weight the crucible was cooled and weighed, the final residue being ash. The " fixed carbon," being the combustible substance left after the volatiles were driven off, was obtained by difference.

The following table gives the results of proximate analyses of peat obtained from different sources :—

No.	Kind of Peat.	Calculated on anhydrous Peat.		
		Volatiles.	Fixed carbon.	Ash.
		Per cent.	Per cent.	Per cent.
1	Brown peat, Ticknevin	67·24	31·76	1·00
2	,, ,, ,, ...	59·56	—	—
3	,, ,, ,, ...	60·73	—	—
4	Black peat, Ticknevin	65·12	27·04	7·84
5	Derrybrennan (near Ticknevin), 9 in. below surface	70·14	27·82	2·04
6	Dense black peat, Umeras . .	65·47	27·38	7·15
7	Black peat, well humified, Dartmoor	65·30	32·79	1·91
8	Light fibrous peat, Denbigh Moor	70·41	28·88	0·71
9	Dense black peat, Denbigh Moor (shallow peat)	61·84	22·98	15·18

Anhydrous peat contains from 60 per cent. to 70 per cent. volatile matter and about 30 per cent. of fixed carbon, the former decreasing and the latter increasing slightly with the depth and degree of humification of the peat.

The ash content varied from practically zero up to about 7 per cent. in the samples of Irish peat examined, and, on the whole, it increased with the depth. At Ticknevin, however, the bottom layers were in many cases found to contain less ash than those immediately above, although, of course, very close to the subsoil the proportion of ash may be very high. Fig. 30 shows the ash contents of a number of samples taken at different depths in Ticknevin district. The average of these was 2·62 per cent.

Diagram showing percentage of ash found at various depths in bog at Ticknevin.

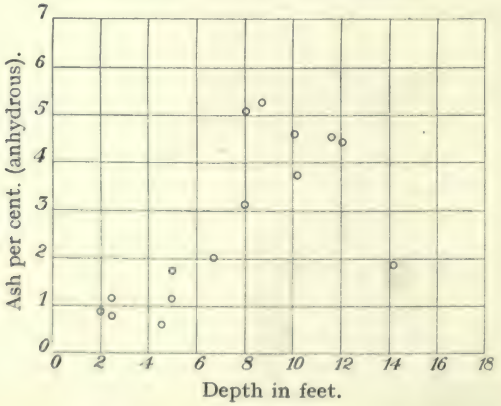


FIG. 30.

The following table gives the calorific values of a number of samples of peat. Most of these results were arrived at by experiments carried out by Miss Phyllis Ryan, M.Sc., and all were obtained by using the Mahler Donkin Bomb Calorimeter :—

Source of Peat.	Depth in feet.	Ash.	Calorific value (anhydrous).
Ticknevin—		Per cent.	B.Th.U. per lb.
Lullymore bog ..	(*a*) 2	0·89	8,917
,, ,, ..	(*b*) 2¼	0·79	8,349
,, ,, ..	(*c*) 2½	1·15	9,298
,, ,, ..	(*c*) 4½	0·56	9,508
,, ,, ..	(*b*) 5	1·74	10,241
,, ,, ..	(*a*) 5	1·14	10,113
,, ,, ..	(*c*) 6½	1·94	10,233
,, ,, ..	(*a*) 8	3·10	9,260
,, ,, ..	(*b*) 8	5·00	9,848
,, ,, ..	(*c*) 8½	5·22	9,235
,, ,, ..	(*c*) 10	3·76	10,035
,, ,, ..	(*b*) 12	4·43	9,985
,, ,, ..	(*a*) 12	4·39	9,548
Mean of Ticknevin samples ..		2·62	9,660

The letters *a*, *b* and *c* above refer to sites from which samples were taken.

The calorific value (anhydrous) in B.Th.U. per lb. of twelve samples taken from machine peat produced by mixing all the layers from the surface to a depth of 6 ft. and spread at Turraun during season 1920, were :—

10,196 ..	9,995 ..	9,914	Mean of Turraun samples .. 9,953
9,904 ..	9,666 ..	9,982	
10,493 ..	9,780 ..	10,215	
9,928 ..	9,438 ..	9,931	

Source.	Depth of sample in feet.	Ash.	Calorific value (anhydrous).
		Per cent.	B.Th.U. per lb.
Turraun bog	2	1·25	8,936
,, ,, ...	10	9·56	8,820
,, ,, ...	10	2·88	9,582
,, ,, ...	10	2·53	9,530
,, ,, ...	14	5·63	9,470
,, ,, ...	18	5·37	9,233
Mean		4·54	9,262

Source.	Depth of sample in feet.	Ash.	Calorific value (anhydrous).
Connacht bogs—samples collected by Prof. Cronshaw.			
Sample No.			
49 Laragh bog, Attymon	½	—	9,331
48 ,, ,, ,,	3	—	9,617
46 ,, ,, ,,	5½	—	9,274
45 ,, ,, ,,	7	—	9,305
24 Tiaquin ,, ,,	7½	—	9,925
95 Ballinasloe bog ..	7¾	—	10,183
33 Tysaxon bog ..	8	—	9,804
94 Ballinasloe bog ..	8¼	—	9,595
44 Laragh bog, Attymon	8½	—	9,949
70 Woodlawn bog ..	8½	—	9,378
93 Ballinasloe bog ..	9¼	—	9,729
92 ,, ,, ..	10	—	9,425
43 Laragh bog, Attymon	10	—	9,167
Mean ..	.. ..	..	9,590
Miscellaneous samples—			
Rahan, Offaly	—	—	9,487
Umeras, Kildare ..	—	—	9,471
,, ,, ..	—	—	8,913
Carrigaholt, Clare ..	—	—	10,201
Inverin, Galway ..	—	—	10,926
Glencree bog	—	1·06	9,578
Denbigh Moor, Wales ..	—	—	9,320

(25) *Note on the Drainage of Bogs.*—One of the most remarkable properties of peat is its capacity for retaining water. Peat bogs which consist of a mass of water in which less than 10 per cent. of solid matter is distributed exist not only in low-lying plains, but on the sides of mountains, the water being held so tenaciously in the cells or pores of the peat that the natural forces of gravitation are insufficient to separate out the water and bring it to lower levels. If a large block of peat be cut out

Water contents at some points in vertical section of narrow turf bank.

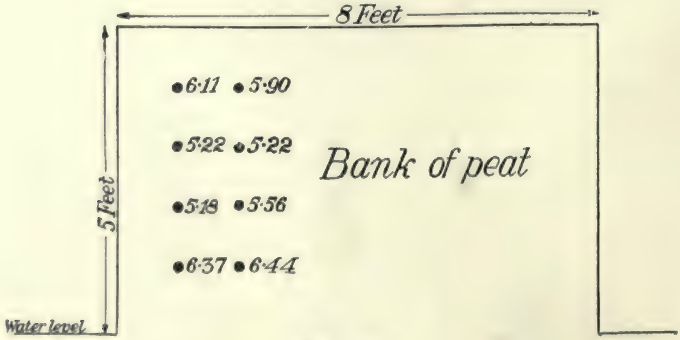


FIG. 31.

of the bog moisture will not flow from the sides, nor is water as a rule found issuing from the vertical face of an old exposed turf bank except after rain, although the bank consists of more than seven-eighths water.

The result of somewhat ideal drainage conditions is shown in Fig. 31, which gives the water contents at some points in the vertical section of a narrow peat bank which was isolated for years and was sometimes used as a roadway through the bog. The outside crust at the faces of this bank was well weathered and appeared to be in a half air-dried condition, but it will be seen, nevertheless, that within 1 ft. of the face the water content was 84 per cent. The higher percentage of water near the top surface was, no doubt, due to recent rain. The condition realized in this case is, of course, not generally possible in practice.

Experiments were made on a laboratory scale with a view to studying the laws which govern the flow of water through a peat mass, but these were mostly abortive. Peat varies so much from point to point in physical characteristics and differs so considerably in its successive strata that results of small-scale experiments were inconsistent and of little general value.

(26) (*a*) *Water Contents of Various Samples of Raw Peat*

Description of Sample.	Water.
At Ticknevin.	Per cent.
10 ft. from surface (part of old submerged dam)	89·2
11 ft. ,, ,, ,, ,, ,, ...	89·5
5 ft. from surface, 4 ft. from face of bank	88·5
5 ft. ,, ,, 4 ft. ,, ,, ...	88·3
5 ft. ,, ,, 2 ft. ,, ,, ...	87·4
5 ft. ,, ,, 2 ft. ,, ,, ...	86·4
Various points from 0 ft. to 10 ft. deep and within 6 ft. from exposed face	88·1 88·9 88·5 87·6
8 ft. deep (full of small twigs)	87·3
11½ ft. ,, (" stone turf ")	88·7
13 ft. ,, (" brittle turf ")	87·1
Piece of timber from peat 8 ft. deep	89·6
Raw peat as cut for fuel	91·7
,, ,, ,, ...	90·1
,, ,, ,, ...	89·0
,, ,, ,, ...	89·4
,, ,, ,, ...	89·9
,, ,, ,, ...	89·5
,, ,, ,, ...	89·1
,, ,, ,, ...	88·5
,, ,, ,, ...	89·4
,, ,, ,, ...	90·7
,, ,, ,, ...	89·4
,, ,, ,, ...	88·5

(26) (*a*) *Water Contents of Various Samples of Raw Peat*—cont.

Description of Sample.	Water.
At Turraun.	
Macerated peat (layers mixed)	89·7
,, ,, 2 ft. from surface	88·2
,, ,, various depths	88·5
,, ,, ,, ,, ...	89·5
,, ,, ,, ,, ...	90·1
Macerated peat	89·1
,, ,, ...	88·1
,, ,, ...	89·0
,, ,, ...	90·4
,, ,, ...	89·1
Cut peat	88·5
,, ,, ...	89·0
Taken 9 in. from surface in undrained bog	92·0
,, 9 in. ,, ,, ,, ...	92·0
Sample taken 50 yd. from drained face, 3 ft. deep	93·4
,, 50 yd. ,, ,, 6 ft. ,, ...	93·2
,, 50 yd. ,, ,, 8 ft. ,, ...	92·1
,, 50 yd. ,, ,, 25 ft. ,, ...	89·9

(26) (*b*) *Water Contents of Air-dried Peat Blocks*

Description of Sample.	Water.
	Per cent.
Samples of air-dried cut peat taken at Ticknevin, 1919	25·5
,, ,, ,, ,, ,, ,, ...	24·8
,, ,, ,, ,, ,, ,, ...	33·5
,, ,, ,, ,, ,, ,, ...	24·0
,, ,, ,, ,, ,, ,, ...	26·8
Peat used for domestic heating at Turraun (February, 1920) ..	35·6
,, ,, ,, ,, ,, ..	35·0
,, ,, ,, ,, ,, ..	34·6
,, ,, ,, ,, ,, ..	29·7
,, ,, ,, ,, (exposed to rain) ..	46·6
Machine peat filled into bags (October 21st, 1920)	25·5
,, ,, ,, ,, ,, ...	33·3
,, ,, ,, ,, ,, ...	24·0
,, ,, ,, ,, ,, ...	25·8
,, ,, ,, ,, ,, ...	24·3
,, ,, ,, ,, ,, ...	26·7
,, ,, ,, ,, ,, ...	25·9
,, ,, ,, ,, ,, ...	25·9
Machine peat in clamp (August 10th, 1920)	22·7
,, ,, ,, ,, ...	24·0
,, ,, ,, ,, ...	26·8
,, ,, (October 21st, 1920)	25·7
,, ,, ,, ,, ...	26·1

APPENDIX II*

PEAT-WINNING EXPERIMENTS OF THE CANADIAN PEAT COMMITTEE, 1918–1921

Canadian Department of Mines : Mines Branch. The interest of the Canadian Department of Mines in peat dates from 1907, when Mr. Nystrom visited Europe and the Department published a report by him on the then position of the peat industry. From 1908 onwards a systematic survey of the Canadian bogs was undertaken, and from time to time reports, with maps, were issued, giving the depth, character and fuel content of the different bogs.

Experiments on the manufacture of machine peat fuel were undertaken in 1908 at the Victoria Road bog, near Peterboro', Ontario, in continuation of work done by Mr. E. V. Moore, the object being the production of sufficient peat for experiments with a Köerting producer. This work was continued at Alfred bog in 1910, and in the spring of 1913 an overhead telpher system designed by Moore was employed.

Subsequently reports were issued dealing with the peat industry in Canada and other countries, the most valuable being "Peat, Lignite and Coal," by B. F. Haanel, B.Sc. Valuable reports on experiments with peat fuel in gas producers (1911) and in locomotive and water-tube boilers (1917) were also issued. The work of the Canadian Department of Mines on peat was suspended during the war until 1918, when it was resumed, and is being continued during 1922.

Work of the Peat Committee.—Owing to the shortage of coal supplies in Canada in the winter of 1917–18, and particularly in the Province of Ontario, which is almost entirely dependent on the United States for its coal supply, the question of utilizing the large fuel reserves in the peat deposits of Ontario and Quebec assumed considerable importance.

The Federal Government and the Government of the Province of Ontario agreed to co-operate and, by Order in Council of April 24th, 1918, a Peat Committee with representatives of the Federal and Provincial Governments was set up to investigate the possibility of manufacturing peat fuel on a commercial scale. Mr. B. F. Haanel, B.Sc., Chief Engineer of the Fuel Testing Division, Department of Mines, Ottawa, and whose work and writings on peat are widely known, acted as Secretary and

---

* This Appendix is the digest of a Report made to the Fuel Research Board in October 1920 on a visit paid in July and August 1920 to Alfred Bog, Ontario, on which the Canadian Peat Committee were conducting mechanical peat-winning experiments. The Report is supplemented by information received subsequently on the work carried out by the Committee during the 1921 and 1922 peat seasons.

member of the Committee, and Mr. E. V. Moore, B.Sc., A.M.E.I.C., was appointed Engineer to the Committee.

Mr. Moore has been working on peat development for the past fifteen years and has had very considerable experience in the application of mechanical plant to the excavation, spreading, harvesting, drying and briquetting of peat, and one of the main objects of the Committee was to test plant No. 2, which had been designed and developed by Mr. Moore.

The Peat Committee has reported on its work during the period 1918 to 1920, and a report is being prepared on the work during 1921 and 1922 and will soon be published. The work of the Committee was continued during the 1921 and 1922 seasons by the Federal and Provincial Governments.

Owing to post-war conditions it was late in the spring of 1919 before the necessary plants were assembled. Much initial work had to be done before the No. 2 plant had developed a cutting face or ditch from which it could work efficiently, and during this period many changes had to be made in the plant, which was of a novel character. Indeed, it was only in May, 1920, that Worthington water-tube boilers, properly designed and proportioned for the consumption of peat fuel, could be obtained and installed. While a little work was done with the No. 2 plant in 1919, and some alterations made as a result during the winter of 1919, it was not in proper working order until May 14th, 1920.

Alfred Peat Bog.—The Alfred peat bog, on which the work of the Committee is being carried out, lies south of the Ottawa River, the short line of the C.P.R. between Montreal and Ottawa passing through the bog and alongside the peat works. Alfred station is 41·5 miles from Ottawa and 69·7 miles from Montreal, and the peat works are about 1 mile east of the station.

The bog has an area of 6,800 acres and the depth varies from 3 ft. to 18 ft., the estimated fuel content of the bog being 7,000,000 tons. About 200 acres of the bog, from 7 ft. to 10 ft. in depth, are leased to the Peat Committee for the purposes of the experiment.

Certain areas of the bog surface are covered with about 12 in. to 15 in. of loose moss, through which small pine and tamarac trees protrude. Over the drying area all trees have been cut away, but the stumps have not been removed. In places it is covered with blueberry and cranberry bushes.

The surface of the bog is, generally speaking, level, although rough and uneven. Frequent fires have burnt holes and left depressions, so that the surface can in no way be considered favourable to the mechanical spreading of peat. The general tendency of the passage of the three caterpillar tractors and the spreader of the No. 2 plant over the bog is to level and consolidate the surface. The spreader presses down the blueberry bush and the heavy covering of raw peat holds it down, so that it acts as a drainer, isolating the peat to a certain extent from the wet surface of the bog.

There are few cross drains in the new peat area, but in the drying-ground of the No. 1 plant frequent cross drains were cut some years ago, and as a result of this the ground is drier.

The surface of the bog appeared to be wetter early in July, 1920, than would be the case in a *drained* Irish bog at that period of the season, although there was an entire absence of those pools of water and soft patches characteristic of Irish bogs. On August 16th, when a second visit was paid to the bog, the surface was very wet, due to the fact that during the previous week (August 13th) 1·6 in. of rain had fallen in one hour, 2·0 in. being recorded in four hours.

In selecting Alfred bog for their experiments, the Peat Committee did not wish to pick the best-drained bog nor the best peat, so that if their plant was designed for moderate conditions and proved successful, it could then be recommended for use generally. The bog at Alfred contains a large proportion of tamarac, pine and other roots, varying from 4 in. to 9 in. in diameter, and also some stumps. These roots are practically undecayed, and being tough and fibrous, they render the process of excavation and maceration an extremely difficult one. They also give trouble with the excavator chain and buckets, besides stopping the macerator. Even the small roots require considerable power for their disintegration. The difficulties from these causes have been greatly reduced by overhauling the macerator and providing a stronger dredge chain and knives. It may be stated that there are grounds for believing that, although large logs are met with near the margins of Irish bogs, there does not appear to be the same succession of roots as at Alfred, and that in many cases where timber does occur, it is so much decomposed as to be readily dealt with by the excavator and macerator.

The peat in the bog has a less humified appearance than Irish peat, and the pulp, after efficient maceration, seems coarser in texture. The percentage of ash is about 6, and the calorific value 8,900 B.Th.U. per lb. anhydrous. (For average conditions in Irish bogs, ash may be taken as 4·0 per cent. and calorific value 9,700 B.Th.U.)

The air-dried peat is very brittle and there seems to be a great lack of the finer fibre and dark gelatinous matter which binds the better qualities of Irish peat so well. The brittle and friable character of the peat, when reduced below 30 per cent. moisture, is also no doubt increased by the very rapid drying of the surface of the blocks, which occurs in Canada on days when the temperature is as high as 90° and the humidity as low as 20 per cent. With machine peat, owing to the increased shrinkage compared with cut peat, to get the best results it is undesirable to dry it too rapidly, as otherwise a dry exterior coating is produced, which shrinks and cracks over the wetter and less shrunk core.

Some of the conditions at Alfred bog compare unfavourably with those obtaining on Irish bogs, particularly in respect of the quality of the peat and the quantity of undecomposed roots encountered.

Rate of Air-drying Peat under Canadian Conditions and Length of the Peat-winning Season—In Canada, with a temperature of 30° F. below zero, the bogs are frozen solid to a depth of 1 ft. to 2 ft. every winter, and until the peat is thawed no work can be undertaken. The winter of 1919–20 was unusually severe, and the peat did not thaw until late in May, and even in June large lumps of frozen peat were excavated. Again, peat spread in 1919 after August 20th could not be dried before the frost set in, and was a total loss. It may therefore be taken that the peat-winning (excavating) season in Canada will not, as a rule, exceed three months, and that four months is an outside figure. It appeared to be agreed that work is impossible before May 1st. Taking account of holidays and broken weather, it would not be safe to assume a peat-winning season of more than 95 working days. The usual length of shift worked in Canada at present is 10 hours.

The meteorological observations at Alfred, and a detailed study of the rate of drying peat, are in charge of Mr. H. A. Leverin, of the Department of Mines, but the results are not published so far. At certain times the rate of drying must be quicker in Canada than in Ireland. For instance, when the temperature rises from 75° in the morning to 90° or 93° F. in the shade by 2 p.m., and the relative humidity drops from 40 per cent. at 10 a.m. to an average of 25 per cent. for six hours during the middle of the day, the rate of drying must necessarily greatly exceed that in Ireland. Under such exceptional conditions, if no rain falls, it may be possible to dry to 30 per cent. moisture in 14 days, but on the average at least 28 days will be required for drying without footing to 30 per cent. moisture.

System of Air-drying.—After the peat has been spread flat on the bog surface and cut into separate blocks, it is left for seven or eight days, when it is turned and left flat until completely air-dried. Previous to the 1920 season, the peat when spread for eight or nine days was always raised into cubes or small piles, in which it remained until dry. Since then no " cubing " has been attempted, the peat blocks—after the upper surface has dried somewhat—being merely turned over four or five at a time by a long-handled rake. In a good season, under Canadian conditions, this method should produce, in the middle of the peat-winning season, peat dried to, say, 30 per cent. moisture, and with the peat at Alfred it is not desirable to allow it to dry to a lower moisture content, as it becomes too friable and will not stand handling and transport.

It is doubtful if turning the peat alone would under Irish conditions reduce the moisture below 35 per cent. unless in an exceptional season and on a very favourable spreading ground.

When the peat has dried sufficiently it is loaded direct into side-tipping waggons which hold about 3,000 lb. These waggons stand on a temporary narrow-gauge track and, when loaded, six or seven are coupled up and hauled out to the permanent

Fig. 32.

PS 363[illegible], 19444, 700/1010. 1000 5/23.

road by a small petrol locomotive, which then hauls them direct to the loading stage. Here the waggons of peat are hauled up to the top of the stage and either tipped into C.P.R. hopper waggons, which take 25 tons to 30 tons of peat fuel (110,000 lb. to 140,000 lb. of coal), or else are tipped on the store pile near the station. (Fig. 33.)

FIG. 33.—Peat dump, Alfred Station.

General Outline of the Scheme.—The accompanying sketch (Fig. 32) shows the general lay-out of the scheme. A little to the east of Alfred C.P.R. station a loading gantry is installed, up the inclined side of which waggons filled with 3,000 lb. of air-dried peat are drawn by a cable operated by a 10-h.p. steam engine (Fig. 33). The peat is tipped from the waggons into railway trucks on the siding, or on to the store pile round the trestle " B." A weighbridge is installed at " D " on the narrow-gauge track leading to the gantry, so that all peat passing is weighed and a record kept of shipments.

The No. 2 plant has cut a ditch 5,000 ft. long by the C.P.R. line, and as the track is on a curve here, the ditch consists of three straight lengths united by short curves. The inclined ladder of the No. 2 plant removes a slice about 6 in. thick from the face of the trench, which is about 8 ft. deep. The plant is mounted on caterpillars and, while making its cut, moves parallel to the trench at a rate of 6½ ft. per minute (Fig. 37). The excavated peat is macerated and delivered to a belt conveyor carried on a bridgework 159 ft. long, mounted on a bearing caterpillar. The peat pulp is tipped where required into a spreader attached to, and moving with, the bridgework, so that a strip of peat 12 ft. wide by 5 in. thick is laid down parallel to the face at a uniform rate of 6½ ft. per minute.

The first row is spread close to the machine, and when this is completed the spreader is changed to the other side of the bridgework and moved 12 ft. farther out, so that on the return journey another strip of peat is laid down close to and parallel to the first. The 1920 bridgework had sufficient length for 10 such rows. When the peat is dry it is thrown on to the conveyor belt, which carries it to the outer end of the bridgework, where a stacking elevator tips it either into peat waggons or else forms a stack parallel to, and clear of, the spreading ground.

As the dry peat is cleared off the ground, fresh strips of peat pulp are spread to take its place. Mr. Moore contemplated the spreading of one row and the removal of the adjoining one at the same time, and the objections to this system are dealt with later. The No. 2 plant also works along another ditch 3,000 ft. long, marked " J K " on Fig. 32, the peat being spread over the area " B."

Passing the "A" ground of the No. 2 plant, the office and workshop lie on the left and, farther on, the men's quarters. Dormitory accommodation is provided for about 30 men and, adjoining, is a recreation ground and a refectory where excellent meals are obtainable at moderate charges.

Anrep Plant No. 1.—During the 1919 and 1920 peat seasons the No. 1 Anrep plant was operated on a drying-ground 3,000 ft. long by 800 ft. wide. This plant cuts a prism 30 ft. wide by 9 ft. deep, each movement of the ladder being at an angle of 45 deg. with the face. After each slice is cut the whole platform, mounted on three caterpillars, moves forward 6 in. and rests while another slice is being cut. The excavated peat is macerated and conveyed in 1 cub. yd. tip waggons around a spreading rectangle operated by a cable (see Fig. 34). The peat is tipped from the waggons into a spreader, which lays down a strip of peat 7 ft. 6 in. wide by 5 in. thick and 800 ft. long in a direction at right angles to the face " L M."

