Mr. E. A. Cowper was glad that this subject now appeared to receive more attention than in past years, as so many schemes had been tried, resulting in so many failures, that there was a chance of the whole question being put on one side. In certain cases peat answered very well. Cottagers in the neighbourhood of a peat bog obtained enough to answer their purpose; but they did not create a large manufacturing business. In South Holland, and in some parts of Germany, the peat was mashed up in troughs, and then spread out upon the ground in a layer about 3 inches thick. It was next trodden down by men, with boards attached to their feet, into layers perhaps 20 feet wide and 100 feet long; then cut in lines crossing each other by sharp rakes, turned up, and made into bricks, which were dried in the open air. The plan of digging the turf, turning it over, and drying it on the bog, was a simple and economical mode of proceeding, and thousands of tons were so prepared. He had several samples which had been dried naturally. One piece, from Ely, weighed 5 lbs. 9½ oz. when cut, and less than 1 lb. when dried. Another piece, from Inverness, was in a mashed state, and the finger could be easily thrust into it. Other pieces were reduced to about one-sixth of their original bulk and weight in drying. An enormous mass of material had to be dealt with to produce a very small result: hence the labour employed should be reduced to the lowest possible amount. He greatly preferred drying the peat in the open air to drying it in sheds, where the proximity of the pieces to each other prevented a free circulation of the air. The rain was not a matter of importance, because after the peat had been exposed about twenty-four hours it resisted the rain admirably, and would dry, after being wetted, like a piece of wood. Of course it would not do so in the open air in the rain; nor yet in a shed, because the air would be saturated with moisture. When many pieces were put one above the other and close together in a shed, it was only the outside pieces that caught the wind and the sun, and dried quickly. The next point was, how best to save the cost of carriage. He thought the plan adopted in Holland, of making the machine follow the excavation, the peat being mashed and dried in the open air, was the right one. It had never, however, been tried in England, Scotland, or Ireland, though many machines had been used to compress peat artificially. It was impossible to squeeze the water entirely out of good mashed peat; it must be done by air. He had a plan, by which, at an expense of about £1,800, 20 tons of peat per day might be produced. The bog was supposed to be divided into patches or compartments 240 feet in diameter. The machine was placed on a truck running on a railway, and as the peat was mashed it was delivered by boys on to the block indicated. Then the machine was moved forward to other patches successively, until a considerable breadth on each side was covered throughout the length of the railway. After travelling in that way for about twenty days, the first patch would be quite dry; it was then cleared off, and the engine set to work again. It might be asked why it was proposed to work in a long line, instead of adopting a stationary engine, and having the work more compact? The extent of the surface of the ground was so great, that unless the engine was moved along on the railway, covering each patch of ground with peat, the workmen would have to walk a considerable distance to deliver the peat. In order to dry the peat mashed by a machine that would make, say 20 tons of dry peat per day, a patch of ground would be required 1,600 feet in diameter; and, owing to the distance the boys would have to walk, and the number of tramways that would be required, the cost would be about £6,000, instead of £1,800. On a smaller scale, with a machine capable of being turned by a pony or two men, a gang of two boys and two or three men, working a patch 70 feet square each day, would deliver from 5 tons to 6 tons of peat, to produce 1 ton of dry peat.

Mr. H. Clayton observed that a pugmill had been used for working peat at Garnkirk Moss as far back as 1837. Mr. Slight, curator of models and machines in the museum of the Highland and Agricultural Society of Scotland, had treated of this mill and the process of manufacture there pursued, in a letter published in the "Quarterly Journal of Agriculture and Transactions of the Highland and Agricultural Society of Scotland."[1] The Author had failed to draw the distinction between the action of the ordinary pugmill knives upon peat, and the action of the arrangement of the fixed and movable cutters in the machines manufactured by his firm. The first merely tore asunder the entangled fibres of peat; while the knives of the latter comminuted all the fibrous matter, and produced an admixture of the whole body of peat. The comminuting action was indispensable for producing dense peat from fibrous turf by the wet process. If the fibre were not completely cut up into small pieces, the drying occupied a long time, and the quality of the fuel was inferior. With respect to the assertion that the Clayton machine was a fixture, this was not indispensable; the transportable system might be applied equally

[1] *Vide* No. xli., p. 331, *et seq.*

to this as to any of the existing processes where the ordinary wet system of manufacture was pursued; but he was of opinion that the machinery should only be moved every two or three years, as the surrounding peat was cleared away. In Germany many manufacturers had for years past received the peat blocks on boards or trays as they were delivered from the pugmill. Many thousands of trays were thus used and might be seen, even near Berlin. The actual cost of production was under 4*s.* 6*d.* per ton by his firm's process in England. In Germany 3*s.* 6*d.* per ton covered all expenses; indeed the entire apparatus was kept going, from beginning to end, by ten men and ten boys, the production of fuel being from 20 to 25 tons per day by one machine, peat being used for working the engine. Wages at 3*s.* 6*d.* per day for men, and at 1*s.* 6*d.* per day for boys, would leave a margin of 100 per cent. in England for trade charges, rent, &c.; in Germany, wages for men at 1 thaler, and for boys at 10 silver groschen per day, would allow 75 per cent. for similar charges. In County Donegal, the cost per ton was 2*s.* 2*d.* of the dry fuel, treated by the Clayton machine.

Peat fuel, of an inferior quality, when treated by the Clayton system, would evaporate from 5 to $5\frac{1}{4}$ lbs. of water per lb. of peat; but when the peat was naturally decomposed, as much as 6 lbs. had been evaporated. Fibrous peat, if not effectually condensed, could not be used with economy where strong draughts were required, as in portable or locomotive engine work, since, owing to the friable nature of the non-condensed peat, a large portion was carried away by the draught unconsumed.

