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PRACTICAL TUNNELLING

THE SETTING OUT OF THE WORKS,
SHAFT-SINKING AND HEADING-DRIVING,
RANGING THE LINES
AND LEVELLING UNDER GROUND,
SUB-EXCAVATING, TIMBERING,
AND THE CONSTRUCTION
OF THE BRICKWORK OF TUNNELS

FREDERICK WALTER SIMMS



CAMBRIDGE

Practical Tunnelling

*The Setting Out of the Works,
Shaft-Sinking and Heading-Driving,
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and the Construction of the Brickwork of Tunnels*

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THE WORKS AT BLECHINGLEY TUNNEL.

P R A C T I C A L T U N N E L L I N G.

EXPLAINING IN DETAIL,
THE SETTING OUT OF THE WORKS;
SHAFT SINKING, AND HEADING DRIVING;
RANGING THE LINES, AND LEVELLING UNDER GROUND;
SUB-EXCAVATING, TIMBERING;

AND THE CONSTRUCTION OF THE
BRICKWORK OF TUNNELS:

WITH THE
AMOUNT OF LABOUR REQUIRED FOR, AND THE COST OF THE VARIOUS PORTIONS OF THE WORK:

AS EXEMPLIFIED BY THE PARTICULARS OF
BLECHINGLEY AND SALTWOOD TUNNELS.

BY
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TO

WILLIAM CUBITT, Esquire,

F.R.S. M.R.I.A. F.R.A.S. F.G.S.

VICE-PRESIDENT OF THE INSTITUTION OF CIVIL ENGINEERS,

&c. &c. &c.

THIS WORK

UPON

PRACTICAL TUNNELLING

IS MOST RESPECTFULLY

DEDICATED,

BY HIS MOST HUMBLE SERVANT,

FREDERICK WALTER SIMMS.

P R E F A C E .

It was originally my intention to have prepared a general history of Tunnelling operations, and to have given every particular that might be thought interesting or instructive of all such works, from the earliest period. Such a work would have necessarily been extensive, and have required more time in its preparation than I could, at present, devote to it. Upon explaining my plan, and shewing the memoranda that I had made, during the progress of the works under my charge at Blechingley and Saltwood Tunnels, I was advised that their publication, with a practical account of Tunnelling operations as practised at the present time, would be acceptable; particularly to the junior members of the profession, and to many contractors, whose experience has not hitherto been in the construction of such works. I therefore undertook the preparation of this volume, which has for the most part been written, and passed through the press, during the time that I have been actively engaged in my professional pursuits; and which must be my excuse for any trifling inaccuracies that may be detected in it.

I do not profess to describe any new methods of carrying on the works necessary for the construction of Tunnels, but to give in detail that which I believe to be the most approved practice at the present time; and in order to accomplish this, and supply data for correctly estimating the cost of future works of the like kind, I have adopted, as my examples, the two important works executed under my superintendence, with the details and cost of which I am necessarily most familiar; and having as is my custom, kept minutes of the amount of labour consumed in the various parts of the work, I am thereby enabled to furnish the particulars contained in the Tables embodied in the following pages.

The prices paid for Materials are likely to differ in every locality, whilst the amount of labour required to execute any work will remain the same; for instance the article Bricks, which cost in the South-Eastern parts of the country from thirty to fifty per cent. more than they can be purchased for in the central parts of the kingdom; not but the amount of labour consumed in their manufacture or the value of that labour, is the same in both districts, or nearly so, yet the difference exists in the greater value of the fuel with which they are burned. The prices of Timber will also vary; and subsequently to the time when the works described in these pages were executed, a large portion of the duty on foreign timber has been taken off, which would make a considerable reduction in the expenditure, if the same works had now to be con-

structed: the actual cost of the works described may, however, prove useful information.

