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## THE LANDORE SIEMENS STEEL WORKS, ENGLAND.

Condensed from The Engineer.

The principal novelty upon which the processes in operation in these works are based is Mr. Siemens' regenerative gas furnace, by means of which most intense heats are obtained without cutting flames or deteriorating influences. The steel processes carried on are of two distinct kinds In the first, which is called the Siemens-Martin process, scrap metal or puddled blooms are dissolved in a bath of pig metal previously prepared on the open hearth of one of these regenerative furnaces, and spiegeleisen is finally added to impart to the metallic bath the requisite percentage of carbon and manganese. In the other process pig metal and iron ores, previously prepared for the purpose, are brought into combination on the hearth of a similar furnace, to produce the same final result, namely, a steel of excellent quality.

The Landore Siemens Steel Company, Limited, was formed three years ago for the manufacture of steel by the processes invented by Mr. C.W. Siemens, C.E. The regenerating gas furnace, which he had previously invented, gave him the power of producing, at a moderate cost, temperatures before unknown in practical metallurgy; consequently, no great time elapsed before he applied this new power to the manufacture of steel, since the intense heat at his command enabled him to keep in a state of fusion, for a lengthened period, a much larger quantity of malleable iron than was practicable before the invention of his furnace. The difference between the Siemens and the Bessemer process of making steel is, that by the former method the metal is kept for any time slowly simmering in a state of fusion, so that, by the addition of varying proportions of the ingredients, at such times as may be convenient to the manager of the furnace, steel of any temper can be made. The process is so completely under control that steel containing any desired quantity of carbon can be made at will, whereas steel containing a predetermined proportion of ingredients can only be made by the Bessemer process with some difficulty. Mr. Siemens, by melting together samples of iron containing different proportions of carbon, produces steel containing any desired quantity of carbon.

The Landore Works were built nearly two and a half years ago; they cover about six acres of ground, on the west bank of the river Tawe, near Swansea, and at the present time they keep about 400 men in constant employment. They consist of fifty two Siemens producers for the manufacture of the gas, a melting shop containing eight furnaces, and a forge department containing two eight tun hammers, capable of hammering 450 tuns a week. There are six reheating furnaces in the forge department. There are also in the works six double puddling furnaces with shingling hammer, and a mill driven by two of Thwaites and Carbutt's 30 inch cylinder engines, with Ramsbottom's reversing gear.

In the mill department there are three double straightening presses, and one double punching press, one "ending" machine, and one cold saw. Some new works are in course of erection, by the same company, on the opposite bank of the river, a little to the north of the Landore viaduct. At present the company do not make their own pig iron, but in the new works four blast furnaces will be erected for the manufacture of pig, which will then be puddled and melted. Sixteen melting furnaces will be built, and five eight tun hammers put up. It is intended to keep a rolling mill at work night and day.