Colonel A. R. Wragge said that natural drying processes having failed, it was desirable to adopt a system of artificial drying which would be quite independent of atmospheric conditions. This might be accomplished by bringing peat upon wagons into a drying chamber of sufficient dimensions to contain a large quantity, and by exposing the peat to a gradually increasing temperature. The result would be that the evaporation would increase somewhat in geometrical progression, while the temperature would increase merely in arithmetical progression. Beginning at 10° C., 3·7 grains of moisture would be evaporated; but at 100° C., 245 grains would be evaporated: by thus increasing the temperature tenfold, the evaporating powers were increased sixty-fourfold. By this means of artificial drying, which could be carried on throughout the year, large quantities of peat might be produced to supplement the supply of coal.

Mr. A. McDonnell observed that he did not think such a machine as the Messrs. Clayton's was desirable. Cutting peat was often a matter of extreme difficulty, and the machine was frequently choked in the attempt. In ordinary bog there was a large quantity of what was called horseflesh, the cutting of which, from its tenacious and slippery character, was an impossibility. From experiments he had tried, he thought the first cost of making peat would amount at least to 5*s.* 6*d.* a ton. He had employed peat in a stationary engine, a locomotive, and also in Siemens' gas furnace. He ran a light goods train 347 miles with ordinary cut turf, and the consumption was 73·9 lbs. per mile. The same engine ran the same distance a short time before with a somewhat heavier load, and the consumption was 36 lbs. of coal per mile—the amount being large, owing to the many delays on the journey. The average consumption of such a train would be about 32 lbs. of coal per mile. This trial would give 100 parts of peat, equivalent to from 41 to 43 parts of coal. He also ran a passenger train 520 miles, the average load being 7·6 carriages (the six-wheel heavy carriages used in Ireland), the maximum load being 14 carriages; the speed was 29 miles an hour, and the consumption of peat 51·6 lbs. per mile. The same engine ran 663 miles, with an average load of 6·4 carriages, at an average speed of 30 miles an hour, and the consumption was only 20·3 lbs. of coal per mile, but in the previous four weeks, it was about 21·6 lbs. per mile. That experiment would give nearly the same proportion of peat to coal, namely, 100 parts to about 41. With a stationary engine, he found that 36½ cwt. of peat was equivalent to 17½ cwt. of coal, working for one day, which was rather a better result, showing a proportion of 100 parts of peat to 48 of coal. Another experiment with a stationary engine showed that 65 cwt. of peat was equivalent to 27 cwt. of coal, giving a proportion of 100 parts of peat to 43 or 44 parts of coal. He thought the best method by which peat could be used with advantage was in a Siemens' gas furnace. In trials last year, in forging iron, he found that 1 ton of finished forgings required 4·96 tons of coal in an ordinary air furnace; while the same quantity of iron was forged with 5·09 tons of peat in a Siemens' gas furnace. In the case of the gas furnace the loss in the iron was from 5 to 6 per cent. less than when the iron was heated in an air furnace. The result was that the finished forgings in one case cost £22 14*s.*, and in the other £18 6*s.* This referred to the cost of making the peat. The price of coal was 28*s.* a ton, and the peat was taken at what he considered the extravagant price of 14*s.* a ton. To ascertain how quickly the peat might be used after being cut from the bog, on the 1st of April, 1874, he cut some peat, mixed it up in a machine, and dried it in the air; on the 29th of April it was used for forging coupling rods, when it contained probably not much less than 40 per cent. of moisture. The amount of heat from fuel of that kind, in a gas furnace, did not appear to be limited in any way; and it would be as easy to make steel as to forge iron.

Mr. BRAMWELL thought Mr. McDonnell was about to compare the cost of making a hundredweight of forgings in an ordinary furnace with coals, in Siemens' furnace with coals, and in Siemens' furnace with peat.

Mr. McDONNELL said he had only tried coal in Siemens' furnace for a week, which was too short a time for an average to be taken. As far as he had gone, it required 3·3 tons of coal in Siemens' furnace to forge a ton of iron, whereas it took 5 tons of peat to forge the same quantity.

Mr. SIEMENS said, in the course of the discussion, the use to which the peat was to be applied appeared to have been left out of sight. If it was to be worked into peat charcoal, it was of course necessary that it should be thoroughly masticated and compressed, in order to make it of great density. Such peat charcoal was of considerable value, and in blast furnaces he thought it would be better than the best coke that could be obtained, because it was generally free from sulphur. This, however, was not always the case, for at Swansea he had analysed peat, and had found it to contain fully $\frac{1}{2}$ per cent. of sulphur, owing, no doubt, to the presence of the Copper Smelting Works. Again, if peat was required for locomotive work it must be rendered dense, or it would fly out in large quantities from the chimney; in which case a machine like the Messrs. Clayton's might be extremely useful. If, however, peat was only to be used for the production of heat, in stationary steam boilers or in furnaces, it would be entirely useless to subject it to manufacturing operations such as had been described. He agreed with Mr. Cowper in thinking that it was desirable to separate each piece as much as possible from its neighbour, so as to let the wind act upon it, rather than to dry it in sheds by artificial heat, because in the latter case a large proportion of it had to be burnt to produce the heat, and the operation was actually retarded because only a limited quantity of air could be brought in contact with each piece. Air-dried peat, containing 40 or 50 per cent. of water, was capable of producing any degree of heat if properly burnt; and he considered the proper way of burning such fuel was to convert it into a gaseous fuel. The gas was as rich if the peat contained 50 per cent. of moisture as if it contained none; but care should be taken to condense the water out of it before the gaseous fuel was used. He had employed peat so treated for forging furnaces and steel melting furnaces, and found it the best fuel that could be used. He should prefer it even to the best coal for heating purposes, and he believed the time would come when the stores of peat in Ireland, in Scotland, and in the north of England would form a valuable addition to the stock of fuel for all operations for which coal was at present used. Such employment would tend more than anything else to the development of iron industry in Ireland.