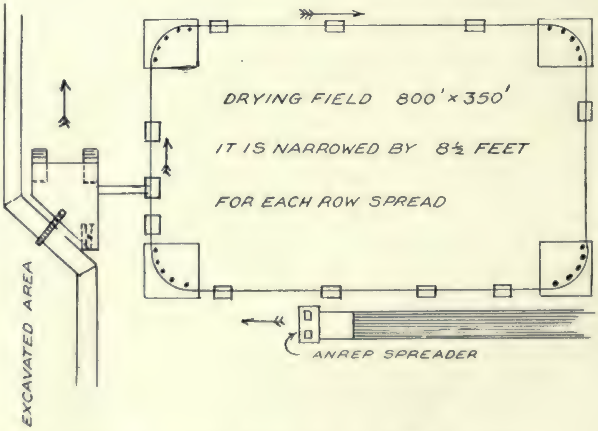


FIG. 34.—Anrep Plant No. 1, Alfred, Ontario.

The arrangements of the No. 1 plant (see Fig. 43), with the exception of the mechanical details, are practically as designed by the late Mr. Anrep, senr., of Sweden. The details of the excavator element and of the platform and arrangement of the macerator have been modified, and the whole has been mounted on caterpillar mattresses instead of wheels working on rails. A platform approximately 30 ft. × 40 ft., of triangular shape, is built up of 12 in. × 5 in. and 10 in. × 5 in. steel joists, and is mounted on three caterpillars, one of which is pivoted for steering purposes.

The framework of the ladder excavating element is 24 ft. long, consisting of angles and flat bars, and at top and bottom of the framework axles and sprocket wheels are fixed, on which the excavator chain revolves. The chain consists of 104 6-in. links, made up of sets of four cutting hoops to each bucket. It contains about 21 buckets (see Fig. 43). The excavator ladder is inclined at an angle of, roughly, 45 deg., but the slope can be varied, as the framework carrying the chain is suspended from a crane and winch, worked by a small steam engine. The excavator chain is driven by a 4 in. × 5 in. twin cylinder vertical steam engine, mounted with the excavating element in a separate housing, which moves along a rack on the sloping side of the main platform.

The excavator chain has a side-cutting action, and as it moves along its track it removes a slice from the face about 6 in. thick by 30 ft. wide by 9 ft. deep. While making a cut the main platform is stationary, and on the completion of its cut the whole machine moves forward 6 in., the excavator then moving back across the face and taking off another 6-in. slice. The excavated peat falls into a trough which is directly underneath the chain, and a left-handed and right-handed helix conveys the peat from either end to the centre. From the centre of this trough the peat is taken by another screw conveyor to an Anrep macerator, which is coupled up direct to a 7 in. × 8 in. twin cylinder vertical engine. At 125-lb. steam pressure this engine develops about 35 h.p. and drives the macerator at 250 r.p.m. Interposed between the macerator and the engine are six hardwood shearing pins, and when the macerator is overloaded or choked with roots or fibre these pins are sheared through and damage prevented. The macerator can then be opened up quickly, the obstruction removed, and new shearing pins put into place with little loss of time.

The macerator is of an improved Anrep type, in which there are altogether 13 fixed and 13 rotating knives of special design. The rotating knives pass in close contact with the fixed knives and all knives cut on both sides. There are two helical feeding blades, and the action of the macerator is very thorough. From the macerator the peat is passed by a screw conveyor up an inclined trough and dropped thence into side-tipping waggons of 1 cub. yd. capacity.

As each waggon is filled the clutch is closed on the cable and the waggon carried round the rectangle (Fig. 34) to the Anrep spreader (Fig. 35), into which it is tipped after being released from the cable. The empty waggon is then hitched on to the cable and proceeds round the rectangle to be reloaded. The Anrep spreader consists of a bottomless box 7 ft. 6 in. wide by 9 ft. long and 15 in. deep, and this is drawn forward by a traction drum driven by a gasoline motor.

As the box is drawn forward the peat is levelled and escapes through a slot in the rear portion, leaving behind a band of peat 7 ft. 6 in. wide by 4½ in. to 5 in. thick.

If the surface of the bog is uneven, then all holes are filled with peat pulp, so that, in places, the peat spread varies from 1½ in. to 15 in. in thickness. The spreader draws behind it a shaft on which are 19 sheet steel discs $\frac{1}{16}$ in. thick and 16 in. diameter. These discs cut the peat into 20 longitudinal strips, each approximately 4 in. × 5 in. cross-section, and after a couple of days, when the peat has commenced to dry and shrink, a wooden roller 8 ft. long and 3 ft. in diameter, with 13 specially shaped fins made of zinc, is drawn over the peat. The fins, of approximately

Fig. 35.—Anrep spreader.

Fig. 36.—Curve at corner of spreading track.

cycloidial shape, clear themselves as they cut the peat into blocks about 10 in. long, and the cross-cutting of 50 tons of peat can be done by this simple apparatus very efficiently by two men in about one hour.

The row spread is 800 ft. long by 7 ft. 6 in. wide, and, when no serious breakdown occurs, about six of these rows are spread in ten hours, or 4,800 ft. The average progress made was about five rows per ten hours—that is, two hours per row—and of this, 15 minutes is occupied in turning round at each end. Each row of 800 ft. produces about 9 tons or 10 tons of peat fuel, so that the output averages about 45 tons or 50 tons per 10 hours. The spreader moves about 8 ft. per minute, but there is no reason why this rate could not be increased if the supply of peat pulp could be kept up.

The rectangle laid out for spreading is about 800 ft. long by 350 ft. wide, and for every row laid down one of the 800 ft. sides has to be shifted some 8½ ft. For this purpose 800 ft. of spare track is provided, so that while the row is being laid down two men transfer the previously used track in 5-metre lengths and complete this before the row is finished. It is then only necessary to move the curves at each end of the track 8½ ft. (see Fig. 36), this being done with the help of winches provided for the purpose.

The slack on the cable is then taken up, and as the spreader has meanwhile turned round, another row is laid down. When everything is working well, 10 minutes to 15 minutes are required for the change round. When the two longer sides of the track come too close together a new rectangle has to be laid out. This occurs every seven or eight days. Numerous stoppages and breakdowns occur with this spreading system, but, apart from mechanical troubles, it cannot be recommended, as it needs too many hands to be economical. The cost of excavation, production of power, despatching and spreading of the peat is as follows :—

	No. of men.	Rate.	Total.
		Cents per hour.	Cents per hour.
Excavating—			
Engineer-driver on main platform	1	70	70
Repairs to plant, clutches, oil, &c.	1	50	50
Fireman	1	45	45
Providing fuel	2	35	70
Excavator runner	1	40	40
Watching roots	1	40	40
Total	7	—	$3·15
Spreading—			
Receiving empty waggons ..	2	35	70
Tipping and despatching empty waggons	2	35	70
Driving engine	1	45	45
Spreading in hopper	1	35	35
Shifting track and cross-cutting	2	35	70
Total	15	—	$6·05

The actual labour costs with this plant for excavating, macerating, spreading and cross-cutting the peat amount to $6·05 per hour, excluding supervision, &c. The net output of the plant may be taken as 5 tons per hour, and this is a generous figure, as the maximum output may be put at 60 tons per 10 hours, from which 3 tons to 4 tons of fuel used must be deducted, so that the labour cost is $1·21 per ton of 2,240 lb. of air-dried fuel spread.

As the spreading system of plant No. 1 is not very suitable for working at night, 5,000 tons of peat per normal season is a generous output to assume. Taking the cost of the No. 1 Anrep plant with rails, cable, cars and spreader complete at $40,000, and allowing 6 per cent. for interest, 9 per cent. for repairs and replacement, 10 per cent. for amortization, that is, 25 per cent. in all, or $10,000 per season, this would amount to $2·00 per ton of air-dried peat produced during the peat-winning season. To this must be added 20 cents per ton for turning the peat on the bog and 50 cents for picking up and filling into trucks, giving a total cost of $3·91 per ton in waggons ready to haul to Alfred C P.R. station. The Peat Committee were selling the fuel at $4·00 per short ton in railway truck at Alfred during September, 1920.

Even at the above cost the peat produced could compete with coal in Canada (price $15.00 to $17.00 per ton) and stand transport charges up to, say, 50 miles from Alfred. None the less, labour requirements are too great, the small output possible in a season results in high capital charges, and a better scheme has since been devised.

SUMMARY OF COST OF PRODUCTION, NO. 1 PLANT (estimated 1920).

	$ per ton.
Excavating and spreading peat	1·21
Turning peat	0·20
Collecting and filling into trucks	0·50
Overhead charges on plant	2·00
Total	$3·91 in peat waggons.

(Charges for supervision, management, office expenses, insurance and working capital not included. Carriage to station also excluded.)

Moore Plant No. 2.—An excavator chain, similar to that on the No. 1 plant, is driven by a 4 in. × 5 in. twin-cylinder steam engine. The excavator chain is fixed in position with reference to the main platform, and moves with it continuously parallel to the sloping face, removing therefrom a layer about 6 in. thick by 9 ft. deep (Fig. 37). The excavated peat is tipped at the top into a hopper leading directly to the macerator. As in the No. 1 plant the macerator is connected up direct to a 7 in. × 8 in. twin-cylinder vertical steam engine, which develops about 35 h.p. and drives it at 250 r.p.m.

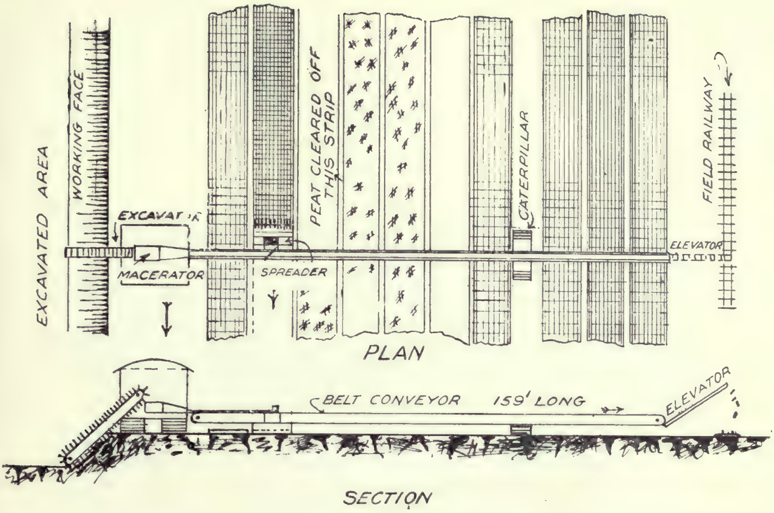


FIG. 37.—Moore No. 2 Plant, Alfred Bog, Ontario,

This engine also works the screw conveyor on the main platform which delivers the peat to the conveyor belt. The conveyor belt in the 1920 season was supported on a steel bridgework 159 ft. long (since increased to 177 ft.) and the 14 in. rubber belt run at 200 ft. to 300 ft. per minute on 27 in. diam. pulleys at either end. The power to drive the belt is taken from the engine driving the macerator, and about 2 h.p. to 2½ h.p. is required for this purpose.

The main platform, with 80 h.p. Worthington water-tube boiler, engines, macerator, &c., is carried on two caterpillar tractors (Fig. 38), the bearing area of each being 14 ft. 6 in. × 6 ft.,

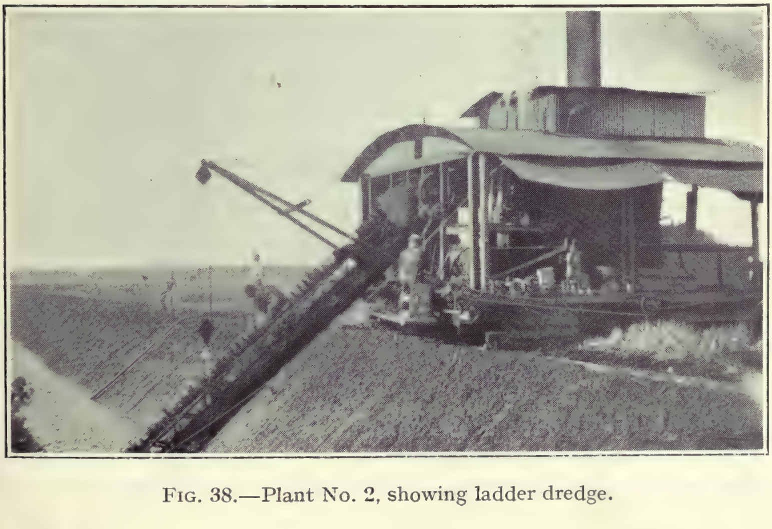


FIG. 38.—Plant No. 2, showing ladder dredge.

or 174 sq. ft., giving a pressure of about 350 lb. per square foot. The steel bridgework carrying the conveyor belt (Fig. 39) and the spreading, harvesting and stacking units are supported on a centre caterpillar similar to those under the main platform. This caterpillar is driven from a $1\frac{3}{4}$-in. diam. shaft inside the bridgework through sprocket wheels with chain drive and a Reeves variable speed transmission gear. There are clutches on each of the caterpillar drives, so that any caterpillar may be cut out for steering purposes.

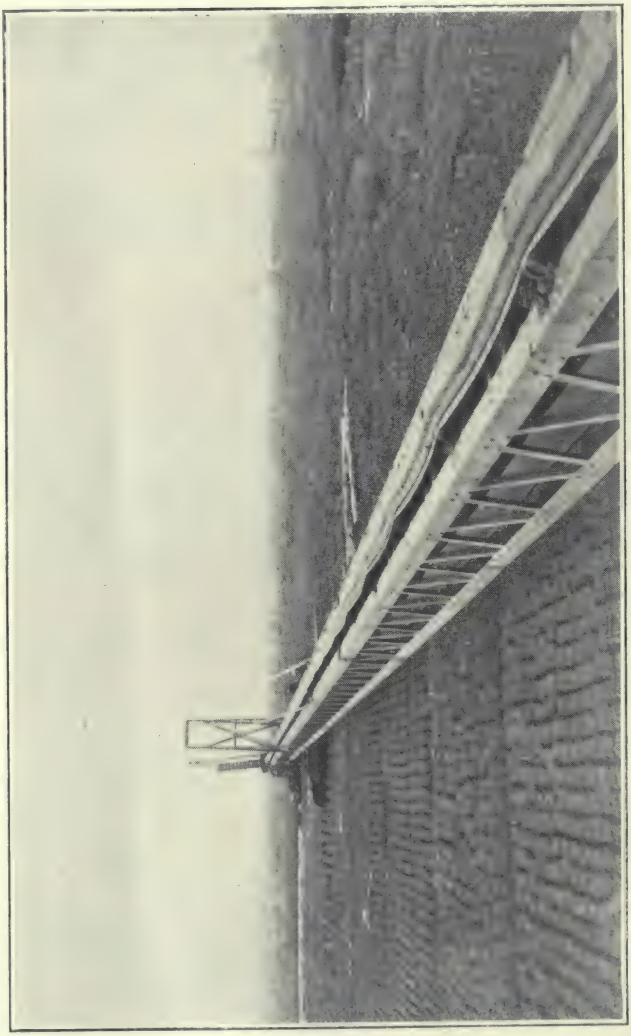


Fig. 39.—Bridgework and belt conveyor, No. 2 plant.

The bridgework is at right angles to and moves parallel to the face, being followed by the spreader, which lays down parallel to the face a band of peat 12 ft. wide by 4 in. to 5 in. in thickness.

The peat pulp is tipped from the belt by a deflector (Fig. 40) and enters a hopper at the centre of the spreader, from which point it is distributed by a left-handed and right-handed screw to either end, so that the feed to the mouthpiece is uniform. The spreader during the 1920 season was drawn along by the bridgework, its weight resting on the bog, but since then two small supporting caterpillars have been fixed (see Fig. 40).

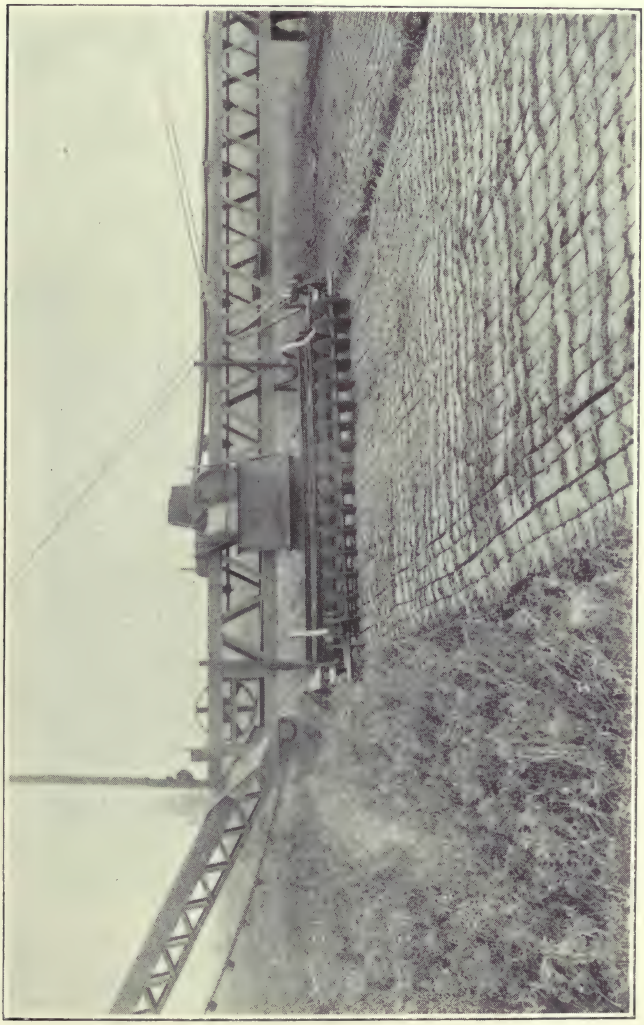


Fig. 40.—Bridgework and spreader, No. 2 Moore Plant (1921).

Behind the mouthpiece 32 circular discs 15 in. diam., made of $\frac{1}{16}$ in. sheet steel, are mounted on a shaft, and as these discs follow the spreader the peat is cut into 32 longitudinal strips about $4\frac{1}{2}$ in. wide. On drying out, the peat opens up along these partings, except when very heavy rain falls soon after the peat has been spread. When this occurs the fine material from the peat is washed into the cuts, and this cements numbers of the blocks together and retards drying. The cross-cutting of the strips, during the 1920 season, was done by a 16 in. diam. plate disc, which is carried across the layer of peat and then lifted clear and brought back to its original position, when it is again dropped into contact with the ground and makes another cut across. All difficulty from the forward motion of the spreader was got over by fixing the rail which guides the cross-cutting disc at a slight angle, so that the disc moved at right angles to the row of peat. During 1921 three knives 12 ft. long were fixed to an improved device for cross-cutting the peat.

FIG. 41.—Section of peat trench; Alfred bog, showing roots.

The length of the bridgework was designed to allow seven rows to be spread inside the bridge caterpillar and four outside, or 11 rows in all, but in practice it only allowed 10 rows to be spread, and has now been increased by 18 ft. to 177 ft. in length, so that 12 rows might be spread. Mr. Moore, in designing the No. 2 plant, thought that by starting the spreading of the first row near to the plant and then laying down row after row, by the time the eleventh row was spread the first and second rows would have completely dried (see p. 71). The first row would then be moved slightly out of the way of the machine and reserved for fuel for the plant, and the second row would be thrown on to the belt and cleared away automatically, so that the space it occupied would be free for laying down a fresh row.

Output.—During certain periods of the 1920 season the No. 2 plant spread a band of peat roughly 12 ft. wide by 5 in. thick and 2,750 ft. to 3,000 ft. long in 10 hours. The rate of movement of this plant was found to vary from 6 ft. 3 in. to 6 ft. 4 in. per minute. On one occasion it was speeded up to 6 ft. 10 in. per minute, which appeared to be the maximum rate possible at that time. If a steady rate of 6 ft. 3 in. per minute were maintained for 10 hours without stoppages, the distance covered would be 3,750 ft., but, owing to breakdowns and lost time at the ends, the average rate was about two-thirds of this. The performance of the No. 2 plant was observed for three and a half days—or 35 working hours—on August 16th, 17th, 18th and 19th, 1920, and during that time three complete rows 12ft. wide, each of 2,934 ft. in length, were laid down, or 8,802 ft. in 35 hours, including turning round twice. This gave an average of 2,515 ft. per 10 hours, or 4·2 ft. per minute, and shows that the plant worked continuously for 67 per cent. of its working time.

Owing to the late period of the season, the band of peat was reduced to 4 in. in thickness to promote quick drying. Assuming a width of 12 ft., and that the peat pulp contained 90 per cent. moisture, which is the average figure obtained by Mr. Leverin for peat samples taken off the conveyor belt, 2,515 ft. of such a row should produce 37·4 tons of 25 per cent. moist peat. As the excavator and macerator are well able to turn out sufficient peat for the 5 in. thickness, the same average speed with a 5 in. band would give 25 per cent. more fuel, or 46·8 tons per 10-hour shift. From both these figures about three tons must be deducted

OPERATION COSTS, NO. 2 PLANT (1920 Season)

	No. of men.	Rate.	Total.
		Cents per hour.	Cents per hour.
Excavating and spreading—			
Engineer-driver	1	70	70
Handy man on repairs, oiling, &c.	1	50	50
Fireman	1	45	45
Picking up fuel	1	35	35
Excavator runner	1	40	40
Watching roots in excavator ..	1	40	40
Providing water for boilers (subsequently dispensed with) ..	(2)	(35)	(70)
Watching spreader	1	35	35
Total	7	—	$3·15
Harvesting	5	35	$1·75

for the fuel actually burned in the boilers. This would leave the net output of plant No. 2 at 3·44 tons and 4·38 tons per hour under 1920 autumn and summer conditions respectively.

It was evident that the time lost in stoppages and changing round at the ends could be reduced very considerably, and that 5 tons per hour was a reasonable output to base costs upon.

Mr. E. V. Moore states that during 1921 the speed of the No. 1 plant was increased to 8½ ft. per minute, so that on June 21st it traversed 3,950 ft. of the working face in a 10-hour shift, including a turn round, giving an average speed of 6·6 ft. per minute. The caterpillar elements added to the spreader make this increased speed possible and save time in changing over at the ends. A length of 3,950 ft. is equivalent to an output of 73 tons per 10-hour shift. For three consecutive days in June, 1921, the output averaged 61 tons per shift and, deducting three tons for fuel used, the net output would be 5·8 tons per hour. This figure, however, could not be assumed as an average over the whole season, but at the same time the increase of 33 per cent. in the output over that obtained during three days of 1920 confirms the opinion formed by the writer that there was still room to increase considerably the output of this plant.

With an output of 5 tons per hour and by working double shifts the working season in Canada might extend to 1,500 hours, giving an output of 7,500 tons per season. Assuming the plant with rails, &c., to cost $30,000, and allowing 25 per cent. for interest, repairs and amortization, the overhead charges would amount to $7,500 per annum, or $1·00 per ton of fuel won. Turning the peat on the drying-ground costs, say, 20 cents per ton and picking up the dried fuel and filling into the harvester 35 cents per ton, so that the total costs may be summarized as follows :—

	$ per ton.
Excavating and spreading	0·63
Turning	0·20
Harvesting to store pile	0·35
Overhead charges on plant	1·00
Total cost	$2·18

To make this estimate comparable with that for No. 1 plant $0·25 per ton should be added to cover the cost of filling the fuel into waggons.

If the No. 2 plant were electrically operated only three men would be required for excavation and spreading in place of seven, and the labour cost of operating the plant would then be about $1·35 per hour, or less than one-half of the present costs. Allowing for power charges and for the lesser capital charges on the cheaper plant, the costs of production with a plant of this type should be under $2·00 per ton.

Criticisms of the No. 2 Moore Plant.—As arranged for work during the 1921 season this plant had a conveyor 177 ft. long, spreading 12 rows of peat each 12 ft. wide, on spreading-grounds 5,000 ft. and 3,000 ft. long, or a total length of 8,000 ft. The maximum speed of the plant is 8½ ft. per minute, and for three shifts in June, 1921, the average travel was 330 ft. per hour. Assuming a seasonal average speed of 320 ft. per hour and that two 10-hour shifts are worked, the plant would traverse a working face 8,000 ft. long in two and a half shifts, and would lay down 12 rows or cover the whole of the spreading-ground in 15 working days, or, allowing for Sundays, in 17 days.