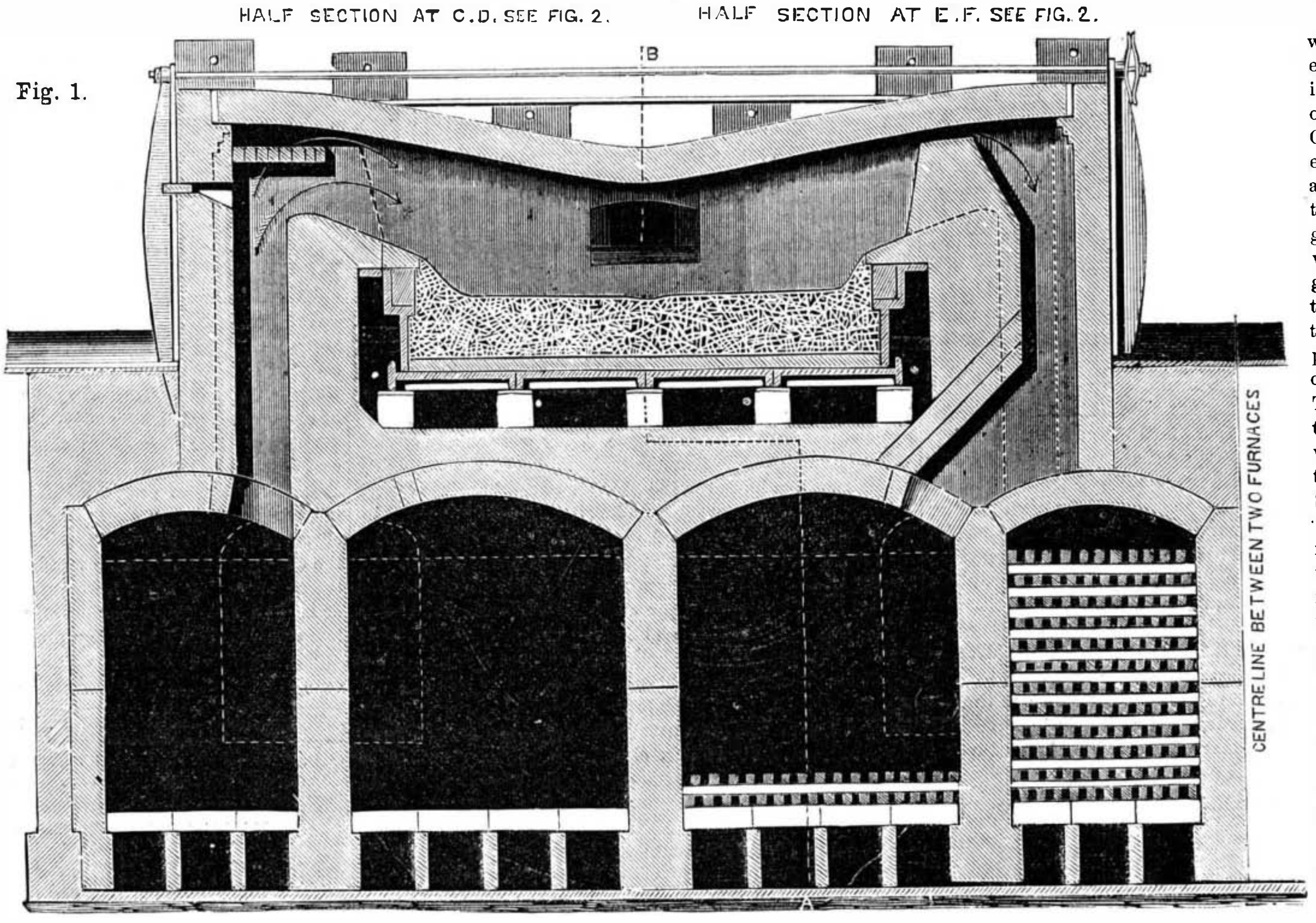
When these new works are completed and the iron trade is brisk, the Landore Siemens Steel Company could find employment for about 1,000 men. In the new steel works gas furnaces only will be used; one great advantage of these furnaces is, that they do not pollute the air with clouds of smoke. The iron ore to feed the blast furnaces will be brought for the most part from Spain.

In the steel works now in operation the fifty-two Siemens producers for the manufacture of gas are arranged in thirteen blocks of four each. The gas is divided into two portions, one of which is conveyed to the melting and puddling furnaces, another portion being conducted by a second large tube to other melting furnaces, and to the heating furnaces for the mill and hammer. The coal used in the manufacture of the gas is obtained from the neighborhood, and consists of equal parts of "slack" of small coal and binding coal.