Mr. Cowper said the hard fuel could be carried without injury, whereas the lighter descriptions when conveyed in a truck would fall to pieces, and were too light to make a good truck load.

Mr. F. H. Danchell remarked that there was no difficulty in macerating and drying peat on a small scale; the difficulty was to make it on a large scale. In France and Germany excellent peat was produced for 4*s.* or 5*s.* per ton; and he had himself contracted in France, where wages were as high as in England, to deliver it at 5*s.* In such cases small quantities only were made, say 4 or 5 tons a day, by three or four men, but all attempts had failed to produce peat at that price in large quantities. He thought that peat should not be macerated too much, as it was then liable to split into fragments. The density of the charcoal depended greatly upon the mode of charring. The slower the charring process the more dense the charcoal. He had in that way made the densest charcoal from comparatively loose peat. Seeing the rate at which peat could be produced elsewhere, he did not understand why the Author should adopt a minimum cost of 6*s.* 6*d.* or 7*s.* That was of course only an opinion; but in such matters opinions did not go for much unless they were based upon actual data.

Mr. Meadows, in reply, said his calculation of the cost was founded in the first place upon the present cost of ordinary peat obtained in the simplest way. It was cut by the spade, removed to the bank, taken on barrows to the drying ground, turned and spread by women and boys, and ultimately heaped together; and at the present price of labour in Ireland the total cost, including all charges, was not less than 4*s.* 6*d.* a ton. It was necessary now to provide for payment of able labour for cutting peat in quantity in Ireland at the rate of 3*s.* 6*d.* a day, and proportionate advances had taken place in the wages of women and children. Ordinary peat, which in the centre of Ireland might formerly be made for 2*s.* 6*d.* a ton, could not now be produced in bulk for less than 4*s.* 6*d.* Besides the charges for the extraction and preparation of the peat, there were the expenses of removal and treatment in the machines, with other attendant expenses, which could not amount to much less than 2*s*. or 2*s*. 6*d*. additional per ton. With regard to the system of sheds, it should be remembered that the period for working without them was limited, and that without the use of sheds a large quantity of peat could not be conveniently produced. He thought a removable shed arrangement would not be found impracticable. With regard to the pugmill, possibly it had been used for peat before the time of Weber, but he believed its introduction as a recognised mode of treating peat did date from the time he had stated. As to the *spécialité* of the Clayton machine he would simply state that samples of peat made by the different processes could be easily obtained, by which any one could judge how far the mechanical refinements claimed for that machine were valuable or otherwise. He thought the inherent difficulties surrounding the production of peat were almost less obstructive to the progress of the manufacture than were the statements sometimes made as to the extreme cheapness of its production. The statement that dense peat could be produced during a considerable period of the year for 2*s*. 2*d*. a ton, presented, in his opinion, one of the greatest difficulties in connection with the progress of the subject.

Mr. R. MALLET observed, through the Secretary, that, in his opinion, the Author had over-estimated the financial saving to be effected by the employment of peat fuel. He held the same views on the subject as in former years.[1] The hot summer sun, in the dry climate of Bavaria and Bohemia, would be far more effective in drying peat than the damp atmosphere of Great Britain.

Mr. A. MCDONNELL, in a subsequent communication to the Secretary, gave the results of the trials of coal and peat in Siemens' regenerative gas furnace, for three weeks, as follows:—

One ton of iron, forged from scraps into finished locomotive forgings, required 2·86 tons of rather small Welsh steam coal, in Siemens' regenerative furnace; it required 4·96 tons of Ruabon coal in the ordinary air furnace; and 5·09 tons of air-dried peat in Siemens' regenerative furnace.

When manufactured by machinery, the peat, reduced to pulp by the machine, was received on small trays made of laths, which were placed on small wagons, with spaces between to allow the air to circulate. A tray held $\frac{1}{3}$ cubic foot of pulped peat. A wagon held 240 trays, or about 80 cubic feet of peat. A cubic

[1] *Vide* Transactions of the Institution of Civil Engineers of Ireland, vol. i., p. 1.

foot of pulped peat weighed 63 lbs., which was 10 or 12 lbs. more than a cubic foot of the wet bog. The wagon held rather more than 2 tons of wet pulped peat. The quantity of air-dried peat which this produced varied with the quality of the bog. A wagon load made from peat taken from 6 feet below the surface of the bog gave 8 cwt. of dry peat. If made from a bog of good quality, the wagon load would produce from 9 to 10 cwt. of dry peat. If made from mountain bog, it would probably produce 12 cwt. or more. Two cubic feet of peat passed through the machine in a minute, or about 120 cubic feet in an hour. The cost of making a wagon load was 3*s.* 2*d.*, including drying the peat and loading it into railway wagons. This could probably be reduced if the peat had not to be raised from so low a part of the bog, and if there was greater space for drying. If the bog produced 8 cwt. a wagon load, the cost of making a ton would be 7*s.* 11*d.*; and if the bog produced 10 cwt. a wagon load, the cost would be 6*s.* 4*d.* a ton. He thought the cost of making a wagon load might be reduced to 2*s.* 10*d.*, and with very good arrangements to even less. In this case a ton of peat from the bog, producing 8 cwt. a wagon load, would cost 7*s.* 1*d.*, and from that producing 10 cwt. a wagon load, 5*s.* 8*d.* The cost of making peat from very good mountain bog would of course be less. Thus the cost of making a certain cubic quantity of wet peat was nearly the same for all qualities of peat; but the cost of the dry manufactured peat depended on the quantity of dry peat produced from a certain cubic quantity of wet peat. It might, therefore, pay commercially to make peat from a good bog, when it would not from an inferior one.

He had tried peat against coal in a stationary engine worked very carefully. The result was that $59\frac{1}{2}$ cwt. of coal kept up steam for two days, and $120\frac{3}{4}$ cwt. of air-dried peat kept up steam for a similar time. The quantity of water fed into the boiler was nearly the same in each case. This would give 100 tons of peat as equivalent to 49·3 tons of coal. He also tried extremely inferior moss turf for two days, in the same boiler, and the consumption was 176 cwt.; this gave 100 tons of such peat equivalent to 34 tons of coal.