If only one 10-hour shift is worked per day, it would take 34 days to cover the spreading-ground, but with an expensive plant of this kind working for a short season, it is essential that double shifts should be worked to increase the output, so that the plant charges may be kept within reasonable limits.

With the system adopted by Mr. Moore, the first row of peat spread should be air-dried and cleared off the ground by the time the twelfth row is completed. As already stated this first row of peat is put on one side and burned in the steam boiler. The second row of the first spreading should now be sufficiently dried to be cast on the belt conveyor and harvested clear of the spreading-ground (Fig. 42), while the space occupied by the first row is being covered a second time. The second row will, therefore, only have 17 days in which to become air-dried. While it may be possible in the summer of an exceptionally fine Canadian peat season to dry peat in 17 days, this cannot be relied on for the whole season. Hence, unless the length of the working face is considerably increased or a greater number of rows laid down, necessitating a longer bridgework, it is not possible to continue with this system of laying down the wet peat and harvesting the dry peat at the same time.

When the writer first visited the Alfred works, in July, 1920, the work of the No. 2 plant was anything but satisfactory. A night shift was started on June 14th and, working under novel conditions, did little good. The season had been bad, and the conditions indicated above had arisen when the peat in the first rows was insufficiently dried to harvest when the tenth row was laid down. (Only 10 rows of peat could be spread, owing to the limited length of the 1920 bridgework, and in 1921 this was increased to 12 rows by lengthening the bridgework.) In addition, sufficent men were not available to keep the peat harvested ahead of the machine with the system then in use. This produced a state of disorganization which only allowed the machine to operate under most unfavourable conditions. The dropping of the night shift and the fitting up of a harvester (Fig. 42) and cross-cutting device designed by Mr. Moore had a most beneficial effect, so much so that on the occasion of a second visit to the plant, on August 16th, a very favourable impression was created.

It seems inevitable that expensive peat-winning plants must be worked day and night to reduce the overhead charges to a figure which the fuel can stand. After inspecting the work of the night shift on the No. 2 plant in July, 1920, the author formed the opinion that when certain mechanical troubles were eliminated and proper arrangements made for harvesting the air-dried peat, there was no reason why it should not operate as efficiently at night as by day. The substitution of electric motors for steam plant will simplify the work, but of course it must be admitted that it is more difficult to deal with breakdowns by night than by day.

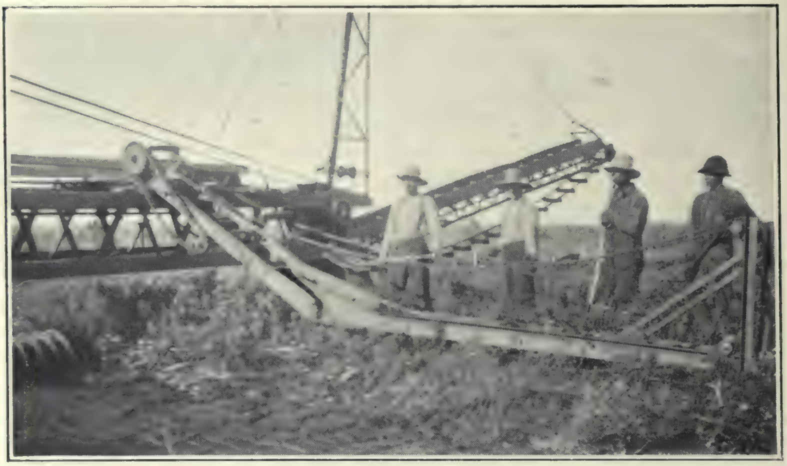


FIG. 42.—Harvesting elevator, No. 2 plant (1920).

A length of 60 ft. of a row of peat 12 ft. wide by 4½ in. thick produces one ton of peat fuel, and it constitutes a further objection to this plant that the whole weight of about 30 tons has to be moved over the bog surface through 60 ft. for each ton of fuel produced. It is clear from the above that it is not possible for this plant, even with a working face 8,000 ft. long, to spread wet peat and harvest dry peat at the same time, while working double shifts. Further, if anything goes wrong with the harvesting work, the spreading of the wet peat is interrupted, in fact the interlocking of the operations is bound to increase the time lost due to breakdowns in either part. The idea is ingenious, but the practical difficulties are too great. It must also be said that, where a number of plants are to be employed, it would be difficult to provide a working face more than 8,000 ft., or over one and a half miles for each peat machine, except on bogs of great area.

With the No. 1 plant at Alfred the excavator platform remained stationary while sufficient peat to produce one-half ton of fuel was being excavated, and then simply moved 6 in. forward. This was possible because the spreading-ground with this plant was 800 ft. wide, with the result that the No. 1 plant only moves 1 ft. for every 60 ft. moved by the No. 2 plant for the same production.

For these reasons the technical advisers of the Canadian Peat Committee at the end of the 1920 season put forward plans for an improved plant, in which the best features of both the No. 1 and the No. 2 plants were embodied. Owing to the time lost in obtaining the approval of the new plans by the Governments concerned, it was late in July, 1921, before the improved plant could be erected on the bog at Alfred, so that little time was left to test it before the end of the season. The No. 2 Moore plant was worked throughout the 1921 season, but as the Peat Committee considered its possibilities had been fully determined, it is now dismantled and will not be worked again.

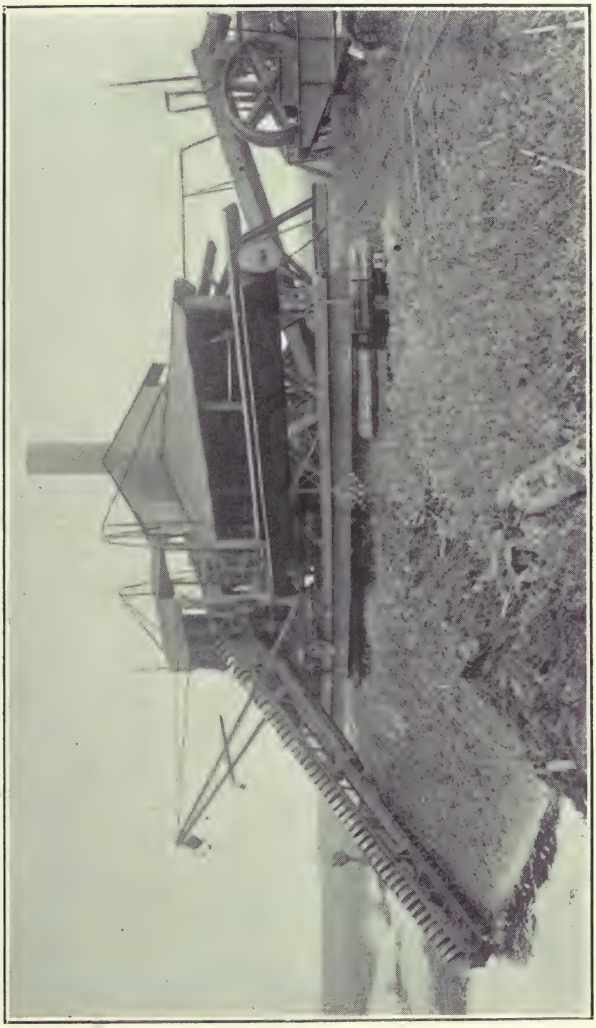


Fig. 43.—Anrep-Moore excavator and end of 860-foot belt conveyor (1922).

The Canadian Peat Committee's Improved 1922 Plant.—Excavator. In the 1921–22 Canadian plant the Anrep excavator (Fig. 43), supported on three caterpillars (as used with the No. 1 1920 plant), works in conjunction with a belt conveyor 860 ft. long, carried by 11 caterpillars, each with a bearing area of 400 sq. ft. (Figs. 44 to 47), which divide it into 10 spans of 85 ft. 10 in. each. The excavated and macerated peat is delivered by an inclined screw conveyor "C" (Fig. 48) to a horizontal trough "D" (see also Fig. 45), in which a screw delivers it to the belt conveyor "E F," to which the trough is attached. A band of peat approximately 8 in. × 5 in. in section is placed on the 24 in. rubber belt, running at 330 ft. per minute. This belt

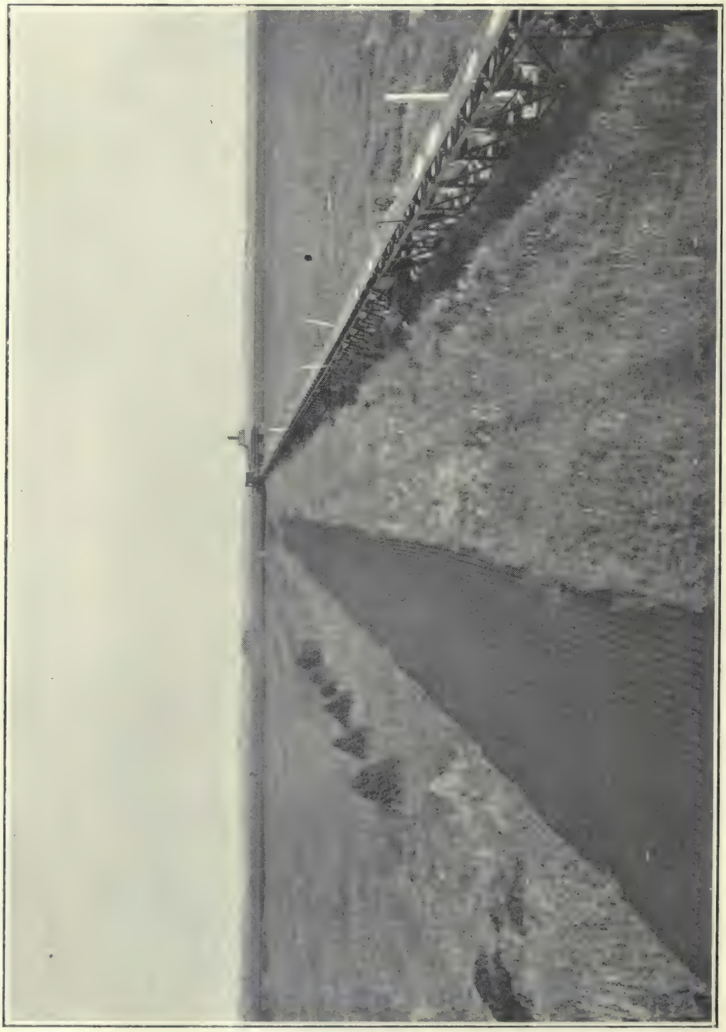


FIG. 44.—General view of the excavator and 860-foot belt conveyor with 12-foot strip of peat spread.

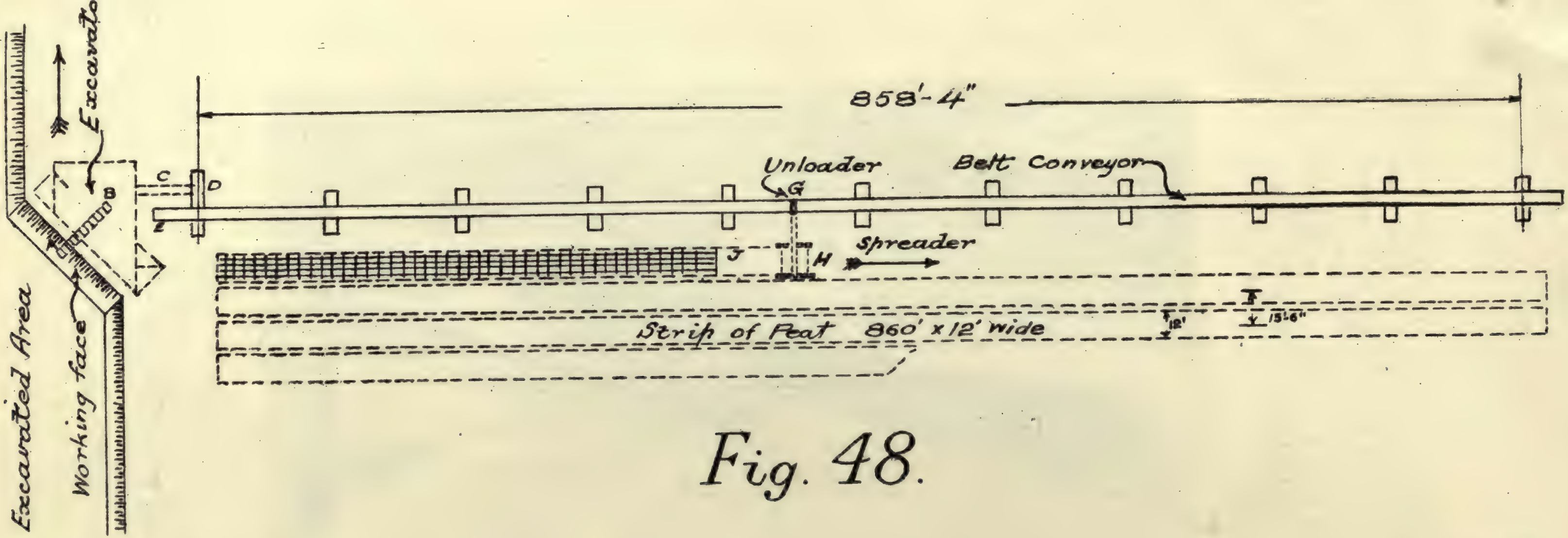


Fig. 48.

PS.36331/18444/700/1010. 1000.5/23.

C&R. Ltd 934.

can handle 200 cub. yd. of 90 per cent. moist peat per hour, which yields on drying 20 tons of 25 per cent. moist peat fuel.

Spreader. A spreader "H," (Fig. 48) constructed on somewhat similar lines to that already used by Moore, is mounted on small caterpillars, worked by a 10-h.p. oil engine (Fig. 50). This spreader moves at a speed of from 6 ft. to 25 ft. per minute parallel to the belt conveyor. An unloading carriage "G" running on the conveyor girder is drawn by the spreader, and a deflector takes the peat off the belt and passes it into a screw conveyor, which delivers the peat into the body of the spreader "H" (see Figs. 49 to 54). In the body of the spreader it is evenly distributed by a right-handed and left-handed helix and extruded from the mouthpiece in a band 12 ft. wide by 4½ in. deep, which is gently deposited on the bog surface. The 860-ft. conveyor bridgework

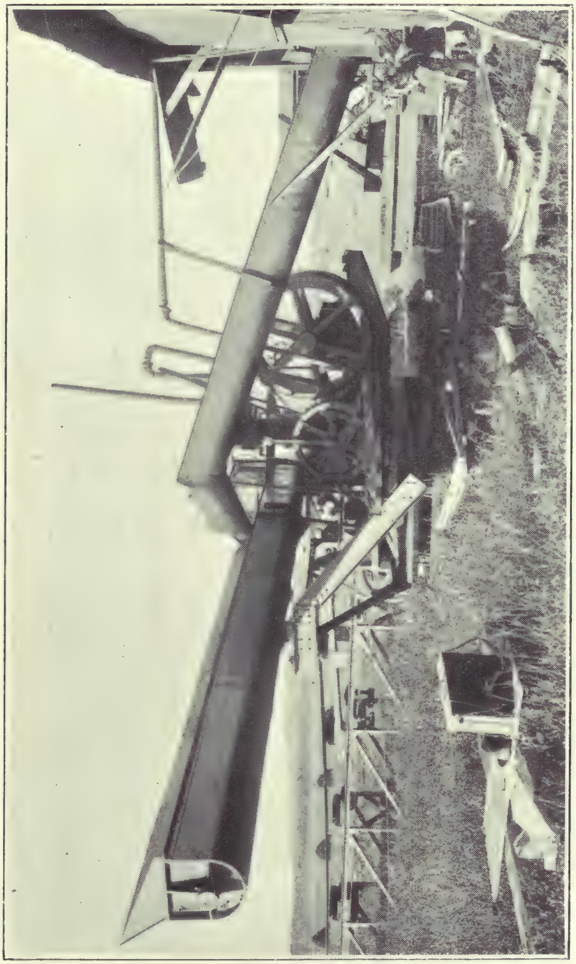


Fig. 45.—Inclined screw conveyor delivering peat from excavator to the belt conveyor.

remains in the same position while the spreader is laying down an 860-ft. strip and, when the length is spread, the conveyor moves forward by its caterpillars parallel to itself through a distance of $13\frac{1}{2}$ ft. to make room for the next row. This operation takes three minutes, and while the conveyor is moving the spreader goes forward, turning towards the conveyor, and is then reversed, moving again towards the conveyor into position for the next row. It takes the spreader about 55 minutes to travel the full 860 ft. length of the conveyor and about five minutes to change the spreader round at the ends. The row of peat produces about 14·3 tons of air-dried fuel, and it is hoped that by laying one row per hour the output per season will average

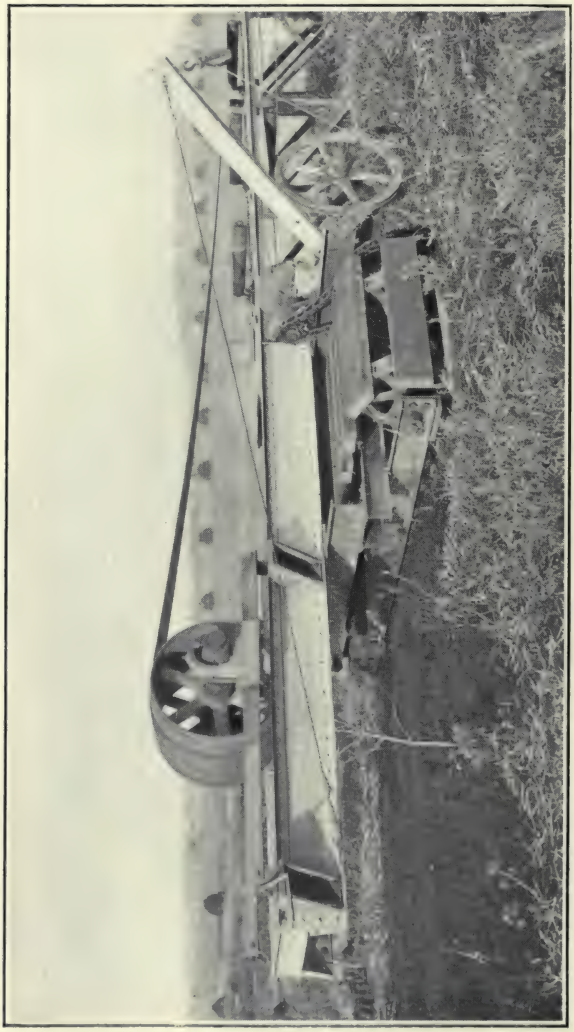


Fig. 46.—Outside end of belt conveyor with outer caterpillar and tension adjustment for belt.

10 tons per hour, allowing for breakdowns and stoppages from all causes.

The opening in the spreader box can be changed by a lever from one side of the machine to the other, so that it is not necessary to turn the machine around at the end of a row. While moving into position the spreader box is raised, and later on lowered and adjusted, and it works equally well in either direction. The peat is cross-cut by three knives 12 ft. long, which are worked by the wheels supporting them, and the longitudinal cuts are made by discs which are thicker at the centre than at the outer

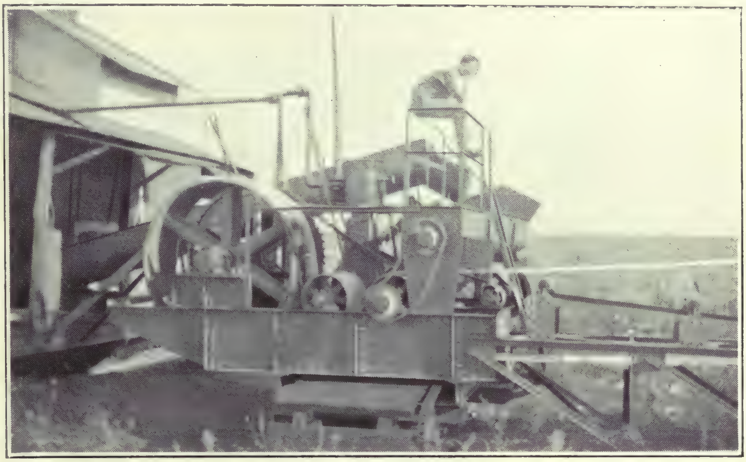


Fig. 47.—Loading and operating end of belt conveyor.

Fig. 49.—Unloading carriage on belt conveyor.

edge (Fig. 50). The new method of cutting the peat separates each block in the wet condition, so that, instead of the one drying face formerly obtained, namely the top, there are now practically five distinct faces, and the time taken in drying is considerably reduced thereby (Fig. 55).

One operator works the spreader, and levers are provided by which he can raise or lower the outer end of the trough conveyor under the unloading carriage, and thus make allowance for inequalities in the surface level. The speed of the spreader can be varied from 6 ft. to 25 ft. per minute, and the main clutch on the inside caterpillar of the belt conveyor can be cut out by the operator on the spreader and the belt stopped at once should anything go wrong with the spreader.

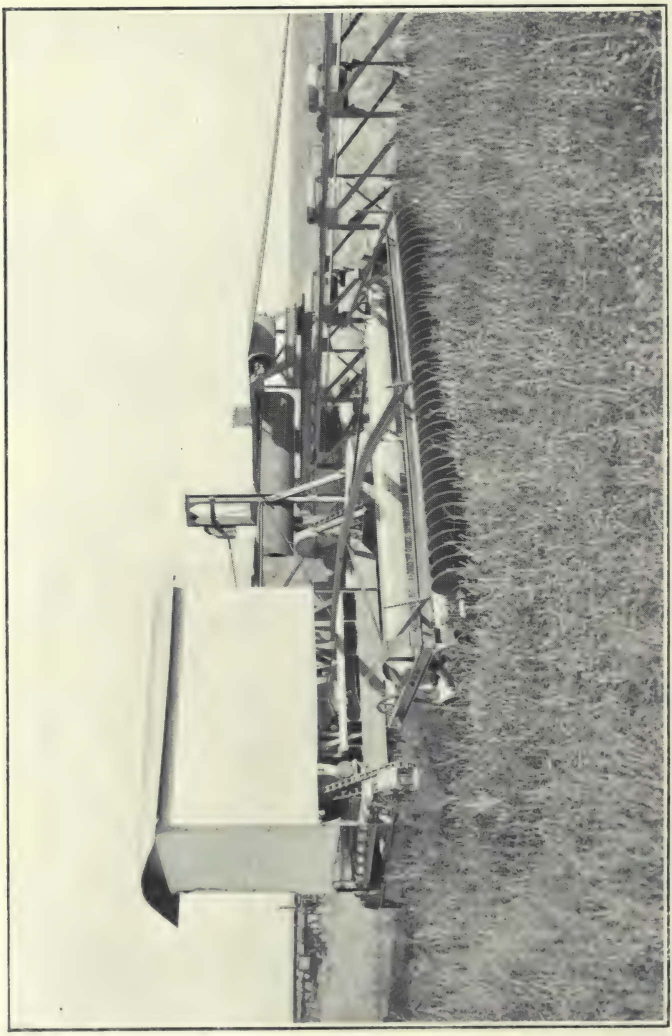


Fig. 50.—View of spreader and unloader from rear.

The conveyor weighs about 100 tons, and the belt, which is 24 in. wide and 1,740 ft. long, weighing 9,000 lb., is formed of five-ply rubber with a $\frac{1}{16}$ in. rubber face on the carrying side.

Fig. 51.—Conveyor, and cable driving eleven supporting caterpillars, also take-up mechanism for the cable.

The carrying rolls are all supported on Hyatt roller bearings, and about 15–18 h.p. is required to drive the belt at 330 ft. per minute when loaded. The caterpillars supporting the conveyor are all moved by a single cable, which is wound once around the driving sheave of each caterpillar (see Figs. 51 and 52).

Fig. 52.—Intermediate caterpillar with driving mechanism and driving cable.

The conveyor made 15 moves of $13\frac{1}{2}$ ft. each during the season, and it was then not sensibly out of line, and the belt showed no tendency to run off the rollers. No difficulty was experienced in moving the conveyor over a drainage ditch on the drying-ground, which was over 4 ft. wide at the top, one side being 18 in. higher than the other and the ditch not at right angles to the working face, and hence not parallel with the conveyor.