In the melting shop there are eight furnaces altogether; four of them are for melting up scrap, and about 62 tuns per week are melted in each furnace; the furnaces work about thirteen heats per week. First, about one tun of pig iron is charged in, then sufficient scrap, with very little carbon in, to reduce the carbon in the metal in the furnace to *nil*, or very nearly *nil*. The little carbon in the metal is partly boiled out, and this is one of the peculiarities of the process, for if the charge in the furnace be left to itself, the carbon is slowly boiled away. The necessary amount of carbon to produce steel is introduced by adding spiegeleisen, which at the same time furnishes the requisite quantity of manganese; but after the spiegeleisen is added, it is necessary to tap the furnace as quickly as possible, or the manganese would be burnt away. The pig iron used in the process is of good quality, and as much steel scrap as can be obtained is very quickly used up at the works. The following is a fair sample of an ordinary charge: —20 per cent pig iron, 20 per cent Bessemer scrap, 10 per cent rough puddled iron, 15 per cent Siemens scrap, 15 per cent old iron and borings, 20 per cent shearings.

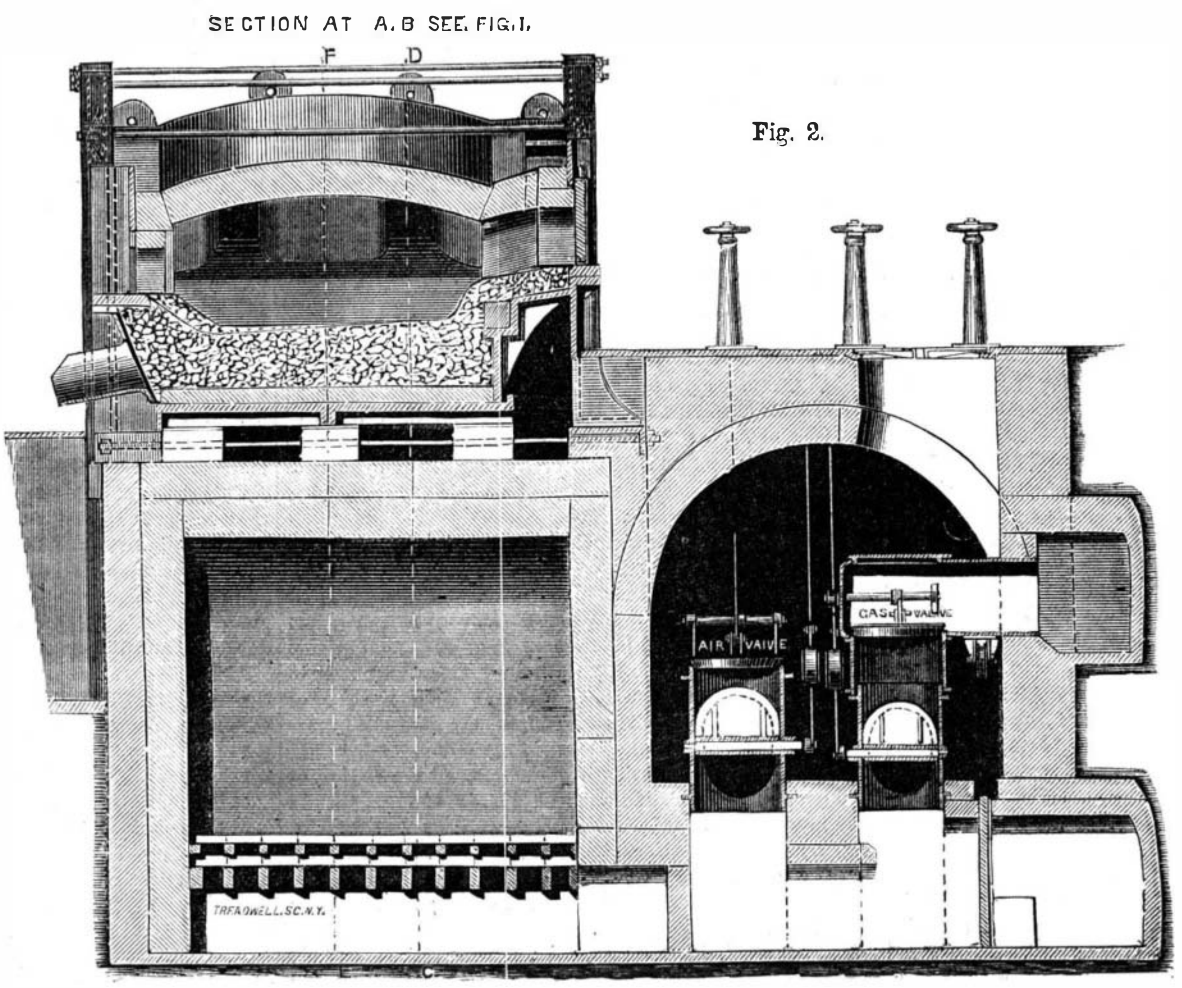
About 7½ per cent of spiegeleisen is then added, which