I am not aware that any part of the *modus operandi* has been omitted; and if it be considered that I have gone more minutely into detail than was necessary, it will, doubtless, at the same time be admitted that the fault is on the right side,—as I do not expect that men experienced in Tunnel works will read these pages in search of instruction; and for those who have not had that experience, too much practical detail cannot be given. There is no royal road to Knowledge, either theoretical or practical; and it is therefore the duty of those who profess to communicate it, to smooth the rugged uphill path thereto, in every possible way. Such a course I have endeavoured to pursue in the preparation of the following pages:—how far I have succeeded must be left for others to judge.

F. W. S.

Hythe, Kent,

August 29th, 1844.

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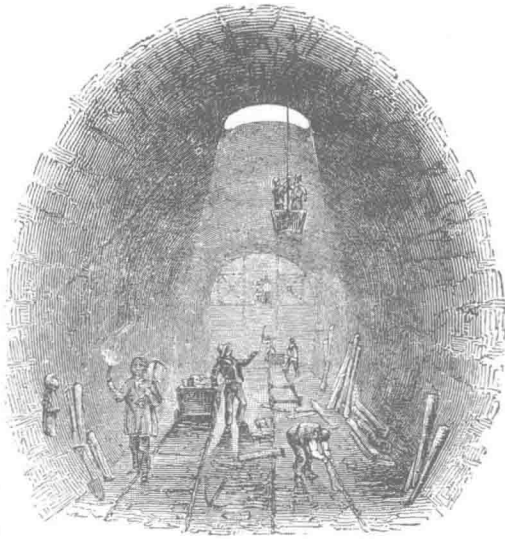
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PRACTICAL TUNNELLING.

CHAPTER I.

GEOLOGICAL FEATURES OF THE SOUTH-EASTERN RAILWAY. — GENERAL ACCOUNT
OF BLECHINGLEY AND SALTWOOD TUNNELS, THEIR COST, ETC.

THE Blechingley and Saltwood Tunnels are situated upon the line of the South-Eastern Railway between London and Dover, which passes through a district of country, not only celebrated for the beauty of its landscape, but highly interesting to the Geological enquirer; the Railway being formed through the Tertiary strata, and the cretaceous group of the secondary formation. Commencing at the Metropolis, it is constructed upon the London Clay till it reaches New Cross; where, at about one hundred yards to the south of the public road bridge, the Plastic Clay formation appears on the slopes near the bottom of the excavation, in situ beneath the London Clay.

The junction of the two formations at this place is described in an interesting paper read before the Geological Society, April 17, 1844, by H. Warburton, esquire, the President, containing some results of an examination of that locality, in which I had the pleasure of assisting him; and is represented in the following section.

London Clay :

- | | | | | | | |
|----|---|------------------------------|---|---|---|---------------------------|
| 1. | { | Yellow clay, | . | . | . | thickness not determined. |
| | { | Blue or slate-coloured clay, | . | . | . | thickness 10 to 15 feet. |

Plastic Clay formation :

					ft.	in.
2.	Rolled flint pebbles or shingle,	.	.	thickness	1	10
3.	Fine fawn-coloured sand,	.	.	.	0	3
4.	Lignite,	.	.	.	0	0½
5.	Fine fawn-coloured sand,	.	.	.	2	0
6.	Ferruginous sand, with marine fossils, oyster shells, and cerithia	.	.	.	0	4
7.	Loose grey sand, with fragments of cerithia,	.	.	.	0	8
8.	Strong black clay,	.	.	.	0	10
9.	Black clay and sand, with fragments of oysters and cerithia,	.	.	.	0	9
10.	Black dirty sand,	.	.	.	0	4
11.	Dark sand, containing fossils, oyster shells, &c.	.	.	.	0	6
12.	Calcareous stone, containing paludina, unio, &c. (freshwater fossils)	.	.	.	0	6
13.	Decomposed stone and sand, with oysters, &c.	.	.	.	0	3

The shells belonging to the upper part of the Plastic Clay series in this neighbourhood have been well described by Dr. Buckland in the fourth volume of the first series of the Geological Society's Transactions, but the occurrence of the paludina and unio in the stratum No. 12 of the above section, which are freshwater shells, thus included between marine fossils, appears to have escaped observation, till now discovered by Mr. Warburton; who describes the stone in which they are embedded, as septaria of a texture considerably more earthy than the septaria of the London Clay usually are.