In another trial of peat in a locomotive with a passenger train, the number of miles run was 694; average load, 7·1 six-wheeled carriages; speed, 29 miles an hour; peat burnt, 15 tons 3 cwt.; consumption per train mile, 48·9 lbs. The average consumption of coal with the same train had been from 22 to 23 lbs. a mile. This would give 100 tons of peat as equivalent to from 45 to 47 tons of Welsh coal.

Mr. F. H. TREVITHICK observed, through the Secretary, that in the year 1868 he rode on a goods engine on the Grand Trunk railway of Canada several consecutive journeys, over a total distance of 683 miles. The weight of the train, exclusive of engine and tender, was 428 tons, and the maximum gradient of the railway 1 in 100. The fuel used was dense peat. There was no difficulty in keeping up steam, and it was not necessary at any time to have the fire-box more than half full of peat.

The consumption of peat per mile of train run, including the fuel used in getting up steam, was . . .	lbs.	70·1
Number of miles run by train per ton of peat consumed	„	31·6
Price of peat per ton	dols.[1]	3·90
Cost of peat consumed per train mile run . . .	cents.	12·43
The average running speed per hour was . . .	miles.	15·8

At Fond-du-Lac, in the United States, in 1869, the following work was performed by one of Hodges' 18 HP. peat machines:—

A canal was cut in a peat bog in thirty-seven working days of ten hours each	7,699 feet long.
Width of canal	19 „ 6 in.
Depth of canal	5 „ 6 „
Greatest length of canal cut per day	314 feet.
Greatest amount of peat excavated per day . .	1,020 cubic yards.
Average length of canal cut per day	208 feet.
Average quantity of peat excavated per day . .	676 cubic yards.
Greatest quantity of dense peat fuel made per day	114 tons.
Average quantity of dense peat fuel made per day	76 „

In estimating the quantities of dense peat made per day, 15 tons had been taken as the produce of 100 tons of raw peat.

In 1870, the cost of making dense peat in Canada by Hodges' machines was $2·37 per ton, including repairs of machinery, superintendence, office charges, and loading the peat in trucks at the bog, and subsequently unloading and putting it into sheds in the yards of the purchasers. The quantity produced at the above rate was 13,000 tons. In the half year ending December 1873, 10,551 tons of dense peat manufactured by the above machines were consumed on the Grand Trunk railway of Canada. The cost of this fuel per train mile run, compared with other fuels, was as follows:—

Firewood.	cents.	10·97
Peat	„	12·83
Coals	„	16·30

[1] One dollar = 4*s*. 2½*d*.; one cent = one halfpenny.

The price of the respective fuels was —

Firewood, per cord	dols.	4·75
Peat, per ton	„	4·00
Coal, per ton	„	6·40

It would be observed that a large difference was shown between the rates of working with wood, peat, and coals. The coal was used on sections of the road where wood was dearest, and the loads hauled by the coal-burning engines were much heavier than those hauled by engines burning peat or wood.

He erected, last year, a peat machine at Campe, in Oldenburg, Germany, similar to those used in America and Canada on Mr. Hodges' plan. It was, he believed, the only one of the kind on this side the Atlantic. It was constructed to cut about 8 feet deep by 20 feet wide. If it were desired to cut deeper, it would be necessary to take a second cut after the whole surface of the bog was removed for a depth of 8 feet, and for this purpose the surface-water must be allowed to run off.

Mr. David Stevenson remarked, through the Secretary, that the subject was interesting as connected with manufactures, and especially in the present state of the coal trade. He thought the general conclusions of the Author were perfectly sound; and he was led to this opinion from inquiries he had made on the subject in connection with the Highland and Agricultural Society of Scotland, for which he acted as consulting engineer. The employment of peat fuel by the inhabitants of some large districts in Ireland, the northern counties of Scotland, and elsewhere, naturally suggested a more general use of that fuel for household and manufacturing purposes. In the Highlands of Scotland the cutting or 'casting' of peats was commenced early in the season. After being cut they were left to be dried by the sun—a process which was fast or tedious according to the state of the weather. After being thoroughly dried, the peat was collected and stacked for winter use.

In order to make peat suitable for exportation, and generally useful as a fuel, it was necessary, first, to compress its bulk, and, secondly, to remove the water, amounting to about 80 per cent. An attempt to accomplish this twofold object by simple compression, by machinery, was made on a large scale at Colzium Moss, near Edinburgh, so long ago as 1830; but after considerable outlay in erecting an engine-house and machinery it proved unsuccessful. Several ingenious contrivances had since then been made. No doubt the thorough maceration of the peat facilitated the expulsion of water; but it was undeniable that the fibrous texture of the peat enabled it to retain much moisture, notwithstanding any amount of maceration and compression hitherto applied to it in the ingenious machines employed; and he knew from personal inquiry that this had proved a great difficulty in the employment of peat-compressing machines. It was not easy to see how this moisture could be removed otherwise than by the old process of drying in the open air, which required a large space, and was wholly dependent on the weather. This, then, was the practical difficulty which had hitherto attended the manufacture of peat fuel, and unless it could be overcome the profitable manufacture of peat fuel in this country could not be regularly and continuously carried out on a large scale. The improvers of peat-making apparatus should therefore, he thought, apply themselves to the best means of effecting its speedy desiccation.