Fig. 1.



STEEL MELTING FURNACE, SIEMENS STEEL WORKS, LANDORE, ENGLAND.

Fig. 2.



much more than covers the waste. Every now and then a little of the melted metal is taken out in a ladle, and plunged into cold water; the sample is then broken upon an anvil. Its fracture should be bright and crystalline, showing a very small proportion of carbon—not more than 0·1 per cent; it should also be tough and malleable. From 5 to 8 per cent of spiegeleisen, containing not less than 9 per cent of manganese, is thereupon charged through the side openings down upon the bank of the furnace, and allowed to melt down into the bath. The amount of carbon thus introduced determines the temper of the resulting steel. In the event of the sample containing too much carbon, as proved both by its appearance and by chemical analysis, the carbon is allowed to boil out if the furnace is too full, as the addition of more iron might cause accidents; but this boiling out takes time. The quickest way is to add more decarburized iron, if there is room for it in the furnace. In judging the amount of carbon present by the appearance of the sample, the rule is "the more silky the metal, the less carbon does it contain," and, when it is half way between the granular and silky states, then the bath is ready for the spiegeleisen.

The accompanying engravings show the form of the interior of the furnace. In charging it, it is first made quite hot, and then one tun of pig iron is charged in; this takes about an hour to melt, and then fills the bath to the proper level. After it is fairly melted, the men begin to charge the scrap on the bank, where it is allowed to get red hot before it is tumbled down upon the melted pig iron; it would chill the bath if it were added cold. The men keep on placing quantities of more or less carburised metal upon the bank, and tumbling it into the bath when hot, until the bath contains about four tuns, filling it to the proper level. The whole operation occupies seven or eight hours. The time varies a little; on a hot day the furnace will not work so well as on a cold one, because of the draught. After four tuns of iron have been melted, the men begin to take samples out, and then go on charging decarburised iron till the metal gets soft enough, at which point there ought to be about five tuns in the furnace. If it is too hard more shearings are added; if not hard enough a little pig iron is put in. Last of all the spiegeleisen is put in; it is placed on the top of the bank, and tumbled in directly it is warm enough. Then the furnace is quickly emptied, for the forgeability of the steel depends entirely upon getting the charge out directly after the spiegeleisen has been put in, or else the manganese would all be burnt out. The process of melting takes about ten hours from first to last. The furnaces work night and day; there are three men continually attending to each furnace, and they work twelve hours each. At present, however, the mill is working only one shift per day, which turns out 350 tuns of rails per week.

From experiments made in France by M. Sudre, at the expense of Napoleon III., it was found that it is just possible to raise the heat of an ordinary furnace, by means of a fan blast, sufficiently to effect the fusion of tool steel upon the open hearth, but that the cost of the fuel and the rapid destruction of the furnace are commercial obstacles to the use of the method.