FIG. 53.—Spreader and belt shortly after erection, before cutting knives were added.

The caterpillars under the excavator have been enlarged and the driving mechanism strengthened since 1920, and with stronger cutting knives on the excavator chain many of the mechanical troubles noticed in 1920 have been eliminated.

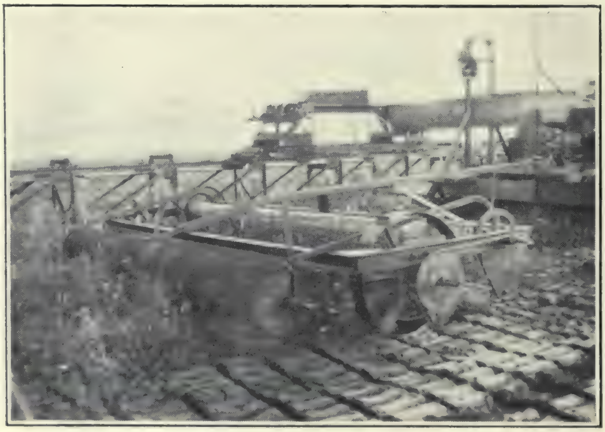


FIG. 54.—Longitudinal and cross-cutting device.

To avoid the delays due to the roots and iron spikes getting into the macerator, a new type of " hammermill " is being tried by which it is hoped to eliminate much of the lost time on this account.

The following hands are required to operate the plant :—

	Men.
Engineer	1
Fireman and a man on fuel supply	2
Excavator runner	1
Picking out roots	1
Spreader operator	1
Spare man	1
Total	7

A rough estimate shows that with this plant the cost of the peat for labour, fuel, oil, etc., f.o.r., is \$2·00 per short ton when paying men 35 to 40 cents per hour, but exclusive of overhead charges, supervision and capital charges on plant. The cost of replacing the complete plant at current prices is estimated at \$90,000.

Mr. B. F. Haanel, member and secretary of the Canadian Peat Committee, speaks in high terms of the performance of this machine during its trial last season. The plant has been operated by night without much difficulty.

It is estimated that the cost of the peat (30 per cent. moisture), f.o.r., is \$4·48 per short ton (2,000 lb.) for a 1,000-hour working season. If the plant can be worked 2,000 hours per season (output 20,000 tons) then the cost is reduced to \$3·50 per short ton, f.o.r.

FIG. 55.—Partially air-dried peat from the new plant, showing the uniform spreading secured.

During November, 1921, a serious fire, the cause of which was rather obscure, occurred in the peat dump at Alfred station, with the result that about three-quarters of the peat stored was destroyed.

APPENDIX III

REPORTS ON PEAT-WINNING PLANTS IN GERMANY AND SWEDEN (JULY, 1921)

GERMANY

I.—ELISABETHFEHN, OLDENBURG: DR. WIELANDT'S PEAT COKE PLANT AND PEAT WORKS

(1) *Coking Plant.*—A peat-coking plant was erected in 1905 by Dr. Wielandt, about 2½ km. from Elisabethfehn, for the Torfkoks G.m.b.H., Oldenburg. In the beginning, hand-cut peat purchased locally was used, but proved unsatisfactory, and in 1909 an area of about 200 acres of bog was purchased and designs were worked out for a peat-winning machine driven by a 20 h.p. petrol engine. From this early machine the present electrically operated automatic sod-spreading machines have been developed. The entire plant is now owned by Dr. Wielandt.

Two large horizontal boilers installed in 1914, fed with refuse peat and surplus gas from the coking plant, supply steam to generate the power for running the elevators, pumps, etc., for the coking plant, and supply 3,000 volt, 3-phase, 50 cycle current for the peat machines. Each Wielandt machine requires 40 h.p., and to provide sufficient current for two machines, a new power plant was being installed in July, 1921. The new water-tube boiler with a flat hearth has 85 sq. metres of heating surface and supplies steam to a 200 h.p. turbo-generator made by Moller. Owing to the variable constitution of the gas from the retorts, due to variation in the moisture content of the peat, Dr. Wielandt does not consider it suitable for gas engines.

There are three vertical retorts built according to Höering-Wielandt patents, capable of coking 30 tons to 32 tons of air-dried peat and yielding about 10 tons of peat coke per 24 hours. The peat coke is hard, will stand a pressure due to 12 metres in height of its own weight, and it is used for copper smelting, case-hardening and the production of high-class steels. It contains 90 per cent. carbon, 3 per cent. ash, and is free from phosphorus and sulphur. The temperature in the retorts varies from 500° C. at the top to 1,100° C. at the bottom.

The factory is situated close to the Hunte–Ems Canal from Elisabethfehn and is built on the sand underlying the bog, on a site from which the peat has been cleared. Storage exists for 1,200 tons of air-dried peat and about 120 tons of peat coke. The production of coke varies from 2,000 tons to 3,000 tons per annum, depending on the demand. About 7,000 tons to 10,000 tons of air-dried peat is used, the net yield of coke being approximately 30 per cent. of the peat fuel used. Peat-winning operations are carried on until the middle of September, or six weeks later than on other bogs where air-dried peat for boiler firing is produced. The peat produced at the end of the season is somewhat wet, and the yield of coke is correspondingly reduced.

The peat fuel is elevated to three peat bunkers, 25 metres above the ground. Each bunker, containing 20 tons of peat, is situated over the retorts, the cross-section of the retorts being 1 metre × 3 metres. The retorts are charged every one-and-a-half to two hours, and the peat coke drawn off at the bottom into waggons with tightly-fitting lids, where it is allowed to cool. Two gas jets with air supplies are fitted to the heating flues on each retort. The gas from inside the retorts is drawn off 2 metres below the top of the retorts and put through vertical scrubbers. About 4 per cent. of dry tar is recovered, but, possibly owing to the low nitrogen content of the peat (0·5 per cent. to 0·75 per cent.), the recovery of ammonia has been given up. The peat tar is sent to a tar distillery near Oldenburg to be worked up.

(2) *Peat Works.*—About 500 acres of the Östermoor have been purchased and thoroughly drained, but in the earlier days pumping had to be employed. The depth of the bog is 3 metres to 4 metres, and as roots are met with only occasionally, this bog—like the other Oldenburg bogs—may be said to be practically free from roots and timber. There is little variation in the surface level of the moor, but the surface is rough, and only in places is it covered with a slight growth of grass. The top layer, about 0·75 metre to 1 metre in depth, consists of a moss litter peat, and after the machine has passed this is stripped off to a width of 1·7 metres and thrown to the bottom of the cut-away bog. The dredger removes the lower 2 metres to 2·5 metres of peat, so that the depth to which the excavation is carried is limited to from 3 metres to 3·5 metres. The main drain runs almost due north through the Östermoor, and the side drains almost due west to connect with it. A cutting face of 2 km. in length can be had in an easterly and westerly direction and there are four faces 1·5 km. long, and four faces 1 km. long, making a total of 10 km. of working face developed at Elisabethfehn.

(3) *Wielandt Automatic Peat-winning Machine.*—This machine consists of a rotating chain of buckets (Figs. 56 and 57) which dredge the peat from a face sloping at 60 deg. with the horizontal. The width excavated is 1·75 metres, and the depth 2 metres to 2·5 metres, giving a sectional area of, roughly, 4·2 sq. metres. A neat arrangement on this machine permits the depth, width and slope of the excavation to be varied. The excavated peat falls from the buckets into a large hopper and thence to the macerator. The body of the macerator is formed of pressed steel plates with welded seams and contains two square shafts with right-handed and left-handed cast steel quadrant helices, which revolve at 180 r.p.m. The macerator is similar to that of the double-spiral Dolberg machine, and there are no fixed or rotating knives. Indeed, since the Oldenburg bogs contain so little timber, mixing action is all that is really required, and knives may be dispensed with. At the same time, we may observe that the

greater the macerating or mixing action, the denser the resulting peat fuel.

The peat issues from the macerator in a stream of elliptical cross-section, 13 cm. × 11 cm., the mouthpiece being detachable. The issuing stream of peat is received on a chain of plates, whose velocity is regulated to correspond with that of the peat stream.

FIG. 56.—Dredger of Wielandt machine.

If the velocity of the plate conveyor is slower than that of the issuing stream, its cross-section becomes enlarged, and it may coil up and fall off the conveyor ; on the other hand a blockage of the macerator may allow the plates to go forward empty, and a vacant space is left on the drying-ground unless the machine is stopped. As the stream issues it engages paddles attached to a light cycle wheel mounted over the conveyor, and as the paddles are carried forward they cut into the stream of peat and make partings along which the blocks divide as they dry out. The dimensions of the raw peat blocks are 40 cm. × 13 cm. × 11 cm. On the Dolberg and some of the Strenge machines an attempt is made to give a parallel motion to the paddles, so that they remain vertical as they engage the peat stream, but the simple paddle wheel at Elisabethfehn seemed to work satisfactorily. On the Wielandt machine at Scharrel a more positive form of chopper was provided for making the cross-cuts.

FIG. 57.—View of Wielandt dredger from trench.

Fig. 56 shows the construction of the dredger as erected at the maker's works. The chain contains 30 buckets, 1·7 metres long, 25 cm. diam. at the outer end, and 12·5 cm. diam. at the inner end, forming a half-truncated cone. This shape allows the buckets to empty themselves readily into the hopper over the macerator. Forty of the buckets pass a given point each minute, but as a rule they are not all completely filled. The buckets are light and well-designed for the work. They have three teeth or knives fixed to the outer edge and guides, which slip on light steel rails, attached at the back. It is certain that these light pressed steel buckets and the light chain carrying the buckets will be easily damaged by contact with roots or other obstructions. The motive power for driving the chain is arranged through bevelled gearing operating from the shaft driving the macerator. A solid link chain operates shafts at the top and bottom of the dredger on which the sprocket wheels carrying the dredger chain are mounted. Fig. 57, taken from the cut-away bog, shows the dredger in operation.

A steel plate half a square metre in area is attached to the dredger frame and presses against the sloping face of the bog, midway between the surface and the bottom of the excavation. This acts as a skid and supports part of the overhanging weight of the dredger, thus reducing the overturning moment and pressure on the upper surface of the bog. A steel guy rope fixed to the girder of the conveyor from the top of the dredger frame also takes up portion of the overhanging weight.

The conveyors used on the Wielandt, Strenge and Dolberg machines consist of a number of plates attached to an endless chain, the plates going out fully loaded on the one side from the macerator and returning empty on the other. The power required for operating the plates is usually supplied by a motor situated near the macerator, but in the case of the Strenge machine at Wiesmoor synchronous motors are provided at both ends.

The conveyor at Elisabethfehn has an effective length of 42 metres, and the plates themselves measure about 42 cm. long and 23 cm. in width. The plates are attached to an endless chain and are supported in a horizontal position by two 2 in. × 2 in. × $\frac{1}{4}$ in. longitudinal angle irons, on which the outer and inner edges of the plates run. While the conveyor is being charged with peat, the outer angle iron is on the same level as the inner one and the plate remains horizontal. When the chain of plates is fully laden, a pin in the chain drive engages a lever, the long outer angle iron is pulled forward, and, being attached to swinging links, it drops about 6 in. As the centroid of the block of peat and plate lies outside the point of support on the chain, the outer edge of the plate tips downward, following the angle iron support, and the band of peat slides quietly over on to the bog surface. The height from which the peat is actually tipped is not more than 35 cm. to 40 cm., and the blocks keep their shape fairly well. Immediately the plates have tipped and are freed from the weight of the band of peat, a number of spiral springs pull back the outer angle iron to its horizontal position and at the same time restore the chain of plates to the horizontal. It takes, however, a second or two for the plates to tip and return to the horizontal and during that interval the stream of peat extruded from the mouthpiece of the macerator is allowed to fall on the bog, producing a heaped-up appearance close to the machine. Dr.

Wielandt states that the difficulty has been got over by the introduction of a simple arrangement.

Occasionally it is found that, with the Wielandt, small Strenge, and also the large Strenge machine at Wiesmoor, several rows of peat are tipped on top of one another. This may be due to the conveyor not moving forward as fast as the excavator, or due to want of adjustment, the excavator taking out too large a section for the length of the conveyor. If the peat is spread to an average thickness of 10 cm. on the drying-field, the length of the conveyor must be 10 metres for each square metre of cross-section excavated. These heaps of peat eventually dry out, but more slowly than the rest, and require some extra handling. The shape of the blocks is of little importance where the peat is required for industrial use, but, if required for transport and sale for domestic use, a regular shape and size is desirable and prevents loss.

The peat machine, including under-carriage, motor, macerator and dredger, weighs 5,000 kg., a movable turntable and spares make up 500 kg., and the 42-metre transporter and conveyor weigh 5,500 kg., so that the whole plant weighs about 11 tons, including rails.

The under-carriage has flangeless wheels, running in channel irons, supported on wide timber sleepers 4 in. thick by 12 in. to 15 in. wide, and, say, 5 ft. long. This method of support is very elastic and allows the machine to climb out of slight hollows, but sand has to be freely supplied to the channels to prevent the wheels slipping. The cutting face slopes at from 60 deg. to 75 deg. with the horizontal, or a batter of, say, 1 in 5. Even with an exposed face 2·5 metres high on this very dry bog considerable cracking and settlement of the face was observed. The slope of face may be varied from 45 deg. to 75 deg. and the depth of the excavation can also be varied between 1 metre and 4 metres by an ingenious system of driving.

The conveyor girder is supported on eight light caterpillar supports, spaced 5 metres apart. The caterpillar slats (Fig. 58) are of malleable cast iron, supported on a central chain with sprockets. Forward motion is given to the rear sprocket wheel by a ratchet worked by the tension on a long rod. Provision is made for adjusting each ratchet at its caterpillar as well as for a general adjustment at the end of the rod near the machine The machine can be moved forward at 28 metres per hour, but the usual speed is 9·5 metres per hour.

There are supports on the conveyor at regular intervals for carrying electric lamps (110 volts) for night working ; 3,000-volt, 3-phase current is transmitted to the moor on copper, iron or aluminium wires, supported on larch poles driven into the bog, the transmission lines being laid along the back of the drying-ground at each face. A transformer station is placed at the middle of each line, and the current is transformed down to 500 volt, 3-phase, which goes right and left on lighter wires. The current for the machine is picked up by a 150-metre length of flexible cable connected up at every fourth post, the posts being 40 metres apart. The machine takes about 40 h.p. and, for the night shifts, the lighting current is transformed at the machine to 110 volts. A 50-h.p. (37 kw.) 3-phase motor is provided, but only 40 h.p. is required, the macerator taking 20 h.p. and the transporter, dredger and forward movement the remaining 20 h.p. The current consumed is stated to average 5 kw.-hours per ton of peat produced.

FIG. 58.—Wielandt transporter with caterpillar bearings.

FIG. 59.—Wielandt sod transporter.

(4) *Output.*—The sod transporter is 42 metres long, and as it tips once in every 45 seconds the velocity of the issuing stream of peat equals 56 metres per minute. The area of the cross-section of the peat band is 112 sq. cm., so that the volume extruded equals

37·6 cub. m.* per hour, which, if taken as 90 per cent. moist peat, would be equivalent to 5·02 tons per hour of air-dried peat with 25 per cent. moisture. The maximum area of spreading-ground covered in two 10-hour shifts has been 210 metres long by 42 metres wide, and taking the average thickness as 10 cm., this equals 882 cub. m. in 20 hours, or 44·1 cub. m. per hour, equivalent to 5·88 tons of air-dried peat per hour, but this was an exceptional output for the machine. A forward movement of 190 metres in 20 hours would represent the maximum to be expected under ordinary conditions, and this would correspond to 798 cub. m. of raw peat spread, equivalent to 106·4 tons of air-dried peat in two 10-hour shifts, or 5·32 tons per hour. A further check is available—the machine has an output of 140 sods per minute and these average 0·60 kg. each when air-dried ; on this basis the output would amount to 5·04 tons per hour.

An output of 5 tons of air-dried peat per hour may be regarded as a reasonable figure on which to base production costs for the machine at Elisabethfehn. The power consumption is 5 kw.-hours to 6 kw.-hours per ton of air-dried peat excavated and spread.

If we take a working season of six months, including 2,100 actual working hours, the total output per machine per season would be over 10,000 tons. There are 10 km. of cutting face developed at Elisabethfehn and the one machine now working is said to cover the four 1·5 km. faces, or 6 km. in all, three times in the season. This would give 3 × 6,000 × 42 × 0·1 = 75,600 cub. m., or, say, 10,000 tons of air-dried peat per season.

The difficulty of providing so many long faces for machines of this type is dealt with elsewhere, and also the added difficulty when provision has to be made for sufficient machines to give an output as large as 100,000 tons per annum.

From four to five men—generally four—are employed on this machine, as follows :—

	1 stripper, cutting away the surface peat.
	2 men, shifting rails under the main machine.
	1 man, on motor.
	1 man, looking after the conveyor.
Total	5 men.

The two men shifting rails could be dispensed with if caterpillar mattresses were arranged under the carriage as in the Baumann-Schenck and Moore machines. The machine should then only require three men so far as the excavating, macerating and spreading are concerned, and if the surface peat were fit to use the stripper could be dispensed with and only two men would be required.

In the summer, two shifts of 10 hours are worked, namely,

---

* Cub. m. = cubic metre : 1 cub. m. of raw peat = one metric ton approximately, and 7·5 cub. m. of raw peat containing 90 per cent. moisture produces one ton of air-dried peat with 25 per cent. moisture.

4 a.m. to 2 p.m., and 2 p.m. to midnight. Last season it was proposed to work two 12-hour shifts on this bog.

Dr. Wielandt considers the effective length of his conveyor is limited to 42 metres to 50 metres on account of (*a*) the size of the section which must be excavated to fill the conveyor and spreading-ground ; (*b*) the inferior drainage conditions of the bog at over 50 metres from the face ; and (*c*) the cost of collecting and clearing the peat off a wider drying-ground when room must be found for a second spreading. He does not think it desirable to excavate deeper than 3 metres to 3·5 metres, owing to the weight of the dredger and the danger of the subsidence of the bog through the sliding out of the lower and softer peat. He recommends taking out the deeper bogs in two layers, but there are serious objections to adopting this course (p. 19).

The conveyor plates are horizontal, except when tipping and turning round at the ends, and as the plates are rubbing in contact with the outer and inner angle irons, considerable wear occurs. In the Dolberg sod-spreader provision is made for this by attaching rubbing strips to the plates to take up the wear.

Work begins at Elisabethfehn on March 20th to 25th and ends between September 1st and 20th, but the peat laid out towards the end of the season is only dried down to 50 per cent. moisture content. It is then clamped and remains unaffected by the frost. In the other districts of Oldenburg the season runs from March 1st to July 15th.

Dr. Wielandt states that his peat-winning machines are employed on the following works :—

Heseper Torfwerk, Meppen.
Vereinigte Torfwerke Janssen, Fehndorf b/Meppen.
Elektromechanisches Torfwerk Gross-hoppenbruch, Ostpreussen.
Salinenamt, Rosenheim, Oberbayern.
Stadtverwaltungen, Kiel, Oldenburg, Hamburg.
Friedlander Torf unds Kokswerke, Friedland in Mecklenburg.
Erziehungsanstalt Johannesburg b/Papenburg-Ems.
Torfwerk Hasenmoor, Einfeld in Holstein.
Staatliches Kohlenverteilungsburo, Klasienavee, Holland.
Staatliches Torfwerks Lamprechtshausen b/Salzburg.
,, ,, Worschach in Steiermark.
,, ,, Tiffen, Karnten.
,, ,, Keszthelyi, Nadasladany, in Hungary.
Others in Switzerland, Italy, Sweden, &c.

II.—Scharrel Brickworks, Oldenburg

(5) *Peat-winning Plant.*—The brickworks use peat fuel for steam raising for power purposes and also in conjunction with coal slack for firing the tile and brick kilns. The company own a part of the Wester Moor, 7 km. almost due south of Dr. Wielandt's coke-works. There were two automatic peat-winning machines at work in July, 1921, a Wielandt and a light pattern Strenge machine. Both were electrically operated, the current being transmitted on overhead lines from the brickworks.

The Wielandt machine, similar to that at Elisabethfehn, was not working when the writer visited the plant, as both the spreading-ground and working face on the part of the bog where it was standing were imperfectly drained, being worked for the first time. The machine was stopped while the drainage was being improved, as the peat was so wet that it lost its shape when tipped from the sod transporter. The operator, however, switched on the motors and the machine worked quite steadily, but the peat was too wet to retain its shape.

(6) *Light Pattern Strenge Automatic Machine.*—This machine excavates a section 2 metres wide by 1·75 metres deep from a vertical face. The buckets are really scrapers 2 metres wide, formed of light pressed steel plate, tipping at the top into a trough conveyor, which feeds the macerator. The weight of the excavator is supported by a derrick pole resting on the peat machine and guyed back to a point on the conveyor. The effective length of the conveyor is 35 metres, and it is supported at the rear on 16 rollers 18 in. diam. by 24 in. long, mounted between the outgoing and returning chain of plates and eight leading rollers in front of the conveyor. These 24 rollers are light pressed steel drums. Fig. 60 shows the dredger taken from

Fig. 60.—View of Strenge dredger from rear.

the rear and Fig. 61 from the front of the conveyor, looking back towards the peat machine. As will be seen, the macerator has a double mouthpiece and the double stream of sods is neatly cross-cut and well-shaped. Fig. 62 was taken when the conveyor plates were being tipped and shows that, with the machine at Scharrel, this operation does not take place simultaneously. In this case the peat sods are turned completely over and the plates, after tipping, remain vertical. The arrangement of the conveyor plate is as follows :—

Fig. 61.—Strenge conveyor.

Fig. 62.—Strenge light pattern conveyor tipping.

The conveyor plates "A" (Fig. 63) are pulled along by the chain " D," being kept in the horizontal position under the guide angle " B." When the band of plates is fully laden a pin on the driving chain engages a lever and this operates a mechanism which moves the angle " B " horizontally to one side into the position " B_1," clear of the plate "A." The plate "A" then tips itself automatically and the peat sods fall to the surface of the bog, as shown. After the plates have tipped the angle " B_1" swings back into the position " B," and the plates continue round the conveyor in a vertical position, as may be seen in Figs. 61 and 62. As the plates return to the macerator end they come in contact with an inclined rail, which restores them to the horizontal. This enters them under the angle " B," when they are again ready to receive the band of peat extruded from the mouthpiece of the machine.

As the conveyor band is an endless chain of plates, the process of charging the band is continuous. However, some time is required for the six spiral springs to pull the long angle iron " B_1" back to the position " B," and during that interval the plates drop to the vertical position and the peat is allowed to fall to the ground. This difficulty has been met by an arrangement which ensures the instantaneous return of a 2-metre length of the long angle-iron next to the macerator mouthpiece. The improvement has been effected on the Strenge machines at Fintlandsmoor, and it appeared to work satisfactorily. The peat machine and conveyor are pulled forward by a steel cable wound on a drum attached to the peat machine and passing through pulley blocks fixed to large anchors let into the bog about 100 metres ahead.

(7) *Output.*—The forward movement of the conveyor is about 10 metres per hour, and, taking the average depth of the peat spread as 10 cm., this would mean an output of 35 cub. m. of raw peat per hour, equivalent to 4·66 tons of air-dried peat per hour. The output may therefore be taken as approximately 4½ tons air-dried peat per hour. Four men are employed on the machine, working a 13-hour shift, i.e., 6 a.m. to 8 p.m., with one hour interval for meals.