Mr. H. P. Fenton, Her Majesty's Consul at Munich, in a report dated March 1867, "on the use of Turf as Fuel for Railway Engines, and on the mode of preparing the Pressed Turf used for that purpose in Bavaria," stated that—

"The first experiments with turf as fuel for railway engines were made on the Government railways of Bavaria towards the close of the year 1845, about five years after the opening of the first Bavarian railway; and these succeeded so well, that it was soon afterwards decided to despatch one of the regular trains—that running between Oberhausen and Nordheim (in the neighbourhood of Augsburg)—with an engine burning turf only. The journey was performed successfully, the turf (which was used in the rough or unprepared state, as cut from the moor) having been found equal to the production of the steam power required for propelling the engine at the usual rate of speed attained when firewood was employed. The only alteration which it was found necessary to make in the heating apparatus of the engine, in order to adapt it to turf fuel, was the raising, to some extent, the fire-bars in consequence of the flame from the turf not rising so high as that from wood, and therefore not producing the proper effect on the boiler when the fire was placed as low as had been customary. The distance performed by the train on this occasion was 15 German miles ($4\frac{61}{100}$ English miles each), and the quantity of turf consumed was 3,527 Bavarian pounds (about $26\frac{1}{2}$ cwt. English). As compared with the average consumption of wood—which at that period was the fuel chiefly used on the Bavarian railways—this result was very satisfactory, the difference in the cost of the fuel having been as five to six in favour of the turf.

"Experiments on a larger scale were subsequently made for two or three weeks consecutively with two engines, the one heated with turf, and the other with wood, for the purpose of testing more accurately the relative cost of the two descriptions of fuel. Although the difference was not found, in the long run, to be so great as on the occasion of the first trial, the advantage remained decidedly on the side of the turf. At the same time the practicability of producing, by means of turf fuel, the requisite steam power for engines, even when drawing heavy trains, was placed beyond all doubt.

"It was in consequence determined, with a view of introducing the system of turf-firing on the State (or Government) railways, to turn to account a large tract of turf land lying between Munich and Augsburg—known as Haspelmoor—and belonging to the State. In the course of the summer of 1846 above 700,000 cubic feet of turf were cut from it for the use of the railways. At first some difficulty was experienced in drying the turf sufficiently to make it really serviceable, as its efficiency as fuel for engines was found to depend, to a great extent, on its being thoroughly dry. But this difficulty was, in a great measure, overcome; and by the month of May 1847, it was found practicable to dispense with wood-firing on the southern section of the State railways, and to establish the system of turf fuel in its stead.

"But the great bulk of the turf, in its rough state, proved a source of considerable inconvenience and expense, as it rendered necessary the erection of vast magazines for storing the turf under cover, and also made it indispensable to employ two tenders instead of one with every engine.

"With the object of remedying these evils, by reducing the original bulk of the turf, a system of manipulation was introduced, towards the beginning of the year 1849, by which the turf, before being employed as fuel, was reduced to a comparatively compact substance; and an establishment for preparing turf according to this system was put on foot at Haspelmoor. The process was similar to that of the first stage of brick-making, that was to say, the turf was broken up, mixed with water, and well kneaded to the consistency of clay; and was then formed into squares or bricks, which were placed under sheds to dry.

"Turf treated in this manner, and known as prepared or moulded turf, was found, notwithstanding the water used in the process, to dry more rapidly, and, when once dry, to be less liable to imbibe damp, than turf cut from the moor in the ordinary manner, and left to dry in its original state.

"It formed a tolerably compact mass, less bulky by one-third to a half, in proportion to its weight, than common unprepared turf, and was found to answer very well as fuel for engines, whether employed in drawing passenger trains or heavy goods trains. But it was found impossible to prepare a sufficient quantity of turf of this description to supply the increasing requirements of the railways as fresh lines were constructed; and the bulk of the turf, even in this form, still caused inconvenience. Trials were consequently made, with the object of producing, in larger quantities, a more completely condensed description of turf with a system of pressing by steam. After several experiments, the administration of the State railways established, in the year 1858, a factory at Haspelmoor, for the purpose of carrying into effect a system of this kind.

"The process adopted, and which was still pursued at the present time, consisted in reducing the turf to powder, or nearly so, by means of breaking up and sifting, drying the powdered turf in an oven, and then pressing it while in a dry state by means of a steam press, which transformed it into hard, solid cakes.

"He had obtained, from a gentleman connected with the Engineering Department of the Bavarian State railways, a memorandum containing a detailed description of the whole process of preparing and pressing turf according to this system, as well as of the apparatus made use of. A translation of that memorandum was annexed as a separate document.

"Turf pressed according to this system was reduced to about one-third of its original bulk; but it would appear that this reduction in the volume, and the absence of moisture, alone constituted the advantages of the process, as it seemed to have been ascertained beyond doubt that the pressed turf did not, in proportion to its weight, produce a more intense degree of heat than ordinary unprepared turf, when properly dried. On the contrary, the intrinsic quality of the turf was supposed rather to suffer than to gain by the process of sifting and pressing. But by the great reduction in the bulk, no doubt the chief practical objection to the use of turf as fuel for railway engines, namely, the space it occupied, was, in a great measure, removed.

"It would not appear, however, that up to the present time pressed turf had been brought exclusively into use on the Bavarian railways, the quantity consumed on the State lines—on which alone turf fuel in any shape was employed—constituting, according to the latest returns, only about 8 or 10 per cent. of the total consumption of turf on those lines. This was, perhaps, to be accounted for by the fact that hitherto the employment of pressed turf had been considered rather in the light of an experiment than as an established system; and that, therefore, its manufacture was as yet limited to what the one establishment at Haspelmoor was able to produce.

"It had already been stated that in the year 1847 the system of turf fuel was universally adopted on the southern section of the Bavarian State railways. Since that period considerable additions have been made to the southern network; and on all the lines composing it, turf, either in the rough state or pressed, had been constantly, and still was, employed as firing for engines, almost to the exclusion of all other fuel. The southern network consisted of the line between Munich and Ulm (on the frontier of Wurtemburg), and of all those lying to the south of that line and to the south of Munich, and constituted about half of the entire network of railways belonging to the State.