In the Siemens steel furnace, the direction of the flame is from end to end, and the regenerators are placed transversely below the bed, which is supported on iron plates kept cool by a current of air; this cooling of the bed is very necessary to keep the slag or melted metal from finding its way through into the regenerator chambers. The bottom of the furnace is formed of siliceous sand. Instead of putting moist sand into the cold furnace, Mr. Siemens calcines the sand, and introduces it into the hot furnace in layers of about one inch in thickness. The heat of the furnace must be sufficient to fuse the surface of each layer; that is to say, it must much exceed a welding heat at the end of the operation, in order to impart additional solidity to the uppermost layers. Care must be taken that the surface of the bath assumes the form of a shallow basin, being deepest near the tap hole. Some white sand—such, for instance, as that from Gornal, near Birmingham—will set, under these circumstances, into a hard, impervious crust, capable of surviving from twenty to thirty charges of liquid steel, without requiring material repair. If no natural sand of proper quality is available, white sand, such as that of Fontainebleau, may be mixed intimately with about 25 per cent of common red sand, when the same result will be obtained. The actual requirement is sand containing about 96 per cent of silica and 4 per cent of alumina or magnesia.

After the steel is melted, it is tapped out of the furnace into a ladle, as in the Bessemer process, and is then run into ingots.

The rails for the Metropolitan Railway, made at the Landore Steel Works, have a flange of 6$\frac{3}{8}$ inches across, which is a great width to "bring up" in steel, and can only be done with good metal; the steel, if of second rate quality, will crack along the edges of the flange.

We saw several testing machines in the works where inspectors employed by the different railway companies test the rails before accepting them of the makers. The test for the bridge rails used on the Great Western Railway is a weight of 21 cwt., allowed to fall from a height of 6 feet 4 inches upon the center of a piece of rail supported upon bearings 3 feet 6 inches apart. The blow is repeated three times upon the center of the same piece of rail; and if the center of the rail be then deflected about 7 inches, the steel is considered to be good. Sometimes the result is a deflection of not more than 5 or 6 inches, and sometimes the piece of rail breaks, but not often.

The total fall of the machine is 24 feet, upon an anvil block of solid iron weighing 15 tons. The rigidity of the anvil is an important point in testing steel rails or bars.

The test of the Bristol and Exeter Railway Company is a 10 feet fall of 2,240 lbs.; three blows; 5 feet bearings.

The rails for the Metropolitan Company weigh 86 lbs. to the yard, and are tested, not by a falling weight, but by the dead weight produced by hydraulic pressure. A piece of the rail is placed upon 5 feet bearings, and a slightly curved iron surface 3$\frac{3}{4}$ inches in width is made to press upon the center of the sample rail selected for testing. The test is that under these conditions a pressure of 40,000 lbs. shall not deflect the centre of the rail more than 1 inch; also that 60,000 lbs. shall deflect it 9 inches without breaking it.

A steel rail has fully six times the life of an iron rail, and the difference in price between them is about £5 per ton. Steel rails now cost £12 per ton.

There is a laboratory attached to the Landore Steel Works, under the direction of Mr. A. Wallis, where every sample of iron which enters the melting furnaces is first analysed to ascertain the proportion it contains of sulphur, phosphorus, and silicon. Every charge from the melting furnaces is tried also by the color test for carbon. If the proportion of carbon is found to be rather high, a rail is rolled and a piece of it cut off and tested before the remainder of the ingots are hammered. If it does not stand the test, the ingots are sent back to the furnaces.

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## DURABILITY OF TIMBER.

The following is an extract from the new edition of "Tredgold on Carpentry," edited by John Thomas Hurst, and noticed in another column:

Of the durability of timber in a wet state, the piles of the bridge, built by the Emperor Trajan across the Danube, are an example. One of these piles was taken up, and found to be petrified to the depth of three fourths of an inch; but the rest of the wood was little different from its ordinary state, though it had been driven more than sixteen centuries.

The piles under the piers of old London Bridge had been driven about 600 years, and, from Mr. Dance's observations in 1746, it did not appear that they were materially decayed; indeed they were found to the last to be sufficiently sound to support the massy superstructure. They were chiefly of elm.