III.—FINTLANDSMOOR PEAT WORKS, NEAR OCHOLT, OLDENBURG

(8) *Peat-winning Plant.*—The Fintlandsmoor G.m.b.H. Torffabrik controls over 5,000 acres of Fintlandsmoor, the depth varying from 2 metres to 5 metres. The moor is said to be one of the best-situated, as regards drainage, in northern Germany, and has been systematically drained for the last four years. A loading gantry constructed in reinforced concrete, on a double-line siding from the Oldenburg–Leer railway line near Ocholt, allows the peat waggons from the bog to be tipped directly into railway waggons, each having a capacity of 10 tons air-dried peat. The siding is about three miles from the portion of the moor where the peat machines are at work. Forty 10-ton waggons (400 tons) can be loaded per day, but so far only 20 have been filled. A small peat-fired steam locomotive hauls a train of 36 double side-tipping waggons containing 28 tons to 30 tons of peat fuel

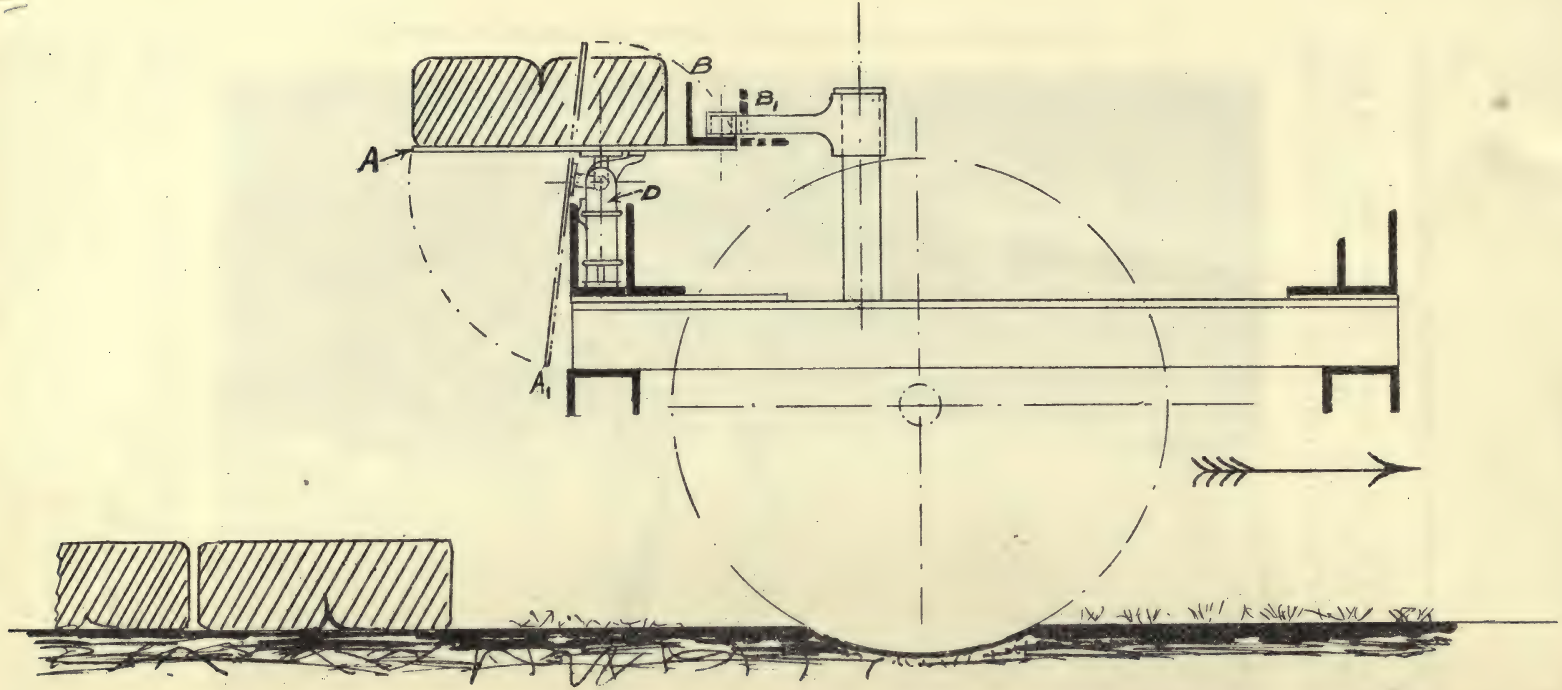


Fig. 63.

C&R Ltd 934.

from the moor to the loading gantry, where they are discharged. Ten waggons can be accommodated at a time on the top of the gantry. The metre-gauge line from the loading gantry to the bog is well graded and ballasted and stands comparison with the lay-out on any bog visited.

There are three light Strenge pattern automatic excavator, macerator and sod-spreading machines employed, the output being about 25,000 tons for the 1921 season. An output of 40,000 tons was looked for in 1922. Between 200 and 240 people (mainly men) are employed on the bog, and two shifts of 11 hours are worked.

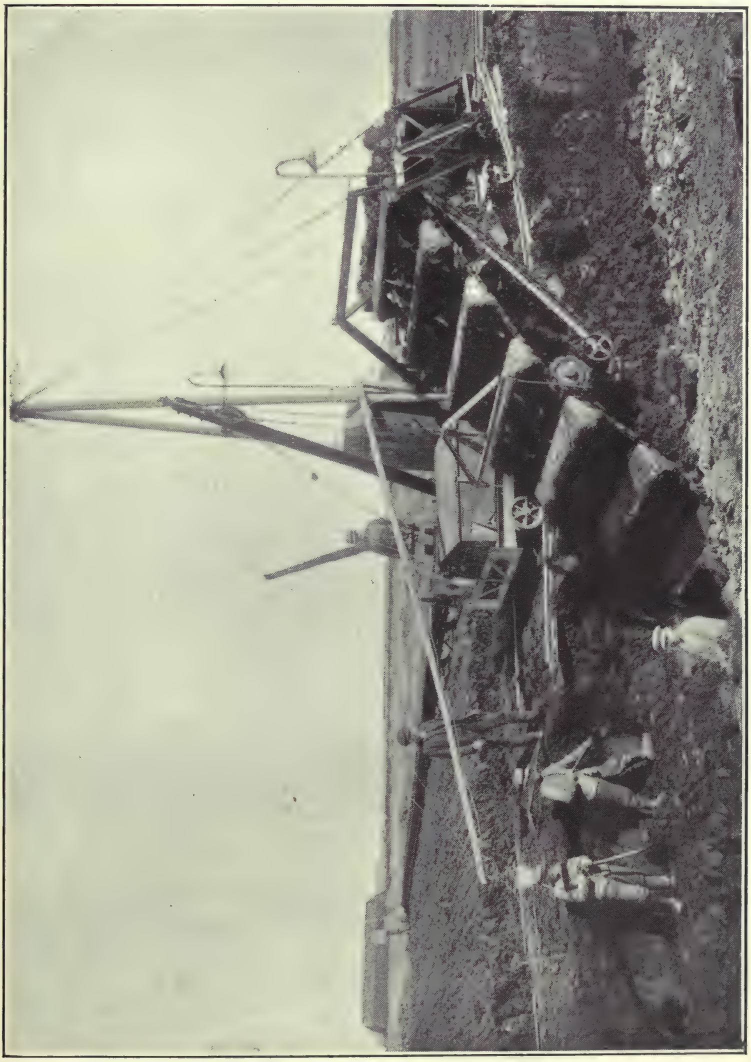


FIG. 64.—Electrically operated Strenge machine by Orenstein and Koppel.

The machines, made in a small works at Ocholt, have 35-metre sod transporters and are very similar to the one at Scharrel, except that they are operated from a 25-h.p. steam engine, fired with peat. The conveyor tips every 70 seconds and the usual progress is 100 metres to 120 metres forward per shift of 11 hours. The average progress in a day and a night shift may be taken as 200 metres, which is equivalent to an output of 100 tons of air-dried peat, or, say, 4½ tons per hour.

The working face is 3·25 km. long, and each plant operates on two such faces. From seven to eight men, including those attending to the steam engine, are required to operate the plant. With electrical operation less than half as many would be required. The overhanging weight of the dredger is balanced against the weight of the conveyor by means of a steel cable passing over a jib on the peat machine.

The peat-winning season on this moor extends from April 15th to August 1st, and the machines were still at work on July 21st.

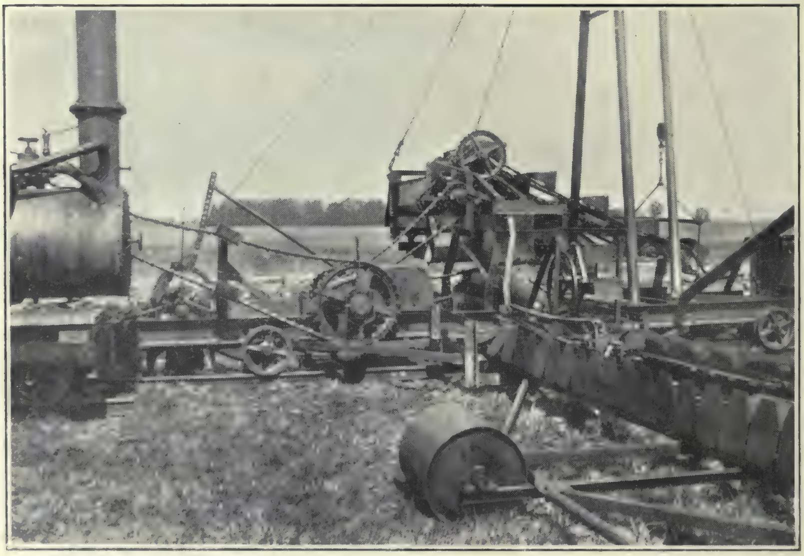


FIG. 65.—Strenge machine by Orenstein and Koppel, operated by steam engine.

Two spreadings of peat are made on each drying-ground during the season, but during the exceptionally dry season of 1921 three spreadings were said to have been made, the first spreading being dry early in June.

About one-half to one metre of the surface moss litter peat is stripped off and thrown on to the cut-away bog. The peat in this bog is very well drained, but it is difficult to accept the statement made that the moisture content is only 82 per cent. It is possible that it may average 87 per cent. near the face. The peat blocks are not turned, but when dry enough are lifted and " footed " and then collected into waggons and hauled direct to the loading gantry, so that the handling charges are low. The cost of the small Strenge machine, exclusive of the steam engine and boilers, was 200,000 marks in July, 1921 (about £750 at the rate of exchange then current).

The O. and K. Strenge automatic machines made by Orenstein and Koppel, illustrated in Figs. 64 & 65, with sod transporter, weigh 15½ tons, and, arranged for steam or electrical drive, but without engine or motors, cost £770 f.o.b. Hamburg, in December, 1921.

(9) *Modified Pattern Strenge Excavator.*—In a recent design Orenstein & Koppel have adapted the Strenge excavator to working in bogs up to 6 metres in depth. The peat machine is kept back about 3 metres from the working face, and the excavator, suspended from a jib, is made 4 metres wide and subdivided into four separate dredgers. Each dredger is 1 metre wide and removes a bench 1 metre wide by 1·5 metre high, the actual slice removed being 6 sq. metres cross-section. It is hoped that, by leaving the face stepped in benches 1·5 metre high by 1 metre wide, the 6-metre face exposed may be stable, but this is doubtful, and the mechanical difficulties inseparable from working four separate dredgers on the one shaft are obvious.

IV.—HAMBURG STATE BOG, HEIDERFELD, NEAR SIEGEBERG, HOLSTEIN

(10) *Plants in use.*—The moor at Heiderfeld, about 40 km. north of Hamburg, is at present being worked by the Hamburger State. The moor is an extensive one and there are 16 Dolberg plants and 14 by other makers at work on the bog. The scheme appears to have been instituted with the idea, firstly, to provide employment and prevent the spread of Communism amongst the unemployed in Hamburg, and, secondly, to provide peat fuel to make up for the shortage of coal existing in Germany owing to various causes.

The plants working at Hiederfeld are mainly hand-fed elevator macerator machines of the well-known Dolberg type, in which the peat extruded from the mouthpiece is received on boards and these boards transported on a small waggon to the drying-ground, where the peat is spread by hand. There is no electrical transmission on this bog, so that all machines are driven by small peat-fired steam boilers. While these machines with hand-fed elevators are very useful where the bog contains a large proportion of timber, they require a gang of some 14 to 18 men to work them, of whom 10 to 11 are solely employed in spreading the peat.

At Heiderfeld the gang operating the machine was made up as follows :—

Engine-driver	1 man.
Excavating (4 to 6)	4 men.
Feeding boards to macerator	2 ,,
Cutting to lengths	1 man
Loading trucks	2 men
Pushing trucks to drying ground and unloading	6 ,,
Total	16 to 18 men.

The output with this machine would be about 40,000 pieces of 0·40 kg. to 0·50 kg. each, say, 18 tons in 10 hours, whereas it was stated that under pre-war conditions the same number of men would have produced 60,000 to 80,000 pieces in 10 hours. The method of operating these machines and the lay-out of the bog may be obtained from Hausding's Handbook on the "Winning and Utilisation of Peat."

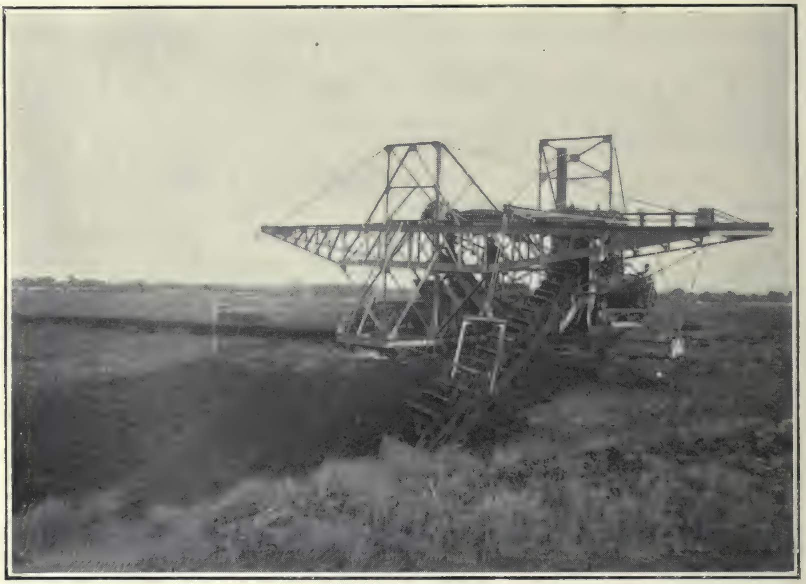


FIG. 66.—Automatic sod-spreading machine by R. Dolberg & Co.

When the output of a machine of this character is considered in comparison with one having automatic distribution, operated by not more than one-third the number employed on this machine, it will be clear that such machines can be of little interest in connexion with the development of the peat fuel industry on a large scale.

The majority of the machines employed at Heiderfeld had straight elevators, but some of the machines employed had bent elevators of the type illustrated in Fig. 69. This elevator, which has a short horizontal portion, allows the workmen to cast down large blocks of peat with little trouble, so that the amount excavated per man per day would considerably exceed that which would be possible with the ordinary straight elevator.

On the portion of the bog visited all the plants, with the exception of one, were of the elevator type. One of Messrs. Dolberg's most recent designs of fully automatic excavating, macerating and spreading peat machines was employed on the bog for part of the 1921 season. This machine is illustrated in Figs. 66 to 68. An inclined dredger is suspended from a counterweighted gantry, along which it may be traversed, the excavated peat falling into a horizontal conveyor, which takes it to the macerator. The dredger removes a slice from the sloping face of the bog, somewhat in the same way as the Anrep No. 1 excavator works at the Alfred bog in Canada. The links in the dredger chain are of substantial construction, and attached to every fourth link are sharp knives, which make vertical cuts as they are drawn through the peat. These knives are sufficiently sharp and strong to cut through roots 2 in. or 3 in. in diam., and should be well able to cut through and break up even larger trunks which are decayed. The buckets are really scrapers and their leading edge, which is curved and set at an angle, is kept very sharp in order to give sufficient cutting action. Fibre brooms are fitted at the head of the dredge chain and these brooms brush the edges of the knives after the buckets have tipped their charge of peat and remove the remains of cotton grasses, &c., which collect and interfere with the proper cutting action of the knife edges.

FIG. 67.—Near view of knives on excavator chain and horizontal screw conveyor.

Between the dredge chain and the spur wheel which operates it soft steel shearing pins are inserted which readily shear through before damage can be done to the dredge chain on encountering any tough material or obstruction. From the macerator the peat is delivered on to a chain of plates, by which it is conveyed out and automatically tipped on the surface of the bog. The sod transporter (ablegeband) of the machine at Heiderfeld is 58 metres in length and has an effective spreading length of 50 metres. It is built up in 10-metre lengths, and when moving from one face to another it can be dismantled into these lengths for convenience of transport.

The chain of plates embodies some improvements in design as compared with either the Strenge or Wielandt transporters. Every third link of the chain, which is shorter than the others, is supported on a small carriage with two wheels, so that rolling friction is substituted for the sliding friction in the case of the Wielandt and Strenge transporters. This must reduce the wear on the plates and the pull required to operate the chain, and it should therefore be possible to work this conveyor to greater lengths than in the case of other transporters. The importance of increasing the length of the conveyor has been dealt with on p. 20 of this report. Rubbing strips are also attached to the

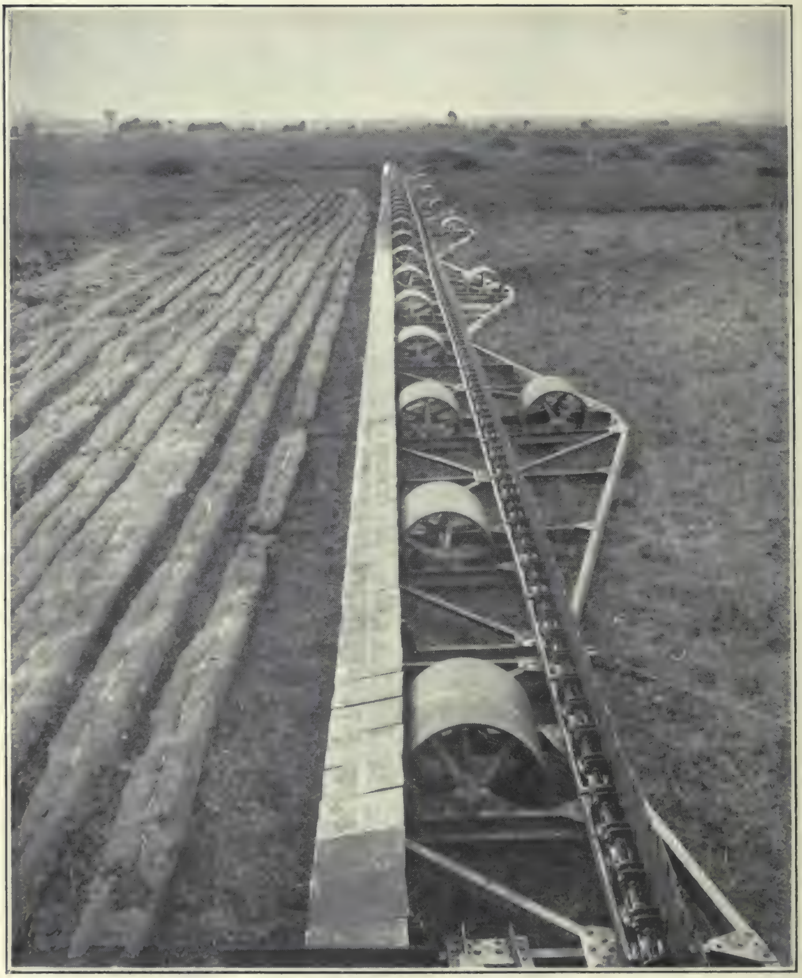


FIG. 68.—Dolberg sod transporter.

plates to take up wear, and in many other details careful design is exhibited.

The conveyor plates come into a horizontal position as they pass under the mouthpiece of the macerator, and are kept horizontal until the full length of the conveyor is loaded. The weight of the plates is taken by a longitudinal **T**-iron, and when the whole band is fully loaded a special arrangement removes a catch from the **T**-iron, which is then pulled forward by six strong helical springs. This causes the **T**-iron to swing vertically upwards around swinging links and tips the peat sods on the bog surface.

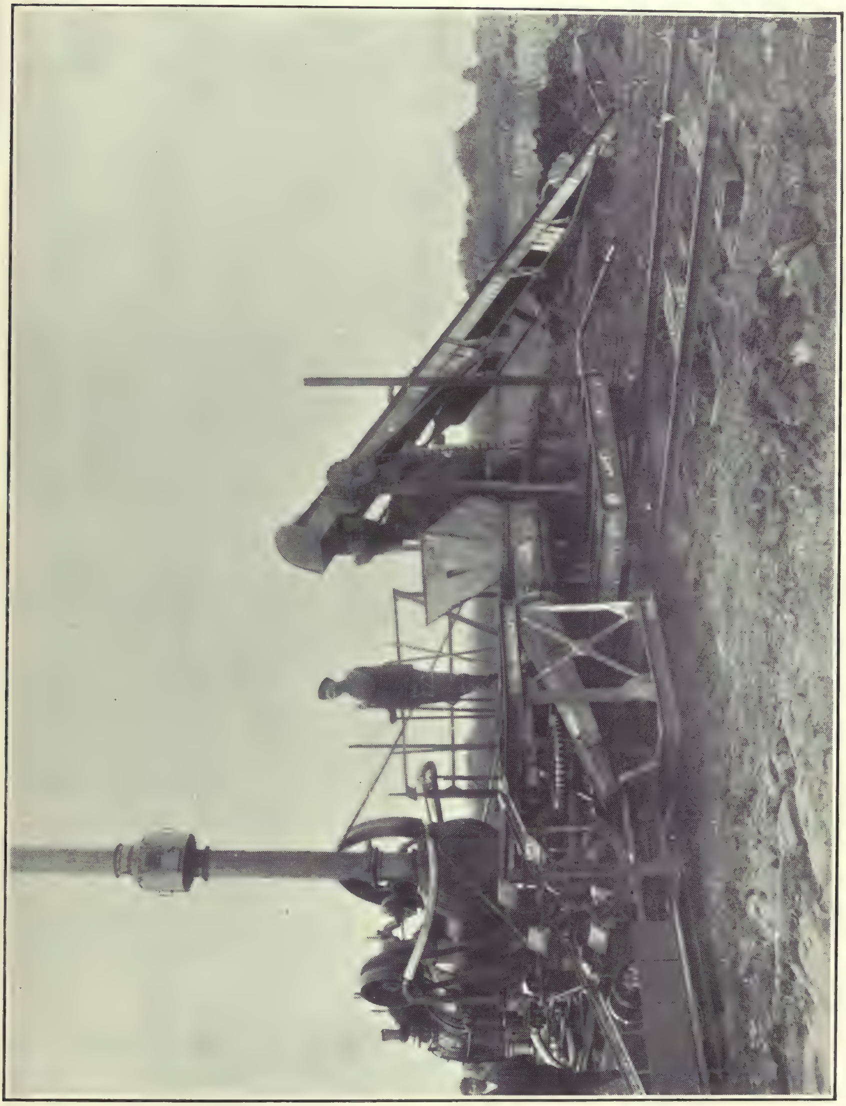


FIG. 69.—Hand-fed elevator with sod transporter, R. Dolberg & Co.

The peat is tipped from a height of 26 cm. over the bog surface and retains its shape very well. After tipping the plates remain vertical and travel on, passing round the other side of the transporter, still remaining vertical until they again approach the macerator. The actual weight of the complete chain of the conveyor is 22·3 kg. per metre, including plates, rollers and all accessories. About 3·5 h.p. to 4 h.p. are required to operate the 58-metre conveyor at a speed of 30 metres per minute.

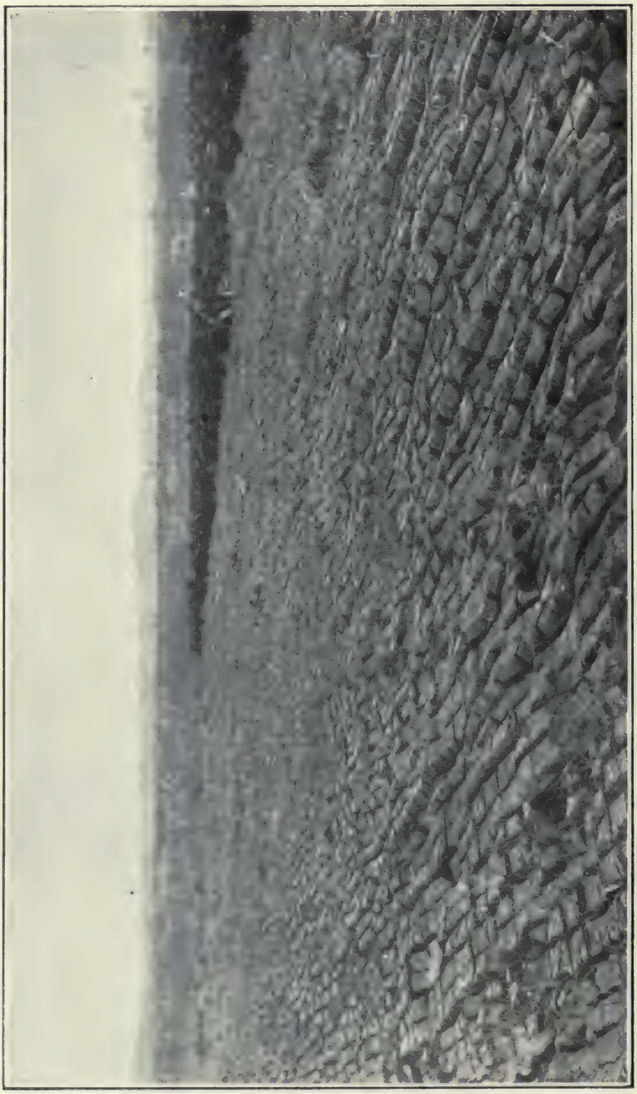


Fig. 70.—Peat spread on drying ground by Dolberg sod transporter.