"But turf fuel had scarcely been adopted on any portion of the northern section of the State railways, except on part of the line between Augsburg and Gunzenhausen, coals or coke being made use of almost exclusively on all the lines which lay north of the latter place. This was easily accounted for by the fact that the coal used as fuel for railway engines in Western and North-Western Bavaria was imported chiefly, if not entirely, from Saxony and Rhenish Prussia (scarcely any of the coal found in Bavaria itself being adapted for that purpose), and found its way into Bavaria through the stations (belonging to the State lines) of Hof and Aschaffenburg, situated, respectively, on the extreme north-east and north-west frontiers of the kingdom. Consequently, all the Saxon or Rhenish-Prussian coal required for use in Southern Bavaria had to be conveyed from one end of the State to the other, at an expense for carriage nearly equal to its cost at either of the above-mentioned frontier stations. The natural consequence was, that the price of coal was nearly twice as high in the southern as in the northern districts of the State. Turf, on the other hand, was found in abundance in several localities in the south; and, in comparison with coal or wood, was extremely cheap. Hence the use of coal on the northern, and turf on the southern divisions of the Bavarian State railways. As regarded the advantages, in an economical point of view, of the use of turf as fuel for railway engines in Bavaria, the following details, procured from an official source, showed the results obtained on the State railways. These were, as it had already been stated, the only railways in the Bavarian dominions on which turf fuel, of any kind, was used,.

coals or coke being alone employed on all other Bavarian lines, namely, those of the Eastern Company, and those of the Trans-Rhenane Province of the Palatinate. The former (which intersected the whole of the eastern and north-eastern portions of the kingdom) were in direct communication with Bohemia, where coal was extremely cheap, and used exclusively coal from that country. The latter derived their supplies from the rich coal district through which those railways passed, and from the adjoining coal districts of Rhenish Prussia.

"The administration of the Bavarian Government railways stated the average cost of the different descriptions of fuel employed by them to be as follows:—

Ordinary turf (at the place where it was produced), fl. 3 30 ks. = 5*s.* 10*d.* per 100 cubic feet.[1]

Pressed turf (at the place of manufacture), 22 kr. per 100 zoll pounds[2] = 12*s.* 5*d.*, per ton English weight.

Saxon coal (at the station of Hof), 24 krs. per 100 zoll pounds = 13*s.* 6*d.* per ton English weight.

Ruhr (Rhenish Prussia) coal (at the station of Aschaffenburg), 28 krs. per 100 zoll pounds = 15*s.* 9*d.* per ton.

From experiments made on the State railways, with the object of testing the heating power of each of these different descriptions of fuel, it had been ascertained that, taking an average, they bore the following proportion one to the other:—

100 cubic feet of ordinary (unpressed) turf = 1,200 zoll pounds of pressed turf = 700 zoll pounds of coal (Saxon or Rhenish-Prussian).

"The following would, therefore, be the scale of cost, in proportion to its heating power, of each of the four different kinds of fuel:—

	fl.	ks.		*s.*	*d.*
Ordinary turf (100 cubic feet)	3	30	=	5	10
Pressed turf (1,200 zoll pounds)	4	24	=	7	4
Saxon coal (700 zoll pounds)	2	48	=	4	8
Ruhr coal (700 zoll pounds)	3	16	=	5	5

"This showed a decided advantage in favour of coal; but, as would be observed, the figures represented the cost of the turf in the southern locality, where it was produced; and the cost of the coal delivered at the stations of Hof and Aschaffenburg (previously referred to), on the northern frontiers of Bavaria. If, therefore,

[1] The Bavarian foot is less, by a small fraction, than the English foot, viz., $1\frac{4}{100}$ Bavarian = 1 English foot.

[2] 100 zoll pounds = $110\frac{1}{4}$ lbs. avoirdupois.

the expense of carriage to the south—which could not be calculated at less than from 80 to 90 per cent. on the cost—were added to the prices paid for coal at the northern stations above mentioned, *the relative cost of the different kinds of fuel, in proportion* to their heating power, would stand about as follows, in the southern districts:—

	fl.	ks.		s.	d.
Ordinary turf (100 cubic feet)	3	30	=	5	10
Pressed turf (1,200 zoll pounds)	4	24	=	7	4
Saxon coal (700 zoll pounds)	5	22	=	8	11
Ruhr coal (700 zoll pounds)	5	50	=	9	8

—the difference being greatly in favour of the two descriptions of turf fuel.

"The result would therefore appear to be, so far as the question of cost price was concerned, that, while coal was the most economical description of fuel in the northern part of Bavaria, turf was decidedly more advantageous in the south; especially as the average price of fl. 3 30 ks. per 100 cubic feet of ordinary turf, as assumed by the railway administration, must be considered an extreme one in Southern Bavaria.

"Independently, too, of the apparent advantage with respect to price, other considerations might be supposed to weigh in Bavaria in favour of the turf fuel for railways belonging to the State, wherever it could be adopted without positive loss. Turf was the produce of the country itself, whilst the coal employed for railway engines was imported from abroad. In the digging and preparing of the vast quantities of turf consumed on the railways of Southern Bavaria (12,511,696 cubic feet of ordinary, and 6,167 tons of pressed turf in the year 1865) employment was provided for many hundred individuals of the native population, and that, too, in districts which (from the usual poverty of the soil where turf existed) the demand for labour was, as a general rule, limited.

"There were also some special advantages as regarded the railway engines themselves, in connection with the employment of turf fuel, on which considerable stress was laid by the administration of the Bavarian State lines. These were—

"1. Turf, being entirely free from sulphur, produced a much less detrimental effect on the heating apparatus and boiler of the engines than coal or coke, so much so, it was stated, that where turf was used those parts of the engines (*cœteris paribus*) would last nearly three times as long as where coal or coke was burnt.

"2. The dust or ash from the turf, being not nearly so hard or gritty as that from coal or coke, caused much less damage to the engines from friction; they also required less repairing and painting, and were much more easily kept clean.