We have also some remarkable instances of the durability of timber when buried in the ground. Several ancient canoes have been found, in cutting drains through the fens in Lincolnshire, which must have lain there for many ages. In the *Journal of Science*, etc., published at the Royal Institution, one of these canoes is described, which was found at the depth of eight feet below the surface of the ground. It was 30 feet and 8 inches long, and 3 feet wide in the widest part, and appears to have been hollowed out of an oak tree of remarkably fine free grained timber.

Also, in digging away the foundation of old Savoy Palace, London, which was built nearly 700 years ago, the whole of the piles, consisting of oak, elm, beech, and chestnut, were found in a state of perfect soundness; as also was the planking which covered the pile heads. Some of the beech, however, after being exposed to the air for a few weeks, though under cover, acquired a coating of fungus over its surface.

On opening one of the tombs at Thebes, M. Belzoni discovered two statues of wood, a little larger than life, and in good preservation; the only decayed parts being the sockets to receive the eyes. The wood of these statues is probably the oldest in existence that bears the traces of human labor.

A continued range or curb of timber was discovered in pulling down a part of the Keep of Tunbridge Castle, in Kent, which was built about 750 years ago. This curb had been built into the middle of the thickness of the wall, and was no doubt intended to prevent the settlements likely to happen in such heavy piles of building; and therefore is an interesting fact in the history of constructive architecture, as well as an instance of the durability of timber.

In digging for the foundations of the present house at Ditton Park, near Windsor, the timbers of a drawbridge were discovered about ten feet below the surface of the ground; these timbers were sound but had become black. Hakewell says that Sir John de Molines obtained liberty to fortify the Manor house of Ditton, in 1396; and it is most probable the drawbridge was erected soon after that time; and accordingly the timber had been there about 400 years.

The durability of the framed timbers of buildings is also very considerable. The trusses of the old part of the roof of the Basilica of St. Paul, at Rome, were framed in 816, and were sound and good in 1814, a space of nearly a thousand years. These trusses are of fir.

The timber work of the external domes of the Church of St. Mark, at Venice, is more than 840 years old, and is still in a good state. And Alberti observed the gates of cypress to the Church of St. Peter, at Rome, to be whole and sound after being up nearly 600 years.

The inner roof of the Chapel of St. Nicholas, King's Lynn, Norfolk, is of oak, and was constructed about 500 years ago.

Daviller states, as an instance of the durability of fir, that the large dormitory, of the Jacobins' Convent at Paris, had been executed in fir, and lasted 400 years.

The timber roof of Crosby Hall, in London, removed in 1869, was executed about 400 years ago; and the roof of Westminster Hall, which is of oak, is now above 340 years old.

The rich carvings in oak which ornamented the ceiling of the king's room in Stirling Castle, are many of them still in good preservation. It is nearly 360 years since they were executed, and they remained in their original situation till a part of the roof gave way, in 1777, when the whole was removed, and has since been dispersed among the collectors of curious relics of old times.

Moreton Hall, in Cheshire, where "the staircase winds round the trunk of an immense oak tree," and the building itself is chiefly constructed of wood, has now existed nearly 300 years.

And Mr. Britton describes an old house at Islington, constructed chiefly of wood, which he has ascertained to be about 240 years old.

Other notices of extraordinary durability will be found in the descriptions of the different kinds of wood. But enough already has been collected to show that timber is very durable where nothing more than ordinary means have been used to render it so; that is, nothing more than judicious selection and good seasoning.

Every permanent support should be formed of a good and sound piece of timber; inferior kinds should be used only for temporary purposes, or where no strain occurs, and where they can be easily renewed without injury to the strength of the building.

Mr. Barrow, in writing on this subject, very judiciously remarks, "that the felling of timber while young and full of vigor, making use of the sapwood, and applying it to ships and buildings in an unseasoned state, have no doubt contributed to make the disease of dry rot infinitely more frequent and extensive than it was in former times, when our ships were hearts of oak, and when, in our large mansions, the wind was suffered to blow freely through them, and a current of air to circulate through the wide space left between the paneled wainscot and the wall. In those old mansions, which yet remain, and in the ancient cathedrals and churches, we find nothing like dry rot, though perhaps

"perforated sore
And drilled in holes, the solid oak is found
By worms voracious eaten through and through."