The dredger and transporter are operated by one man, standing on a central platform. The power is supplied by a 35-h.p. steam engine which precedes the machine, the power being transmitted by a belt. The machine is mounted on a carriage in which a turntable is included, so that the machine can be turned round at the end of each run. The total weight of the machine, including dredger, gantry, gearing and conveyor, but excluding the steam engine, is 23 tons. The centre of the machine is at a distance of 7 metres from the edge of the trench being excavated. For economical operation this machine should operate on a cutting face not less than 3 km. in length, in order to avoid the delays attendant on removing the machine to another cutting face. The overhead gantry supporting the dredger appears to be rather top-heavy, but the weight of the dredger is counterbalanced by the tension in a steel cable connected at a point on the transporter, on which heavy weights are placed. Both the peat machine and the transporter are moved forward by the pull on a cable around an anchored sheave, the cable passing over a winch attached to the machine. Messrs. Dolberg have made four machines of this type. If an electrical drive were substituted for the present steam plant, synchronous motors could be fitted to drive the conveyor chain from both ends. This would permit its length to be increased from 50 metres up to about 100 metres, and would allow a larger section to be excavated from the face. The only objection to such a method would lie in the inferior drainage conditions existing at a distance of 100 metres in from the face and the difference in level or undulations occurring on the bog surface.

The plant at Heiderfeld was designed for an output of 45 cub. m. of raw peat per hour, which should produce about 6 tons of air-dried peat. In this way, working three 8-hour shifts, its output should be about 120 to 140 tons of air-dried peat per 24 hours.

The conditions under which this machine had operated at Heiderfeld during the 1921 season could hardly be considered favourable, as the machine had to cut its own trench and develop a working face. This meant lifting the ladder dredger up, laying it on the surface of the bog and then allowing it to cut vertically downwards until the proper slope was reached. Working in these adverse circumstances, the results appeared to be very satisfactory. Normally the ladder dredger will remain at a constant angle with the horizontal and, starting at the outside of the face, will shear off inclined slices perpendicular to the face, leaving at all times a sloping surface exposed.

The labour required to operate the machine is as follows :—

Firing steam boiler	1 man.
Driving machine and operating levers.. ..	1 ,,
Carrying forward rails and sleepers to support the machine	2 men.
Total	4 men.

Assuming that the peat layer spread averages 10 cm. in thickness and the effective length of the spreader is 50 metres, this will give 5 cub. m. of raw peat per 1 metre forward. As the machine travels about 8 metres forward per hour, this would give an output of 40 cub. m. per hour, equal to 5·33 tons of air-dried peat. The average output of the machine at Heiderfeld could not be placed higher than 4 tons per hour, but it is thought that this machine can be considerably improved. The cost of the machine in July, 1921, allowing for the rate of exchange, would be £2,000.

The Heiderfeld bog is about 6 metres in depth. Excavation was not carried to a greater depth than 4·5 metres. The bog contains a moderate amount of timber, and notwithstanding this, the dredger had operated satisfactorily, but if heavy undecayed timber were encountered it would not be possible to operate this dredger or any other of a rotary type.

(11) *Semi-automatic Dolberg Peat Machine.*—Messrs. Dolberg also make a machine in which a bent hand-fed conveyor with a horizontal portion is combined with a plate transporter for use in bogs containing timber (Fig. 69). With a machine of this kind the output is limited by the number of men who can be employed at excavating the peat. With five men excavating it should be possible to have an output of 25 to 30 tons of peat per 8-hour shift, or, say, 75 to 90 tons per 24 hours. The cross-section excavated is governed by the length of the conveyor. With a conveyor of 50 metres it is not possible to excavate a greater cross-section than 5 sq. metres, and this limits the number of men who can be employed at the cutting face.

V.—WIESMOOR PEAT-FIRED ELECTRIC POWER STATION

(12) *Development of the Power Scheme.*—The conception of the Wiesmoor " Zentrale " had its origin in the various schemes for peat development and bog reclamation which followed the formation of the Central Moor Commission in Prussia in 1876. The reclamation of Wiesmoor and the erection of the power station were largely due to the efforts of Dr. Ramm, of the Ministry of Agriculture.

It was proposed to reclaim and ultimately to cultivate about 15,000 acres of the Auricher Wiesmoor. To provide the necessary power for the reclamation an initial installation of 200 h.p. was first considered in 1906–7. The scheme was finally approved in the summer of 1907, and the erection of the plant commenced by the Siemens Schuckert Coy. in the spring of 1908. In 1908 the power supply was limited to one 200-h.p. compound engine, current being generated at 5,000 volts, 50 cycles, for local transmission. In January, 1909, the extension of the station was commenced, and a subsidiary company of the Siemens Schuckert (Siemens Elektrische Betriebe) was formed and entered into contracts for supplying current to Leer, Emden and Wilhelmshafen and other towns in the Duchy of Oldenburg. At first the manufacture of the peat fuel was under the control of the Government, convict labour being largely used for this purpose, and the Government contracted to supply as much peat fuel as was required at a fixed price of 5 marks per ton. This arrangement only continued for a short time, and convict labour has never been used for the peat-winning in connexion with the Siemens Elektrische Betriebe.

The new plant came into operation in December, 1909, and by August, 1910, it was increased to 5,600 kw. Since 1912 the plant has steadily increased to 7,320 kw., 11,070 kw. and, in 1919, another 10,000-kw. Zolley turbine unit was added, bringing the total installed plant to over 21,000 kw. Three-phase, 50-cycle current at 5,000 volts is generated and stepped up to 20,000, 40,000, and, for long distance transmission to Bremen, to 60,000 volts. In the year 1911, 7·8 million units were sold, rising to 9·5 million units in 1913, but no further statistics are available.

The following brief particulars about the scheme may be of interest :—*

The Wiesmoor Power Station (Fig. 71) lies some 11 km. north-east of Bagband on the Bagband to Friedeburger Road. The area of the bog operated by the Company is about 4,300 acres. The power station contains the following steam turbo-generators :

Two	1,250 kw.
Two	1,550 kw.
One	1,720 kw.
One	3,750 kw., and
One	10,000 kw.

All the steam turbos are of the Zolley type, some being made by Siemen's Schuckert, others at the M.A.N. Works. The most recent addition to the plant—the 10,000-kw. turbo-generator—was made by Escher Wyss, Zurich, and this unit was carrying the full load on the occasion of its inspection. In the boiler-room are four boilers with chain grate stokers, fired with coal, and eight boilers with step grates working on peat fuel. The coal-fired boilers use about 30,000 tons of coal and the peat-fired boilers, roughly, 60,000 tons of peat fuel per annum. The 10,000-kw. turbo-generator requires two cooling towers, using 1,600 cub. m. per hour, the water leaving at 10° C. There are, in addition, four other water-cooling towers with a capacity of 500 cub. m. per hour, the condensing water being obtained from the canal adjoining the works. Altogether about 70 men are employed in connexion with the work at the station.

The method of conveying the peat fuel to the furnace is interesting. The peat, filled into side-tipping waggons, is hauled up an inclined gantry and tipped over the various peat bunkers. There are eight bunkers each capable of holding 40 tons of peat, about 200 tons being used per day. Great difficulty was at first

---

* For further details and for the early history of this Station, see Teichmüller's paper, "Das Kraftwerk im Wiesmoor in Ostfriesland," an abstract from which may be consulted in "Peat, Lignite and Coal," by B. F. Haanel, Bulletin No. 299, Canadian Department of Mines, or Hausding's Handbook, "The Winning and Utilisation of Peat."

experienced in keeping the peat from arching and sticking in the bunkers. This was surmounted by placing a chute or trough to form the bottom of the bunker, this trough being suspended by a number of clamped oak battens. The trough at the bottom of each bunker is moved slowly forward against the resistance offered by the oak battens suspending it, and is then drawn rapidly back by an eccentric having a throw of 40 mm. During its slow forward motion the peat is carried with the trough and the quick return leaves the peat behind. The vibration of the trough resulting from the motion of the eccentric causes the peat in the bunker to quake and slip down to the bottom, where it

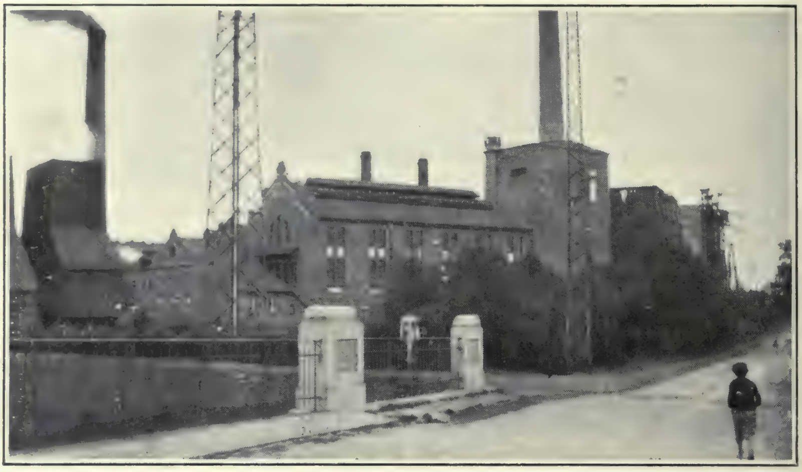


FIG. 71.—Wiesmoor Central Station, from canal bridge.

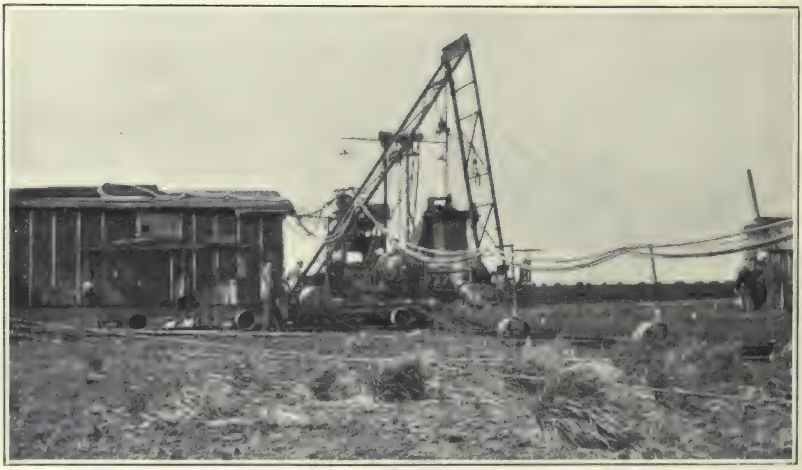


FIG. 72.—Siemens-Strenge peat machine.

continuously feeds the trough, so that there is no jamming. About 15 cwt. of peat are fed at a time on to the step grate, which has a slope of 45 deg. A thick bed of fuel is maintained on the grate and, as the peat at the bottom of the grate becomes consumed the upper peat slips down, giving an automatic feed. The air supplied to the grate is readily controlled by openings in the large doors, which give access to the grate underneath. To prevent the accumulation of large volumes of light peat ash, a small jet of water is allowed to trickle down on the floor of the furnace chamber, and this rapidly reduces the quantity of ash to be dealt with.

FIG. 73.—Macerator and transporter.

FIG. 74.—Cross-cutting device and transporter loaded with peat.

The average result obtained from peat fuel at Wiesmoor is a consumption of 3·0 kg. per kw.-hour. The best result obtained with peat was 2·2 kg. and the worst 4·5 kg. per kw.-hour. With coal, the best result was 1·2 kg. per kw.-hour.

Fig. 75.—Conveyor band tipping.

The current generated is first of all steadied in a transformer to 5,000 volts, previous to being stepped up to 20,000, 40,000 or 60,000 volts for long-distance transmission. Current is transmitted to Norderney and arrangements were in contemplation for supplying current across the frontier to Holland.

Fig. 76.—Outside end of conveyor with synchronous motor.

The following details were supplied by Herr Heinrichs, Director of Works :—

About 700 to 900 men are employed on the bog from March till August during the height of the peat-winning season, three 8-hour shifts being worked both on the bog and at the station. As the usual output is about 60,000 tons per annum, this would represent an output of only 75 tons per man per season, which seems small. Before long it is hoped to increase the output of peat fuel to 100,000 tons per annum, and the engineer at the station expressed a preference for peat fuel, but stated that even with an output of 100,000 tons of peat fuel per annum the four coal-fired boilers would be retained as a reserve against a possible failure of the peat supply during a bad season. The peat season extends from March 1st to July 21st or 30th.

FIG. 77.—Elevator transporter machine, Wiesmoor.

In 1912 the production of peat fuel was 31,000 tons and in 1913, 40,000 tons, and two large Strenge automatic machines with 12 to 35 Dolberg hand-fed elevators were employed. In 1921 four large-sized Siemens-Strenge excavators with automatic plate conveyors for spreading the peat, and two large Dolberg-Strenge hand-fed elevators with plate conveyors attached, and six Dolberg hand-fed machines were employed to produce some 59,000 tons of air-dried peat.

(13) *Large Strenge Automatic Machine.*—These machines were originally designed by Strenge, but have gone through various stages of development, and the present models (Figs. 72 to 76) at Wiesmoor have been improved by the Siemens Elektrische Betriebe. The complete machine, operated by nine men, weighs about 50 tons and about 65 h.p. is required to work the plant. The sod-spreaders on the large machine at Wiesmoor are 70 metres long. One machine with a conveyor 100 metres long has been tried, but did not prove successful.

The excavation is performed by a vertical bucket dredger, which is supported on a horizontal shaft, the outer end of which is carried by a vertical frame supported on the cut-away bog. The near side rests on the peat machine, which works on the surface of the uncut bog. Owing to the weight of this part of the plant, it may be fairly stated that it would not be possible to support such heavy weights near the vertical edge of a deep bog, and it would be equally impossible to carry the outer support for the excavator element on the cut-away bog. At Wiesmoor, were it not for the experience of the men operating the plant and the drainage conditions available, such a system would not be possible.

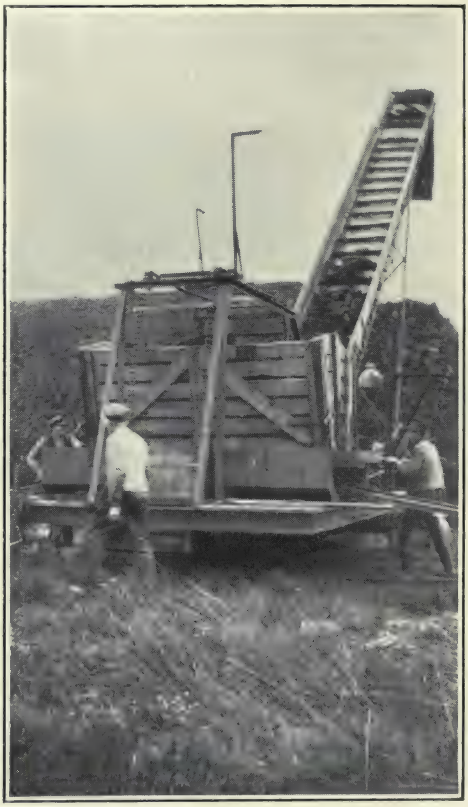


FIG. 78.—Elevator machine for stacking air-dried peat.

The section excavated at Wiesmoor is 4·5 metres wide by a depth of 1·75 metres, equal to 7·87 cub. m. per metre forward, the upper three-quarters of a metre of surface peat being stripped off and thrown on to the cut-away bog. The peat from the excavator is conveyed to the large macerator shown in Fig. 73. From the macerator the peat is extruded in a band 9 in. wide by about 4½ in. deep, the band being divided along the centre. This band of peat is automatically carried forward by a chain of plates very similar in operation to the transporter on the smaller Strenge machines, and when the full length of the 70-metre conveyor is loaded the peat is automatically tipped on to the bog surface. A paddle-wheel arrangement divides the peat stream into lengths of 40 cm., so that when tipped on the surface of the bog the dimensions of each block will be 16 in. long by 4½ in. by 4½ in. cross-section. The rate at which the peat is excavated varies somewhat and with it the velocity at which the peat stream issues from the macerator. For efficient working, the velocity of the chain of plates should coincide with the velocity of the issuing peat stream. To effect this, a workman operates a switch by means of which the speed of the chain of plates is regulated. Fig. 73 shows the end of the macerator and the chain of plates and paddle-wheel dividing the peat band into lengths and also the operator controlling the speed of the transporter—the transporter advancing towards the camera. Fig. 74, taken from the rear, shows the issuing peat stream and the peat on the conveyor. The wavy appearance of the band of peat on the conveyor is the result of the speed of the conveyor not equalling that of the issuing peat stream. Fig. 72 gives a general view of the peat machine in which the various electrical meters and transformers are installed. Fig. 75 gives a view of the spreading-ground and also of the transporter in the act of tipping. Fig. 76 shows the outer end of the 70-metre transporter attached to the large Strenge machine, the motor on the left-hand side of the picture working synchronously with the motor driving the chain close to the excavator. The transporter is supported by a number of rollers, and it is pulled forward by means of a cable arrangement.

The cross-section excavated is roughly 1·75 metres × 4·50 metres, which corresponds with 7·87 cub. m. per metre forward. Taking the width of the drying ground as 70 metres and the average thickness of the peat spread on the drying-ground as 11 cm., this will give 7·7 cub. m. per metre forward, corresponding to a little over 1 ton of air-dried peat per metre forward, if 90 per cent. moist peat is spread. Owing to the variation in moisture content, the yield might easily vary 5 per cent. either way.

At Wiesmoor, in three 8-hour shifts the distance travelled by the excavator varies from 200 metres to 240 metres, corresponding with an output of 200 tons to 240 tons per 24 hours. When the excavation is proceeding at its maximum rate the 70-metre band of peat is tipped once in every 65 seconds. This would give an output of 102·5 cub. m. per hour, corresponding to about 330 tons in 24 hours' continuous work. However, owing to stoppages due to various causes and interruptions for meal-times, it would not be safe to take more than two-thirds of this figure, or an average of 220 tons per three 8-hour shifts.

The peat-winning season at Wiesmoor extends from March 1st to July 21st, or for 143 days, and deducting Sundays and bad weather, this should allow of a 100 working-day season. The output of four of these machines should, therefore, amount to 88,000 tons per season, but it is of course quite possible that the four large machines did not work continuously throughout the season, as the total output during last season was stated to amount to only 59,000 tons of air-dried peat.

(14) *Dolberg-Strenge Hand-fed Machine.*—The two Dolberg-Strenge machines with hand-fed elevators are fed by four to six men and were stated to have an output of 40 tons of air-dried peat per 8-hour shift, or 120 tons for 24 hours. From the macerator the peat is distributed by a plate conveyor (sod-spreader) 35 metres in length and, in addition to the excavators, the machine requires one motor driver and two men working on the field, that is to say, from seven to nine men altogether. Fig. 77 gives a view of the elevator, the bog at this point being about 3 metres deep. This machine would appear to offer possibilities of working where timber is to be found in the bog, and as the elevator and macerator portion of the machine is much lighter than in the larger type, there is less risk of settlement and splitting of the face.

For stacking the air-dried peat in the large stacks near the power-house the elevator shown in Fig. 78 is used. The trucks, loaded with peat, are hauled up a slight incline and tipped over the elevator, which then lifts the peat up and places it on the stack. A considerable amount of breakage was produced by this machine, and tipping from the permanent trestle constructed over some of the stacks seemed to give much better results.

(15) *Large Siemens Elektrische Betriebe Peat-winning Machine.*—A large automatic dredging machine built by the Siemens Elektrische Betriebe on the Strenge system is worked by Messrs. Schmidt, Kuck & Co., at Südmoslesfehn, about 30 km. to 40 km. east of Oldenburg on the Hunte–Ems Canal. The chain of buckets works vertically as at Wiesmoor and excavates a section 6 metres wide by 2 metres in depth, advancing about 10 metres per hour. The machine measures 130 metres long, of which the sod transporter accounts for 104 metres, with an effective length of 90 metres.

The output of this machine is said to be equivalent to 13 to 15 tons of air-dried peat per hour. It is served by eight to ten men and requires five or six motors of a total capacity of 140 h.p., the current consumption being 1,000 kw.-hours per day. The machine is hauled forward by a motor winch mounted on a truck, 200 metres ahead of the plant.

The chain of plates has a speed of 90 metres per minute and tips every 60 seconds, but as the sods are tipped from a height of 20 in. they are badly damaged and deformed. It takes twenty men three and a half days to change the direction of the machine, and the first cost of the plant was high.

VI.—RAUBLING PEAT WORKS, UPPER BAVARIA

(16) *Baumann-Schenck Automatic Peat Machine.*—A plant designed by F. R. Baumann and constructed by Carl Schenck, of Darmstadt, was tried about nine years ago and has since been improved in many of its details. Two of these machines are at work on the Bavarian State Peat Works, Raubling, Upper Bavaria (Bayerische Landestorfwerke).

The output of raw peat is from 40 cub. m. to 42 cub. m. per hour, or approximately 5·5 tons of air-dried peat per hour, and both the excavator carriage and the sod-spreader are mounted on caterpillar supports. In the machines now being made the suspended excavator arm has a dredging length of about 11 metres, which, when inclined 40 deg. to the horizontal, is sufficient for a bog 6 metres deep. Rotating on this arm is a chain of scraper buckets and alongside it, working in a slide, are six wheels with radial arms, each arm bearing **L**-shaped cutting knives. These wheels and cutting knives rotate rapidly and at the same time move together in the slide, slightly upwards and downwards, so as to completely cover the exposed face. The knives are intended to cut the peat and any light timber which may be found in the bog. At the same time they locate heavy timber before the dredger encounters it and shearing pins are inserted which, by giving way, prevent any damage. The knives loosen the peat and push it into the track of the scrapers, by which it is elevated and tipped on to a conveyor, which carries it further to the macerator mounted on the main platform of the machine.

In the most recent design the wheels are about 1·5 metres in diameter, but in an earlier pattern, which is still working on the Raubling Bog, there is only one cutting wheel of 2 metres diameter, which traverses up and down the whole length of the dredger arm.

Each peat block is formed separately and in a different manner from any of the other peat machines. The peat as it extrudes from the mouthpiece of the macerator enters a drum in which the blocks are moulded in separate radial sectors and placed on the plates of the conveyor. The conveyor varies in length from 26·5 metres to 106·5 metres by the addition of 20-metre sections, the normal length being 66·5 metres, with an effective spreading length of 64 metres. The plates of the conveyor are 45 cm. × 16 cm. and run in a supporting girder 65 cm. deep by 50 cm. wide. The lower loaded chain travels at a height of about 60 cm. above the surface of the bog and each plate is hinged at the leading end about an axis attached to the chain. The plates are kept horizontal by pins running on two guide rails and when the latter are withdrawn the plates swing downwards into vertical positions, tipping the peat blocks on to the bog.

The cost of this plant, with a sod transporter 86·5 metres long, but exclusive of motors, was (April, 1922) £1,700. The cutter requires a 20-kw. motor and the excavator and other parts of the plant are driven by a 40-kw. motor.

VII.—MANUFACTURE OF PEAT FUEL IN SWEDEN

(17) *Anrep Svedala Macerators and Persson's Conveyors.*—The Anrep Svedala Macerator (Fig. 79), made by Messrs. Abjörn Anderson at Svedala, is considered the most effective of the Swedish macerators. It contains fixed and rotating knives in addition to the helical screws which push the peat through the body of the macerator. It is now universally accepted that all peat must be thoroughly macerated to obtain the best results, so that a macerator is an essential part of any peat-winning machine.