"3. The turf, when properly dried, and especially the pressed turf, caused but little smoke, and none of the noxious sulphurous vapour produced by coke.

"On the other hand, as already stated, the drawback to the use of turf, in its ordinary or unprepared condition, consisted in its great bulk, which was productive of serious inconvenience, and of expense in a variety of ways. This defect, though considerably diminished, was by no means overcome in the case of the pressed turf; as, even in this condensed form, its bulk, in proportion to its weight and heating power, still remained considerably greater than that of coal. Another, though minor disadvantage attaching to turf fuel, was the great quantity of dust it produced, which found its way from the engine into the passenger carriages in a very unpleasant manner.

"With respect to the mode of using turf fuel on the Bavarian railways, it was said that it was always employed alone, that was to say, not in combination with any other description of firing. The only alteration found to be necessary in the usual apparatus of the engines, in order to adapt them to turf fuel, was that of raising the fire-bars about 8 or 10 inches above the ordinary level, so as to prevent there being too great a space between the surface of the burning turf and the upper part of the furnace.

"It might as well be stated that firewood was no longer made use of on the railways of Bavaria, except for the purpose of lighting the fires of the engines, the cost being considerably greater in the north than that of coal, and in the south than that of turf. In the southern districts the average price of ordinary firewood (fir) might be assumed at fl. 7 30 ks. (12*s.* 6*d.*) per klafter (126 cubic feet). Two-thirds of a klafter of such wood being calculated to produce as much heat as 100 cubic feet of ordinary turf, or 1,200 lbs. of pressed turf, the cost of wood as compared with turf would be as follows:—

	fl.	ks.		*s.*	*d.*
Wood (two-thirds of a klafter)	5	0	=	8	4
Ordinary turf (100 cubic feet)	3	30	=	5	10
Pressed turf (1,200 lbs.)	4	24	=	7	4

"In conclusion, some general observations on the subject of turf fuel, furnished by the gentleman who was at the head of the department of the Bavarian Government under which the administration of the State railways was placed, and who had especially given his attention to all matters connected with the management and practical working of railways, were as follows:—

"'According to my experience, the great advantage connected with the use of turf as fuel for railway engines consists in its much less injurious effect on the machinery than that produced by coal.

"'But I must also observe that scarcely any article offers such marked variations in respect of quality as turf. When, therefore, the word "turf" is made use of as meaning turf in general, great misunderstandings and miscalculations may be the result.

"'The proportion assumed of

1 cubic foot of ordinary (unprepared) turf = 12 zoll pounds weight of pressed turf = 7 zoll pounds weight of turf,

is correct as regards the turf of Southern Bavaria, now made use of on our railways; but it would not apply to turf from moors in other districts; and, in fact, can scarcely be considered as more than an approximative calculation, even with the turf of Southern Bavaria, as it frequently occurs that the quality of turf cut from different parts of the same moor varies considerably.

"'The great bulk of turf, in proportion to its heating power, creates serious difficulties; and the larger the scale upon which the turf is used, the greater do these difficulties become—which is the reverse of the rule generally applicable to matters of this kind.

"'It is with the object of overcoming these difficulties that the various systems of pressing or condensation have been introduced. But there is no doubt that, independently of the question of bulk, ordinary unprepared turf, if properly dried, either in the open air or by artificial means, is more efficient than turf in any other form. Let a given quantity of turf be so worked up as to be reduced in point of volume, it certainly gains nothing in point of efficiency as fuel. On the contrary, I feel convinced that the process of pressing, as carried out at Haspelmoor, deprives the turf of some of its valuable component parts.

"'I am far from maintaining that no process is possible by which the difficulties connected with the use of turf on a large scale can be overcome; but I have little hesitation in saying that all the methods hitherto adopted with the object of reducing the bulk of turf, and facilitating its employment, have failed on the ground of expense.

"'This is indeed evident according to the memorandum (furnished by the administration of the State railways) of the relative cost of pressed turf and coal, viz., fl. 4 24 ks. to fl. 2 48 ks., or fl. 3 16 ks. respectively.

"'The expense of carriage of coal no doubt adds very considerably to its cost; but the pressed turf has also to be conveyed to the locality where it is used; and, as compared with coal, nearly a double quantity is required for supplying the engine, and must be carried on the tender.

"'When it is considered that in the carriage of coal from one locality to another for the use of the railways themselves, only the actual cost of the carriage, and not the tariff rate, can be calculated; when, also, the additional labour involved by the employment of turf, and the greatly increased expenses of warehousing are taken into account, it must be acknowledged that the advantages, in a financial point of view, of the turf fuel on railways in Bavaria are still problematical.

"'Looking at all the circumstances of the case, it is my opinion that pressed turf can only be used with advantage when it can be procured at somewhat less than half the price of coal. And if I am correct in this, it is certain that, with the methods of preparing or pressing hitherto practised, there are very few cases in which turf can compete with coal.'

"It would be seen from the foregoing observations that this gentleman's opinion, which certainly deserves due consideration, was less favourable to the use of turf as fuel for railway engines than might have been expected, looking at the results obtained on the State lines of Southern Bavaria. All the details given in this report have been derived from official sources, or have been officially pronounced to be correct.