In regard to the durability of different woods, the most odoriferous kinds are generally considered to be the most durable; also woods of a close and compact texture are generally more durable than those that are open and porous, but there are exceptions, as the wood of the evergreen oak is more compact than that of the common oak, but not nearly so durable.

Sir H. Davy has observed that, "in general, the quantity of charcoal afforded by woods offers a tolerably accurate indication of their durability; those most abundant in charcoal and earthy matter are most permanent; and those that contain the largest proportion of gaseous elements are the most destructible. "Amongst our own trees," he adds, "the chestnut and the oak are pre-eminent as to durability, and the chestnut affords rather more carbonaceous matter than the oak. But we know from experience, that red or yellow fir is as durable as oak in most situations, though it produces less charcoal by the ordinary process. The following table of the quantity of charcoal afforded by 100 parts of different woods is added, for the information of the reader:—

| Kind of Wood. | Watson. | Mushet. | Proust | Rumford. |
|---|---|---|---|---|
| Oak, dry | 22·92 | 22·6 | 19 | 43 |
| Chestnut | .... | 23·2 | .. | .... |
| Mahogany | 20.82 | 25·4 | .. | .... |
| Walnut | 26·04 | 20·6 | .. | ... |
| Elm | .... | 19·5 | .. | 43·27 |
| Beech | .... | 19·9 | .. | ... |
| Fir | 15·62 | .... | .. | 44·18 |
| Norway Pine | .... | 19·2 | .. | .... |
| Pine | .... | .... | 20 | .... |
| Scotch Pine | .... | 16·4 | .. | .... |
| Ash | 17·71 | 17·9 | 17 | .... |
| Poplar | .... | .... | .. | 43·57 |
| Lime | .... | .... | .. | 43 59 |
| Birch | .... | 17·4 | .. | .... |
| Sycamore | .... | 19·7 | .. | .... |
| Sallow | .... | 18·4 | .. | .... |

In Count Rumford's experiments a longer period was allowed for the process; and, in consequence, his results represent more nearly the real quantities of carbon in each wood than the others. But even according to the common process, it does not appear that the proportion of charcoal is a satisfactory criterion of the durability.

An experiment to determine the comparative durability of different woods is related in Young's "Annals of Agriculture," which will be more satisfactory than any speculative opinion; and it is much to be regretted that such experiments have not been oftener made.

"Inch and half planks of trees from thirty to forty-five years' growth, after ten years' standing in the weather, were examined and found to be in the following state and condition:—

Cedar, perfectly sound; larch, the heart sound, but sap quite decayed; spruce fir, sound; silver fir, in decay; Scotch fir, much decayed; pinaster, quite rotten; chestnut, perfectly sound; abele, sound; beech, sound; walnut, in decay; sycamore, much decayed; birch, quite rotten.

This shows at once the kinds that are best adapted to resist the weather; but even in the same kind of wood there is much difference in the durability, and the observation is as old as Pliny, that "the timber of those trees which grow in moist and shady places is not so good as that which comes from a more exposed situation, nor is it so close, substantial, and durable;" and Vitruvius has made similar observations.

Also split timber is more durable than sawed timber, for the fissure in splitting follows the grain, and leaves it whole, whereas the saw divides the fibres, and moisture finds more ready access to the internal parts of the wood. Split timber is also stronger than sawed timber because the fibers, being continuous, resist by means of their longitudinal strength; but when divided by the saw, the resistance often depends upon the lateral cohesion of the fibers, which is in some woods only one twentieth of the direct cohesion of the same fibers. For the same reason whole trees are stronger than specimens, unless the specimens be selected of a straight grain, but the difference in large scantlings is so small as not to be deserving of notice in practice.