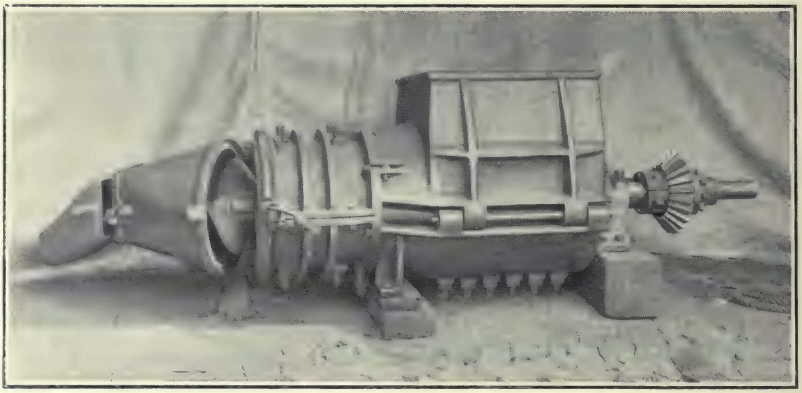


FIG. 79.—Anrep-Svedala macerator (Abjorn Anderson).

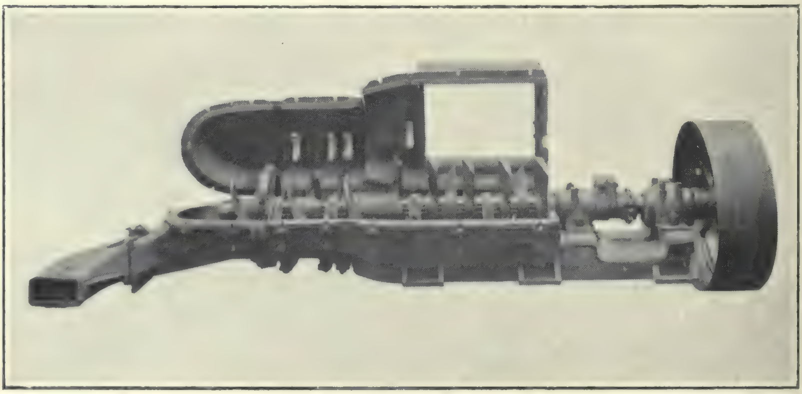


FIG. 80.—Koppel-Anrep macerator.

Messrs. Abjörn Anderson construct a machine with a hand-fed elevator in two sizes, i.e., the No. 1 and No. 2 Anrep Svedala machines. Many of these machines can be seen at work on the Swedish bogs, which, generally speaking, contain so much buried timber that it is difficult to work one of the dredger type ; in fact, the timber in some bogs is so dense that it would be almost impossible to get the peat out by any kind of excavator, unless by the "hydro peat" process and pumping (p. 143).

The wide use of these Anrep machines in Sweden, in conjunction with Persson's conveyors, and the general testimony as to their reliability, would seem to warrant a brief description. The machines require the services of three to five men digging the peat and casting it on to the elevator, and, although the Persson's conveyor is not an automatic distributor, yet it takes the loaded peat pallets from the machine and conveys them to distances of 100 and 200 metres from the cutting face, or from two to five times farther than the automatic sod-spreaders in Germany (35 metres to 100 metres).

The pallets or boards, loaded with peat at the mouthpiece of the macerator, move down a roller table, the peat being cut into lengths by hand as it is extruded from the mouthpiece. A short horizontal part of the roller table is supported by a trigger device until the loaded board of peat strikes the trigger. The table then sinks and lowers the peat pallet on to two endless wire ropes of the Persson's conveyor, by which it is carried out to the men engaged in spreading the peat. When the table is relieved of the weight of the loaded pallet, counter-weights bring it back into position, in which it is held by the re-set trigger until the latter is again struck.

The Persson's conveyors are made in lengths of 100 metres to 200 metres, the usual length being 150 metres. They consist of two endless cables passing over trestles, the upper horizontal member of the trestle consisting of a roller over which the cables pass. The trestles are spaced 8 to 10 metres apart and they are mounted on skids, so as to slide easily over the bog surface when the conveyor is moved forward. At the outer end of the conveyor a carriage running on rails and weighted with large stones is arranged to apply tension to the cables, which pass around wheels and return to the peat machine. The cable is operated from the peat machine and the anchor carriage at the outer end is held in position by large anchor plates driven into the bog. Guides are provided at every fifth trestle to prevent the wind blowing the cables off the supports. There are usually two or three men provided along the cable for lifting off the loaded boards of peat and tipping the peat on to the bog surface. As a rule the band of peat tipped from one position of the conveyor contains about 25 boards of peat. The empty boards are placed on the returning cables which bring them back to the machine, where an arrangement exists for automatically lifting them off the cables.

The boards used are 4 ft. 6 in. long by 7 in. wide and 1 in. thick. As previously stated, the peat on the boards is usually cut to lengths by hand at the machine, or else by circular discs as it passes over the conveyor, but sometimes it is cross-cut by means of a disc cutter after being spread on the ground. Fig. 81

shows the lay-out of the conveyor and spreading-ground as used in connexion with a machine of this type made by Orenstein and Koppel, of Berlin. These conveyors adapt themselves very readily to working over the rough or undulating surface of the bog, and they can be used to convey the peat across wide drains or other depressions. On practically all the bog areas great care is taken in preparing the surface of the drying field by levelling where necessary and also cutting covered-in bog drains.

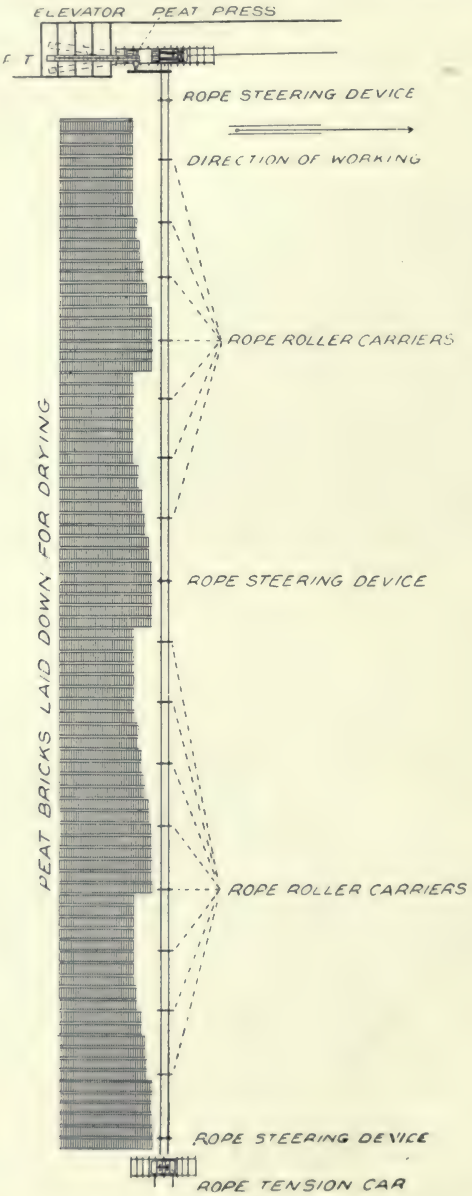


FIG. 81.

Some of the peat machine elevators are arranged parallel to the working face, but in others the elevator is perpendicular to the face. In all cases the working face is left vertical and heavy cracking and slipping of the face was seen on most bogs, however well drained the bog happened to be. The portion which slips in after the machine has passed by is excavated and utilized when the machine comes along next time.

Owing to the widespread system of hydro-electric supply in Sweden the machines are almost all electrically driven—25-kw. to 37-kw. 3-phase motors with 1,600-volt current, being used. With electrical operation seven to eight men and two youths are employed in working a plant of this type, as follows :—

Excavating	3 to 4 men.
In charge of engine	1 man.
Feeding boards and cutting to lengths..	2 youths.
Taking boards off conveyor and spreading the peat	3 men.
Total	7 to 8 men and 2 youths.

The output of such a machine with the above gang would be, roughly, 25 tons to 30 tons per 8-hour shift.

The Persson's conveyor with roller table and stretching gear costs about £300. The elevator, macerator and 150-metre Persson's conveyor has a combined weight of 10½ tons and costs £750, exclusive of motor.

Messrs. Abjörn Anderson also make a peat dredger which is used in connexion with the Anrep macerator and Persson's conveyor. On account of the increased output of the excavator as compared with hand excavation, two roller tables and two conveyors are provided. The first Persson's conveyor has a length of 100 metres and peat is spread from it up to a distance of 100 metres from the peat machine. The second is 200 metres in length and the peat from it is spread from the end of the 100-metre conveyor to 200 metres from the machine. A plant of this type has been working since 1919 for the Skattkarr Peat Fuel Coy., near Karlstad, Sweden. The capacity of the machine is said to be 50 cub. m. to 60 cub. m. of raw peat, or 6⅔ tons to 8 tons of air-dried peat fuel, per hour. It weighs 25½ tons and requires the following motors :—

15 h.p. for the excavator.
40 h.p. for the macerator and truck.
25 h.p. for the conveyors.

The cost in September, 1921, was £2,500, exclusive of motors.

On a bog about 50 acres in extent and 2 metres to 4 metres in depth, about 10 km. north of Svedala, two Anrep Svedala machines with the 150-metre Persson's conveyors were working during the 1921 season. The bog, which is worked to a maximum depth of 3 metres, contains a considerable quantity of timber at all levels, but particularly from a depth of 2½ metres to the bottom.

The bulk of this timber is well preserved and it would be impossible to excavate the peat with any rotary type of excavator.

The cost of production on the bog (July, 1921) was stated to be 15 Kr. to 20 Kr. per ton and it was sold in the district at 30 Kr. to 35 Kr. per ton, the price of coal at the time being about 70 Kr. per ton.

VIII.—SJÖHOLMEN

(18) From Eslöv to Sjöholmen the country is covered with extensive stretches of bog. Near to the latter place a large area of bog has been systematically laid out for a big production of peat, the actual output being about 20,000 tons. A narrow-gauge track with overhead conductor runs from a loading gantry and a large peat shed at the station, through the scrub to the bog a couple of kilometres away. On the bog itself eight machines of the Anrep Svedala type with Persson's conveyors, manufactured by A. B. Korners, of Eslöv, were at work during the 1921 season. The 1,600-volt, 3-phase power-lines from the hydro-electric supply are supported on larch poles driven into the bog along the cut-away portion between the working faces, the current being tapped by a flexible cable at each pole as required. Motors are 30-kw. capacity and use 1,600-volt 3-phase current without transforming. The Persson's conveyors were 100 metres to 150 metres in length and the cross-section of the peat block as spread was 5 in. × 5 in.

The peat-winning season at Sjöholmen extends until July 20th. All the stacks of air-dried peat are set out in regular lines and formed to template in order to facilitate stocktaking. The peat on this bog produces a very good fuel.

IX.—A. B. ROGESTORPS BRÄNNTORVSFABRIK, FALKÖPING, SWEDEN

(19) *A.H.W. Automatic Peat Machine.*—The peat works of this Company are situated at Rogestorps, about 5 km. from Falköping. They have two A.H.W. (Wielandt system) automatic peat-winning machines on a bog of 500 acres, and manufacture peat fuel for sale either for industrial or domestic use. It is interesting to note that the Company also manage, in connexion with the peat works, a farm of a couple of hundred acres, part of which is on bog-land and part on the uplands.

The peat on this bog is a marsh peat and the bog has been well drained and the surface cultivated. The surface is very level and covered with a fair growth of grass, which is grazed by cattle when not required, after the peat-winning season is over. About 9 in. of the surface peat is stripped off in front of the machine and thrown to the bottom of the bog.

Owing to the exceptionally favourable season (1921) the Company had secured all the peat required by an early date and the slump in the demand for peat fuel, owing to its cost as a result of the high wages prevailing in Sweden, did not warrant them in continuing work after July 7th. The usual length of the peat-winning season at Rogestorps is April 15th to July 20th.

The A.H.W. automatic peat-winning machine is manufactured under patent licence from Dr. Wielandt by the A. B. Hässleholms Werkstader at Hässleholms. It is similar to the German Wielandt machine, except that the details have all been re-designed and some slight changes made by the Swedish manufacturers. An Anrep Svedala macerator with a single shaft and rotating and fixed knives has been substituted for the double-shaft macerator having a mixing action only. Better maceration should therefore be produced.

The machine is operated by a 50-h.p. motor, deriving its current through a leather-sheathed, insulated, flexible cable, connected direct to the 1,600-volt 3-phase hydro-electric supply for the district. The motor rarely has to develop more than 35 h.p., and only one fatality has occurred through the use of such a high voltage as 1,600 volts. On that occasion a short circuit caused the death of one of the operatives who happened to touch the conveyor.

The bog is about 3 metres in depth and the dredger works to a depth of 2½ metres. It is freely admitted by both the makers of the machine and by Captain C. G. Son. Lagercrantz, Managing Director of the Rogestorps Company, that the dredger is not built to work in bogs containing timber or roots. In the Rogestorps bog, which is free from timber, it works most satisfactorily and could be constructed to excavate peat to a depth of 4 metres below the surface.

A large bearing plate pressing against the sloping face of the bog helps to take up the unbalanced weight of the dredger, as in the German Wielandt machine. Fig. 82 gives a general view of this machine in operation at Rogestorps, the light band appearing on the excavated face being due to the bearing plate.

The conveyor or sod transporter at Rogestorps has an overall length of about 32 metres from the face and an effective length of 26·8 metres, and consists of an endless chain of plates which tips every 41 seconds and carries 67 pieces of peat each 40 cm. long. The output is approximately 6,000 pieces per hour, each weighing 0·833 kg. when air-dried to 25 per cent. moisture content, or 4·94 tons air-dried per hour. Allowing for stoppages, the output would average 4 tons to 4½ tons of air-dried peat per hour over the whole season.

The outer angle-iron supporting the loaded chain of plates is kept in position by a catch, and when this catch is withdrawn the spiral springs attached are no longer able to support the weight of the loaded band, the angle-iron sinks, allowing the plates to tip the peat on the bog. When the plates are empty the springs are strong enough to restore the chain of plates to the horizontal and the catch is again engaged.

The sod transporter is supported on a number of cylindrical drums or rollers, about 18 in. in diameter, with spiral ribs attached.

The drums nearest the machine are moved forward by a ratchet operated by a long rod worked from the peat machine. The drums at the outer end of the transporter are operated from the chain of plates.

For excavating and spreading the peat the following team is employed :—

1 stripper.
1 man digging to help excavator in the taking out of a section wider than the buckets of the machine, the bog at this point being rather shallow.
1 motor man.
2 men carrying rails and at odd jobs.

Total 5 men.

When the peat is sufficiently dry to stand handling it is placed in "wind-rows" and later in "rickles" with a base 3 ft. in diameter and 2 ft. 6 in. high. At a later date it is collected into stacks containing 100 tons. The harvesting operations are chiefly carried out by women, and the piece-work rates paid at Rogestorps in July, 1921, were as follows :—

Placing in wind-rows	5·00 Kr. per 10,000 pieces.
,, rickles	5·50 Kr. ,, ,, ,,
Collecting and stacking, ·85 Kr. per cub. m. in stack	21·42 Kr. ,, ,, ,,
Total	31·92 Kr. ,, ,, ,,

As 10,000 pieces of air-dried peat with 30 per cent. moisture weigh about 9 metric tons, the harvesting charges amount to 3·54 Kr. per ton (4*s.* 3*d.* per ton at the rate of exchange ruling in July, 1921), or 3·82 Kr. (4*s.* 6*d.*) per ton of 25 per cent. moist peat.

In addition to the two A.H.W. machines at Rogestorps, the A. B. Torvindustrie have three similar A.H.W. machines at work at Slutarp, not far from Rogestorps. There are also several others in Sweden and Norway.

The Hässleholms Werkstader have recently made an A.H.W. automatic peat machine with caterpillars under the truck carrying the dredger and macerator. This should enable two men employed on laying rails to be dispensed with. Fig. 82 shows the machine driven by an oil engine, the dredger—which is of the usual Wielandt type—being omitted.

X.—Manufacture of Peat Powder in Sweden

The preparation and use of peat powder for power production has been practically confined to Sweden and Finland. In 1907 a factory was set up at Bäck, about 20 miles east of the recently constructed powder factories at Vislanda and Vakö. A system developed by Lieutenant Ekelund was used and may be said, briefly, to consist of the excavation, maceration and spreading of the raw peat, containing, say, 90 per cent. moisture, in the form of a layer 10 cm. to 12 cm. thick on the surface of the bog. The peat was excavated by a Munktell digging machine supported on the subsoil of the bog, which was of a sandy nature. During 1910 the Munktell excavator was improved by Ekelund and its output estimated at 35 cub. m. to 40 cub. m. per hour. In addition, a clay-digging machine by Abjörn Anderson, of Svedala, was employed, which worked on the surface of the bog. This proved too heavy, weighing 18 tons to 20 tons, and its weight was not sufficiently well distributed.

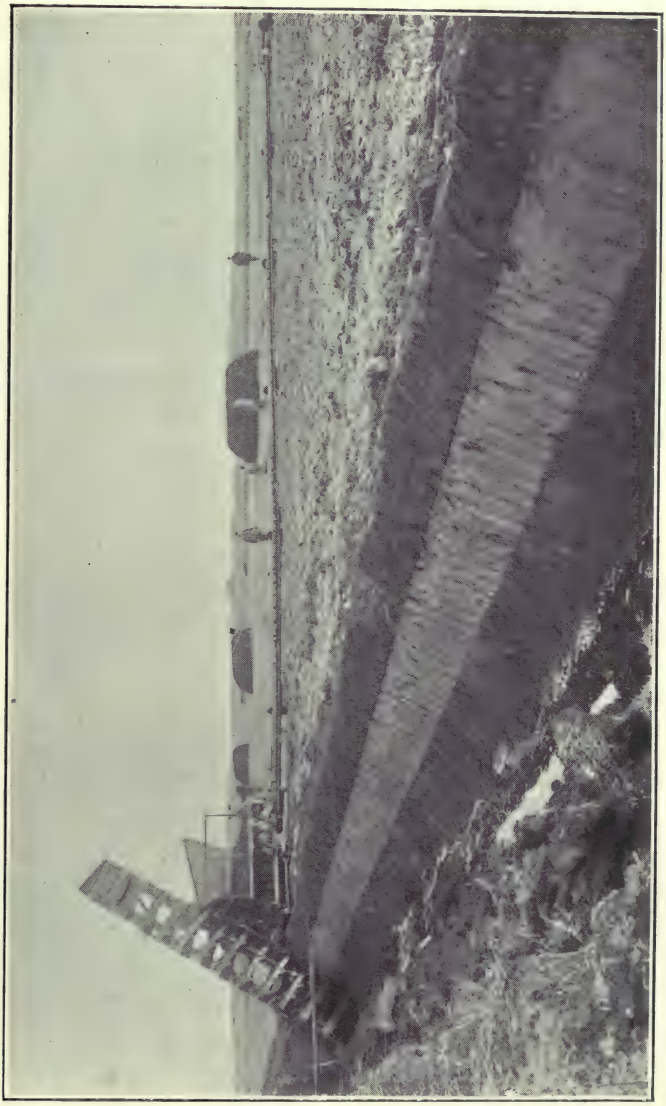


Fig. 82.—A. H. W. automatic machine at Rogestorps, Sweden.

During 1912 two new machines were installed at Bäck, and these Munktell-Ekelund machines were earlier types of the machines which are now used at Vislanda and Vakö. The wet peat was dumped in heaps on the bog surface and then spread by an Ekelund field press and dried by ordinary methods to 35 per cent. to 50 per cent. moisture content.* The Bäck factory was enlarged in 1911 and 1912, and an output of 10,000 tons of peat powder was expected in 1913, but the statistics in the Swedish reports do not show that this was ever realized.

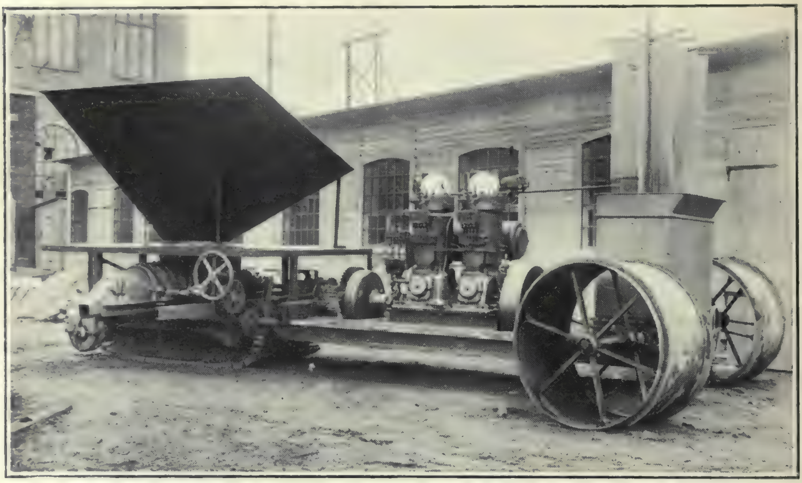


FIG. 83.—A. H. W. peat machine with oil engine and caterpillar support.

FIG. 84.—Ekelund-von Porat excavator, made by A. B. Hassleholms Verkstader.

---

* Bulletin No. 8, Canadian Department of Mines (No. 151), 1912, gives a translation of two full reports written by E. Nystrom and Captain Wallgren, on the Ekelund peat powder process, as carried out at Bäck. See also Hausding, Handbook on the " Winning and Utilisation of Peat," and the annual reports of Captain Wallgren, Swedish Peat Expert, for the years 1911 to 1917.

XI.—Vislanda Peat Powder Factory

As a result of the satisfactory tests made with pulverized peat fuel on the Swedish State Railways,† it was decided to set up a State factory for the production of pulverized fuel. The Hasthägen bog, of about 450 acres, was purchased by the State and a factory erected for the manufacture of peat powder by the Ekelund-von Porat process, in 1917. Parliament voted 1,300,000 Kr. for the purpose, but the expenditure has amounted to 1,800,000 Kr., or approximately £100,000, and a further grant of 500,000 Kr. was applied for. The bog is situated about 2 km. from Vislanda station, 168 km. north of Malmö and 100 km. from Nassjö. The peat powder manufactured is used for locomotive firing on the Swedish State Railways, principally the Nassjö–Falköping line, 112 km. in length. The peat powder, containing 12 per cent. to 15 per cent. moisture, is carried in 15 specially constructed, closed, steel hopper waggons, each of 45 cub. m. capacity and holding 16 tons. There are two discharging valves in the bottom of each car and the powder is stored for use on the railway in silos at Nassjö, Jonköping and Falköping. A reinforced concrete silo at the Vislanda factory holds 200 tons of peat powder and from this silo the railway waggons are loaded. The finished powder weighs about 22 lb. per cubic foot.

This bog has a maximum depth of 3·75 metres and an average depth of 3·5 metres. The floor of the bog consists of sand and is level and firm and well suited for the system used here, in which the peat is excavated by machines supported on the subsoil. The central portion of the bog does not appear to contain good peat, the fuel produced being brittle and having the appearance of a moss litter peat ; the margin of the bog, however, contains a much better quality of peat. A considerable quantity of timber is met with in the bog, some of the stumps being up to 6 ft. in length by 12 in. in diameter. For this reason, machines of the Ekelund-von Porat type, capable of excavating amongst timber, have been employed.

There are three excavating machines of this type on the bog, the total capacity being 25,000 tons of macerated air-dried peat (40 per cent. moisture) between April 1st and August 1st. The peat powder factory commences operations on August 1st and continues during the winter until April 1st, the production of peat powder being 10,000 to 12,500 tons per annum, with a moisture content of 12 per cent. to 15 per cent. If the average moisture content of the 25,000 tons of air-dried peat is 40 per cent., equivalent to roughly 17,000 tons of peat with 12 per cent. moisture, it would seem that from 5,000 tons to 7,000 tons, or over 30 per cent. of the peat treated is used for the production of

---

† Fuel Research Board Special Report, No. 1, "Pulverized Coal Systems in America," by L. C. Harvey. Published by H. M. Stationery Office (Revised edition, 1921), Price 5s. 0d. (by post 5s. 3d.)

the power for peat-winning, for the heat and power used in drying the powder, and waste in various ways.