"The mode of preparing the pressed turf, as practised at the Government establishment at Haspelmoor, in Southern Bavaria, is as follows:—

"The turf, instead of being dug from the moor in the ordinary manner, is cut up by means of a steam plough, the horizontal shares of which enter but a short depth below the surface, thus removing only the upper and drier portion of the turf. By this operation the turf is broken up into small fragments, and the fibres are thoroughly severed, by which the process of drying is greatly facilitated. The turf thus cut from the surface is moved and turned at intervals; it is then gathered into large heaps; and, after remaining exposed to the air and sun for some days, until dry, is removed to the manufactory. It is scarcely necessary to state that the operation of cutting and gathering the turf is only performed during the summer months. Arrived at the manufactory, the turf is passed through sieves having holes a square inch in size, by which the large pieces of turf, the roots, and the tufts of grass are retained. The small turf which runs through the sieves is made to fall into a pit, from whence it is raised to the upper floor of the building by means of two sets of apparatus, similar in their construction to dredging machines; that is to say, a system of buckets made to revolve by means of a large wheel. The turf, as raised by the two sets of apparatus, is thrown from the buckets into the mouths of two cylindrical sieves, made of wire network, placed parallel one to the other. These sieves are 6 feet long, 3 feet in diameter at the upper end, and 2 feet in diameter at the lower end, and both ends are open. These are not fixed horizontally, but at such an angle as to present a fall of $1\frac{1}{2}$ foot in their length of 6 feet. They are set in motion by the steam-engine, and are made to revolve on their own axes, one towards the other. The turf goes through a second process of sifting, all the particles passing through the network of the cylindrical sieves as they revolve. From the sieves the turf, almost in the form of powder, is received upon an inclined plane, down which it falls into a trough a foot wide. This trough is provided with a snake screw, set in motion by the steam-engine, which, as it revolves, pushes the turf powder forwards towards an opening at the end of the trough, through which it falls into the drying oven below.

"The larger pieces of turf, which do not pass through the netting of the cylindrical sieves, slide downwards till they reach the lower end of the cylinder, where, in the same manner as the powdered turf, they are received on an inclined plane, fall into a trough provided with the same description of screw apparatus, and are pushed forward to the end of the trough into a receptacle near the furnace of the steam-engine, for which they serve as fuel.

"The drying oven is built of bricks. It is 15 feet broad, 35 feet long, and 14 feet high, divided into six storeys or floors. Each floor consists of a hollow box 2 inches in height, made of sheet iron; and all these hollow floors are so constructed as to communicate one with the other. The steam, which after each stroke of the piston escapes from the engine, is made to pass through the floors, and thus contributes towards the heating of the oven. In addition to this, a stream of hot air is conveyed into the oven by means of a pipe which passes under the furnace of the engine. By this arrangement the temperature of the oven is maintained at from 45° to 50° of Reaumur.

"On each floor is placed a series of screws working horizontally, which are set in motion by the steam-engine; and at the alternate ends of each floor is an opening which communicates with the floor beneath, and the screws of each floor are made to work in an opposite direction to those of the floor immediately above it. The powdered turf falls from the trough above described into one end of the upper floor of the oven, and is pushed by the motion of the screws towards the opening at the opposite end. It falls through the opening, and is guided, by means of an inclined plane which projects from the wall of the oven a short distance below the opening, to the screws on the floor beneath; and by a repetition of this process it at last arrives at the farther end of the lower floor. The time occupied by the powdered turf in thus passing over all the six floors of the oven is about an hour; and in the course of its passage it acquires a degree of heat of about 40° Reaumur; but it is not completely dried thereby, as, on leaving the oven, it still contains from 10 to 12 parts of moisture. In this condition, however, it can be pressed with advantage. The steam which rises from the turf powder, in the course of its passage through the drying oven, is carried off by means of chimneys leading to the open air. From the lower floor of the oven, the turf powder falls into a large iron funnel; and from this it passes into four smaller funnels, each of which communicates with and feeds one of the presses. Of these there are four. They are ordinary eccentric presses, very strong, but of simple construction. Only three of the four presses are kept constantly at work at the Haspelmoor factory, the other being reserved for use in case one of the three gets out of order. All four are placed in one row, side by side, on the ground floor; and they are set in motion by the main shaft of the steam-engine, which shaft has a diameter of half a foot. For each press the main shaft is provided with a fly-wheel weighing 80 Bavarian centners (123½ lbs. avoirdupois each), a driving-wheel 1½ foot in diameter, and weighing 12 centners, and two rollers. The following is the mode in which the press works:—The main shaft being made to revolve by means of the upper roller, the driving-wheel turns a spur-wheel, having a diameter of 3 feet, and weighing 15 centners. The spur-wheel turns a shaft, on which it is fixed. The latter shaft is not common to all the four presses, each press having its own shaft. On this shaft is fixed the eccentric cylinder, which moves the piston-bars, of which there is one on each side of the press. The piston-rods are 5½ feet long, and have at the farther end a massive tail-piece, which moves backwards and forwards in a space or groove. To the fore part of the tail-piece is fixed the piston of the press, the end of the latter being shod with a steel plate 1 inch thick.

The two piston-rods, the tail-piece, and the piston itself weigh together 38 Bavarian centners. The box of the press, in which the piston moves horizontally backwards and forwards, is made of cast iron, and is of one piece. It weighs 55 centners. The top, or lid, of the press is detached, and can be screwed down more or less closely by means of a screw. The dimensions (breadth and depth) of the piston and of the cavity of the press are the same as those to be given to the cakes of turf when pressed, namely, 7 inches in breadth and 3 inches in depth. Above the cavity of the press, and communicating with it, is placed a funnel, into which the powdered turf falls when it leaves the funnel described above. At each backward movement of the piston of the press, the turf falls from the funnel into the cavity in front of the piston, and by the forward movement of the piston the turf powder is pressed into a solid brick. As the bricks of turf are pressed, they are pushed forward through a tube, till they arrive at the mouth of another tube, whence they fall by their own weight into the truck which carries them away. The piston performs from 42 to 45 movements per minute, by each of which a brick of turf is pressed. The weight of the bricks varies somewhat, according to the quality of the turf; but three-quarters of a Bavarian pound[1] is the average weight of those made from Haspelmoor turf. Each press would therefore produce about 30 lbs. weight of pressed turf per minute. This, supposing the three presses to be kept at work for twenty hours per day during three hundred days of the year, would give a total production for twelve months of 324,000 Bavarian centners (about 17,858 tons English)."

[1] The Bavarian pound weighs 1 lb. $3\frac{3}{4}$ oz. avoirdupois.