(20) *Power Station.*—A vertical reciprocating steam plant made in 1902 and brought here from some other station generates 440-volt 2-phase current. The boiler furnace has a sloping grate and horizontal hearth, and on this a deep bed of peat fuel, largely waste peat and fibre rejected in the grinding process when producing the powder, is used. The current is transmitted on iron wires supported on larch poles driven into the bog and supplies power for the transport and spreading of the raw peat. A benzole locomotive transports the air-dried peat to the powder factory and the dumps near by.

(21) *Peat Winning.*—An output of 25,000 tons of air-dried machine peat, containing 40 per cent. moisture, is obtained from three peat machines, each working three shifts of 8 hours for a 6-day week, during a peat-winning season extending from April 1st to August 1st, and yielding at most 70 effective working days. During part of that time the fuel as ready is hauled in trucks by a small benzole locomotive into four large sheds, containing 2,000 tons each. In addition there is one large open-air stack containing a like amount. After August 1st the remaining peat is drawn into the factory direct, as required. During the peat-winning season the number employed is as follows :—

11 men on 3 shifts at factory	33	men.
Peat winning on bog, April to August ..	81	,,
On transport in July	70	,,
	184	,,
Women and juveniles harvesting	100	
Total	284	

Owing to the abundance of timber in the Hasthägen bog an excavating machine specially designed by von Porat is employed. It was made by Härnösands Mekaniska Werkstads in 1917 and consists of a substantially built dredger chain with buckets, the whole suspended from a jib attached to the main framework. The slope of the dredger chain may be varied and, as the upper portion of the machine is mounted on a turntable, the excavating element can be slewed in any direction desired. The machine works on the base of the bog, which is 3½ metres deep, the undercarriage with the turntable and rack being supported on rails of about 2-metre gauge. The rails with sleepers attached are in 5-metre lengths and can be lifted up and placed in front of the excavator as each length is cut away. The buckets of the dredger work under and around any tree stumps encountered and may also be used to loosen the stumps so that they may be drawn to one side, out of the way of the excavation. Any small roots caught in the buckets are picked out by the operator who stands high up on a platform close to the point where the buckets are tipped. The machine is very similar to that made by the A. B. Hässleholms Werkstader and illustrated in Fig. 84. Five separate motors are provided, one for each movement, those for excavating, turning, moving forward and elevating being 14 h.p. each, while for the macerator a 50-h.p. motor is provided. All motors may be in operation at the same time, but about 70 h.p. to 80 h.p. is the maximum load.

The peat from the buckets falls to the macerator in the base of the machine and, after maceration, is elevated to tip waggons running on rails supported on the surface of the bog near the edge of the excavation. As each waggon receives its load of about ·50 cub. m. it is pushed away, and when 12 full waggons are assembled they are hauled by an electric locomotive to the drying ground and tipped in heaps from a temporary track. These waggons are so spaced that they tip at 2-metre centres and the heaps are levelled off by the field press to a layer 10 cm. thick and divided into separate blocks.

One electric locomotive using 440-volt 2-phase current, fed from overhead wires suspended from movable supports, is sufficient to convey all the peat to the spreading ground. The spreading and drying ground is from 300 metres to 400 metres long.

As soon as rows of peat are tipped on both sides of the portable track it is lifted 2·7 metres to one side and laid down ready for the next row. As this work is done while the empty waggons are returning, no time is lost in shifting the track. The overhead conductors are suspended on posts, each of which is carried on a base readily moved over the bog surface into position for spreading the next row.

The weight of the excavator is 23 tons and cost 21,000 Kr. plus 22,600 Kr. for the motors, a total cost of 43,600 Kr., or at par exchange, £2,450. (In November, 1921, the approximate cost of a similar machine made by A. B. Hässleholms Werkstader, was £4,000.)

The men employed are :

Excavating	1 driver. 1 man in bottom picking out roots, levelling and shifting track.	2 men.
Loading and tipping.	3 men pushing up, loading and despatching waggons. 1 driver on pulp cars. 2 men tipping cars, shifting track and electric wires.	6 ,,
Total		8 ,,

Three 8-hour shifts with 8 men on each are worked at each excavating machine, and 10 rows of peat each 350 metres in length are laid down during the 24 hours.

(22) *System of Pressing.*—The pressing of the separate waggon loads into a layer of peat 2·2 metres wide by an average depth of 12 cm. is done by a gang of three men with an Ekelund field press. This is formed of a bottomless box 2·2 metres wide with skids under the sides. Fixed at the centre of the box is an inclined deflector like a snow-plough, which distributes the peat across the box. The box is weighted and hauled forward by a steel cable operated by a motor-driven winch mounted on anchor cars at either end of the spreading ground. In June and July a layer 14 cm. in depth is spread, but owing to the slower drying in August it is reduced to 10 cm. in thickness.

The layer of peat is cut into longitudinal strips 5 in. wide by a double row of circular discs at 10-in. centres, which are drawn along behind the box. The use of two shafts with discs at 10-in. centres instead of one row of discs at 5-in. centres prevents the lifting of the longitudinal strips, which, if the peat is dry, occasionally occurs when using discs 5 in. apart on the same shaft. The transverse cuts are made by a knife with a wavy edge, 2·20 metres long, operated by a crank.

(23) *Objections to the System of Pressing.*—All field press systems are open to the objection that, if the bog surface is rough or contains any holes or undulations, the hollows become filled up with raw peat to a depth of 25 cm. to 30 cm., instead of the regular 12 cm. thickness, and the high points are covered with possibly 3 cm. or 4 cm. of raw peat. The varying thickness leads to unequal drying and, in addition, the method of spreading tends to press the peat into close contact with the bog, while at the same time there is a tendency for the peat to be dragged along and to be mixed up with the peat debris which remains on the surface from previous spreadings. The effect of this is to produce a brittle fuel. The upper surface of the layers of peat as spread presents a very regular and well-finished appearance, but the defects above indicated are apparent on the undersides of the air-dried blocks.

(24) *Output.*—Twelve waggons each containing about ·50 cub. m. of raw peat were filled in $5\frac{3}{4}$ minutes. Taking 120 waggons per hour multiplied by ·50 cub. m., this gives 60 cub. m. per hour, or 480 cub. m. per shift, but when allowance is made for meal-times and stoppages, the output would not average more than two-thirds of this, or 320 cub. m. per 8-hour shift. There are two rough checks on this, i.e., (1) the 10 rows of peat of 350 metres long by 2·20 metres by ·125 metres thick, laid down in three shifts = 963 cub. m., or 321 cub. m. per shift; and (2) the forward movement of the machine is 25 metres in three shifts and the section excavated 12 metres by 3 metres deep = $\frac{25 \times 12 \times 3,}{3}$ or 300 cub. m. per shift.

Taking an average output of 320 cub. m. per shift, and assuming 7·5 cub. m. of 90 per cent. moist peat to produce 1 ton of air-dried (25 per cent. moisture) peat, the output amounts to 128 tons of air-dried peat in 24 hours, or 5·35 tons per hour.

The piece-work rates at Vislanda are based on the number of cubic metres of raw peat spread. In the following table the labour costs supplied by Mr. Norinder, engineer to the Vislanda plant, are given in shillings per ton of air-dried peat, 30 per cent. to 50 per cent. moisture (rate of exchange, 17·0 Kr. to the £1, July, 1921) :—

Excavating, loading, despatching, tipping, spreading and dividing into blocks by Ekelund press	2·95	shillings	per ton.
Turning partially dried blocks ..	·38	,,	,,
Castling (rickling)	·68	,,	,,
Loading, transport and tipping on store pile	2·53	,,	,,
Total labour cost in store pile ..	6·54 or 6*s*. 6*d*. per ton.	,,	,,

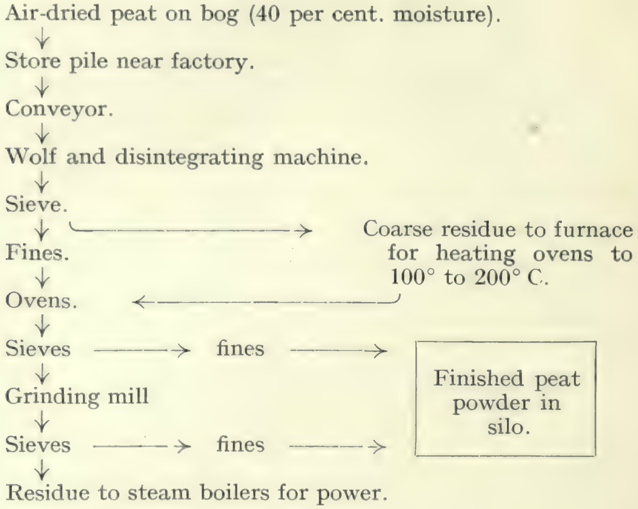
To the above figures add for plant charges on locomotives, peat waggons, tip waggons, rails, Ekelund press, excavator, current and benzole used, rent of bog and administration.

XII.—MANUFACTURE OF PEAT POWDER BY VON PORAT EKELUND PROCESS

The peat is air-dried on the bog, as described above, until its moisture content is reduced to between 30 per cent. and 40 per cent., depending on the season. When dried, the peat is hauled from the bog to the factory or the store pile near by. At the factory the waggons conveying the peat are tipped over a conveyor which elevates the peat into an ordinary wolf or disintegrating machine. In this the peat is broken up and falls on to a sieve which passes the fines on to the drying ovens and rejects the coarser particles and fibre to a conveyor by which they are passed into a furnace to supply the necessary heat for the ovens. The fine peat is elevated to the top of each oven and taken by a scraper over the heated surface of the oven. Having passed through the top cell of the oven it falls to the next cell, through which it is passed until it falls into the third cell, and so on, the peat passing through the various cells down to the lowest. The temperature in the ovens varies from 100° C. to a maximum of 200° C.

After passing through the oven the powder is again thoroughly sieved and the portion passing through the sieve sent direct to the silo ; the residue on the sieve is passed on to a grinding mill, in which it is ground by rotating stones. It is then sieved, the fines are passed to the silo and the portion rejected sent to the boilers for steam-raising.

The schematic arrangement of the peat powder factory is as follows :—



The tonnage of fine powder produced amounts to about 50 per cent. of the air-dried peat dealt with. A standard gauge single-line track, 2 km. in length, leads from Vislanda Station to the reinforced concrete peat powder silos at the factory.

In considering the economic results of the preparation of peat powder, it is difficult to see how with a good peat fuel it can ever pay to incur increased cost so that it may be transformed into a fuel which may be utilized with a slightly higher efficiency than the original peat fuel.

At Vislanda, apparently over 30 per cent. of the dry material in the original peat fuel is used up in supplying power and heat for the process and, in addition, the fixed capital charges on the factory for the output are so high as to make the process entirely impracticable. It must be said, however, that the peat fuel manufactured on a great portion of the bog at Vislanda is not of good quality.

The Hasthägen bog, of 450 acres, taken as 12 ft. deep (and yielding, say, 200 tons of 40 per cent. moist peat per acre foot) contains approximately one million tons of 40 per cent. moist peat, and if this is used up at the rate of 25,000 tons per year, the life of the bog will be 40 years. Since the production towards the end of its life must fall off, and owing to the heavy replacements necessary, it will not be excessive to take amortization on the whole of the capital at 5 per cent. Repairs can hardly be less than 22,000 Kr., so that capital charges are as follows :—

Amortization at 5 per cent. on 1,800,000 Kr.	90,000	Kr.
Interest at 6 per cent. on 1,800,000 Kr. ..	108,000	,,
Repairs	22,000	,,
Total	220,000	

On a production of 10,000 tons the capital charges amount to 22·0 Kr., or 24*s.* 4*d.*, per ton of peat powder produced. (Mr. Norinder states that the capital charges are only 7*s.* per ton of peat powder produced.) The labour charges at the factory amount to 10*s.* 8*d.* per ton, giving a total cost of manufacturing peat powder of 35*s.* per ton.

The labour charges on the peat at bog equal 6*s.* 6*d.* per ton, and the other charges not detailed may be taken at 3s. 6*d.* per ton, or a total of 10*s.* per ton. If the production of 15 per cent. moist peat powder is but 50 per cent. of the original peat produced on the bog containing 40 per cent. of moisture, the final cost is as follows :—

Charges on bog	20·0	shillings per ton powder.
Charges at factory	35·0	,, ,, ,,
Total cost of powder per ton in silo at factory ..	55·0	,, ,, ,,

Since the published figures of tests show that for locomotive firing 1·42 tons of peat powder are equivalent to 1 ton of good English coal, the corresponding competitive price for coal would be about 78*s.* per ton. The labour costs may be reduced with the fall in the rate of wages, but the heavy fixed charges on capital remain unaltered.

XIII.—VAKÖ-MYR BOG AND PEAT POWDER FACTORY

Vakö-Myr is a large bog of almost 4,000 acres, about 3 km. north of Hökön, on the Elmhult to Sölvesborg Railway line. The bog, when drained, is about 3 metres in depth, but one portion reaches 7 metres. It was originally covered with small larch trees, which have now been cut, and although the bog itself does not contain much timber, large granite boulders are encountered resting on the base of the bog. This circumstance makes mechanical excavation rather difficult.

The drainage of the bog was commenced by Mr. Gustav Carlsson in 1915. Although it was then a morass, it is now thoroughly drained, and its level surface readily supports the various peat machines.

(25) *Von Porat Peat Powder Plant.*—The peat powder factory (A.B. Vakö Torfpulverfabrik) erected at Vakö in 1917 on the von Porat-Odelstjerna system, has been closed since 1919. The capital expended on the factory amounted to 2,000,000 Kr., towards which the State gave a grant of 500,000 Kr. The factory does not appear to be well arranged, and as the output was only 5,000 tons of powder per annum, for obvious reasons the manufacture of peat powder could not be successful owing to the very high capital charges. As the process of manufacturing the powder is somewhat similar to that described for Vislanda (pp. 135–141) no further details need be given.

The power station contains a 500-h.p. marine steam boiler, fired with peat, and any surplus current is delivered to the hydro-electric system in the winter, when, owing to low water, the hydro is not producing to its full capacity. The power plant is now kept in reserve, as owing to the closing down of the peat powder factory the works are almost closed in winter and in the summer power is obtained from the 40,000-volt 3-phase hydro-electric system, which is transformed to 550 volts for work on the bog. The total capital expended at Vakö amounts to over £200,000.

The peat at Vakö-Myr produces a tough, hard, black and dense fuel and is undoubtedly equal to the best peat fuel on the Continent. The Report of Swedish Peat Committee (1921) shows the average ash content to be 2·75 per cent, and the calorific value 9,875 B.Th.U. per lb. anhydrous. It is transported to the storage sheds along a narrow gauge line by benzole motors. Close to the factory are five large storage sheds, each being enlarged to contain 3,500 tons of peat. The total capacity is thus 16,000 tons and this is sold to the different railway companies for locomotive firing. A special electrically driven loading apparatus is installed in the sheds for loading the railway waggons.

The 550-volt 3-phase current is distributed on the bog by copper overhead wires on larch poles at 50-metre centres, the current being led by means of a flexible cable to each peat machine. Two fatal accidents have resulted from the use of the 550-volt current.

The production of peat fuel at Vakö is from 15,000 tons to 20,000 tons per annum. There are seven machines of the Anrep Svedala type with elevators (30-h.p. to 40-h.p. motors) and Persson's conveyors 150 metres in length. These machines work on the surface of the bog and have an output of 35,000 pieces of 8 kg. each—25 tons to 30 tons in an 8-hour shift. Two 8-hour shifts are worked at Vakö. These machines have been described elsewhere (p. 127).

In addition to the Anrep machines, there are two others made by the A.H.W. (A.B. Hässleholms Werkstader, Hässleholms) on the von Porat-Odelstjerna system. These machines work on the bottom of the bog and are very similar in action to those used at Vislanda, except that the peat pulp is hauled to the spreading-ground in waggons by benzole locomotives in place of electrical operation. Fig. 84 shows the machine at work. The makers state that the speed of the chain of buckets is ·38 metre per second and the output 45 cub. m. per hour, equivalent to 6 tons air-dried peat per hour, the cost in November, 1921, being £4,000 complete. Mr. Carlsson estimates the output at 45 cub. m. to 55 cub. m. per hour, or 6 tons to 7 tons per hour, but this figure seems high. The average output would not be greater than 5 tons to 5½ tons per hour.

Machines similar to the above, of the A.H.W. semi-automatic type, may be seen at work on the Rodemosse Torffabrik for the Wästergotland–Göteborg Railway Coy., near Oxwall Railway Station.

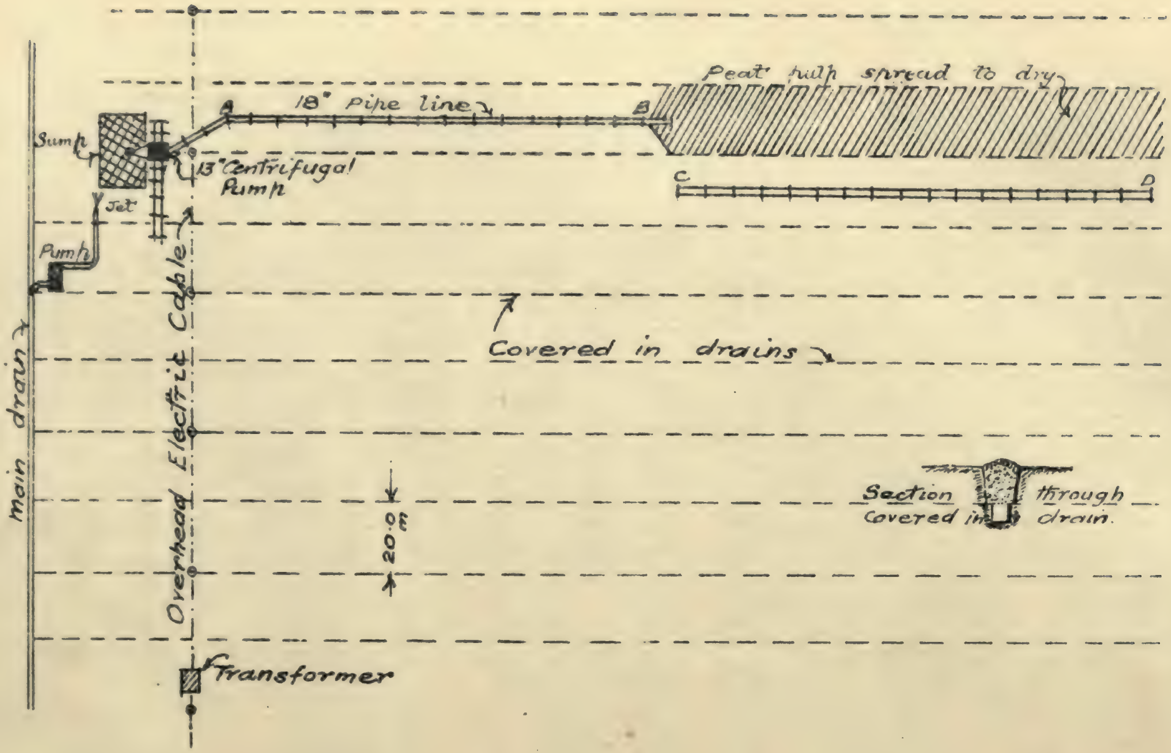


Fig 85. Hydro-peat process

PS 36331 / 19444 / 700/1010. 1000 5'23.

C&R Ltd 934

The drying-grounds at Vakö have covered drains, constructed at regular intervals, and these have produced very good results. The gradients used for the drains are from 1 in 500 to 1 in 1,000, the steeper gradient being the more desirable.

The piece-work rates at Vakö were cut 50 per cent. in 1921, and the costs of production with the Anrep-Svedala-Persson machine were as follows :—

Excavating, spreading and dividing (5·75 Kr.)	6·77	shillings per ton.
Turning peats (·33 Kr.)	·39	,, ,,
Rickling (·45 Kr.)	·53	,, ,,
Loading and transport (·90 Kr.)	1·06	,, ,,
	8·75	,, ,,
Power charges (1·51 Kr.)	1·78	,, ,,
Total	10·53	,, ,,

With the automatic machines made by A. B. Hässleholms Werkstader, the cost of excavation and laying out was given as 3 Kr. per ton, or 3·53*s*., and with the other charges remaining the same as for the Anrep-Svedala-Perssons machine, the cost with the A.H.W. comes to 7·30*s*. per ton air-dried.

XIV.—THE "HYDROPEAT" PROCESS

In bogs containing a large proportion of timber and roots, the excavation of the peat, even by hand, can only be accomplished with difficulty, and it is practically impossible to employ any kind of machine under such conditions. To deal with such conditions, the so-called "Hydropeat" process has been introduced.

A 1-in. diameter water jet from a multi-stage centrifugal pump, at a pressure of 75 lb. to 150 lb. per square inch, is directed against the peat in the bog, washing it down and leaving the timber behind (Fig. 86). The pump should be capable of delivering water at 220 lb. per square inch if required. The peat, when loosened up, runs to a sump as a wet pulp, containing up to 95·5 per cent. water and is pumped by a 13-in. centrifugal pump (Fig. 87) with specially formed impeller which has a certain macerating action. The pump, driven by a 75-h.p. motor, forces the wet pulp through an 18-in. diameter pipe, formed in lengths which are easily handled and moved, as shown in Fig. 88. The drying-ground has a maximum length of 400 metres and is divided into strips 20 metres wide by surface drains, containing the brushwood filling shown in sketch. Dam boards are placed along the top of each drain and the peat pulp flows from the pipe-line till the surface is covered to a depth of 6 in. to 9 in. Some lengths of pipe are then removed and transferred to the next strip to be laid down, and this process is continued until a full strip is completed.

The breaking up of the horizontal structure of the peat in the bog, mixing it with so large a proportion of water, and pumping through the pipe-line is equivalent to thorough maceration. After remaining on the spreading-ground for some hours, a large proportion of the added water is said to drain away and the peat is

Fig. 86.—Hydro-peat process: jet, pump and pipe line.

Fig. 87.—Centrifugal pump with motor over sump.

ready for moulding in from 6 hours to 48 hours after being spread. Forming the peat into separate blocks may be effected by drawing a disc cutter or other suitable type of moulding machine over the spread peat.

If the peat is well humified and not too fibrous or containing too much timber, a jet of 70 lb. to 80 lb. per square inch will be sufficient, but in other cases 220 lb. per square inch may be required. Assuming that the peat in the bog contains 90 per cent. of water (water ratio 9 to 1), it appears to be necessary to add about 330 cub. ft. of water per ton of air-dried peat produced (25 per cent. moisture), so that the pulp contains 95·5 per cent. water (water ratio 21·2 to 1). The water added reduces the friction in the pipe-line, but of course it must necessarily add to the moisture content of the drying-ground, even with the very intensive drainage system provided. To promote quicker drying, it is proposed to mould the blocks to a triangular shape. The pipes are estimated to last from five to ten years, with care in handling.

This process was first tried in Germany, at the Pentane Works in East Prussia, and later during the war by the Prussian Government at Linium, where experiments were conducted under Wittfeld, but the results of these trials are unknown. In Russia the process has been tried and improved during the years 1916–20, and is used in connexion with the large peat-fired station at Bogorodsk near Moscow. It is stated that the Russian Government ordered twenty additional plants during 1922. In 1920 a " hydropeat " plant was installed at Juurikorpi, near Kotka, in Finland, on a bog containing a large proportion of roots. During the 1921 season the process was tried on the Store Vildmose in North Jutland, Denmark—a bog having an area of about 20,000 acres.

FIG. 88.—18-inch diameter pipe line.

Dr. Birk* states that in Germany an output of 6,500 tons of

---

* *Deutsche Torfindustrie Zeitung,* February 12th, 1922.

air-dried peat in 75 working days of 10 hours each, or 9 tons per hour, has been obtained by this process, with 9 men attending the plant in a root-free bog, and 11 men when roots are met with. The plant uses some 200 electrical units of current per hour.

In Jutland an output of 10 tons per hour is claimed, with 6 men and 100-kw. motors to operate the plant. The plant, exclusive of power lines or power station, costs approximately £4,500 for a single unit.

Printed by H.M. Stationery Office Press, Harrow.