The line of Railway continues upon the Plastic Clay as far as Combe Lane, Croydon; where the Chalk crops out from beneath the sands of the last named formation, and is distinctly to be seen on the north-east slope of the cutting. The Railway then crosses the great Chalk range that extends from Dover to

Hampshire, and rises towards the Chalk escarpment at Merstham in Surrey, where its greatest summit level between London and Dover is attained in the tunnel near that place.

In the deep cutting at the south of the tunnel, a good section of the Upper Green Sand stratum appears, cropping out from beneath the Chalk; this is succeeded at the village of Merstham by the Gault, through which the road to Blechingley has been lowered that it might be passed under the Railway.

At a short distance further southward, the Lower Green Sand formation rises to the surface, in beds of fawn-coloured sand, very silicious, and good for Engineering purposes. The middle beds of the Lower Green Sand, as indicated by the presence of rushes and wet land, next appear; and these are followed by the lower beds of the same formation, which contain the Kentish ragstone, fuller's earth, &c.—the fuller's earth pits of Nutfield being near this locality. The lower beds of this formation rise to a considerable height, and form the range of sand hills that passes through the country, parallel to the great chalk range before named.

The place where the railway crosses the sand range is called Redstone Hill, and is the point where the Brighton railway diverges to the south, while the Dover railway passes round the hill with a curve of half-a-mile radius to the eastward; and towards the further end of this curve, near to a bridge at Robert's Hole farm, the next inferior stratum, the Weald Clay, emerges from beneath the sand. This spot may be further identified by the greater width of the excavation, or flatness of the slopes, occasioned by the slipping of the earth at the junction of the two formations, where much water was present. In making this excavation, some stone was found, that was much jointed, and contained innumerable fossils, which, upon examination in April 1843, by Mr. Warburton, Dr. Fitton, Mr. Austen, and myself, was found to include some of the most characteristic of M. Leymerie's Neocomien species, with a few belonging also to the quarystone of Hythe; as, *arca raulini*, *panopœa depressa*, *pholadomya acutisulcata* (Leymerie), *pecten obliquus* (interstriatus), *pinna sulcifera*, *gervillia aviculoides*, *perna mulleti*, *p. alæformis*, *trigonia dœdalea*, *t. Fittoni*, *gryphæa sinuata*, *nautilus radiatus*, &c. This stone appears to correspond with the Atherfield rocks in the Isle of Wight; which it resembles in its mineralogical and geological character. [See paper, by Dr. Fitton, read before the Geological Society, May 24, 1843, entitled "Observations on the Section of the Lower Green Sand at Atherfield, on the coast of the Isle of Wight."]

From Redstone Hill the line passes eastward, along the Weald Clay, in successive cuttings and embankments for many miles, except that near Blechingley there is a tunnel, bearing that name, formed through a spur of Tilburstow Hill: the Weald Clay at this place is indurated into a shale, or blue bind, and being full of joints and faults, caused much difficulty in the work, as will be described in the following pages. The fossils found during the construction of the tunnel, were, portions of the *iguanodon*, *hylæosaurus*, *cypris*, *paludina*, *clathraria* (Lyelli), &c. &c. and a fine specimen of the *lepidotus* (Mantelli), presented by me to the Geological Society, accompanied by a short paper upon the subject of the strata at this place, which was read at the Society's meeting on February 21st, 1844.

Near the town of Ashford the line leaves the Weald Clay, and again enters upon the Lower Green Sand formation, which continues to be its base as far as Folkestone, a distance of about fifteen miles: the summit is passed by means of a Tunnel, at Saltwood, not far from the out-crop of the Sand from beneath the Gault; consequently the shafts were sunk through the upper beds, and the tunnel is formed at the junction between that and the middle bed; where a large quantity of water was encountered, which greatly retarded the progress of the works. Among numerous fossil remains found at Saltwood, chiefly in ferruginous concretions, the following may be particularly enumerated: *nautilus radiatus*, *gervilia aviculoides*, *terebratula*, *tethys major*, *panopœa*, *trigonia alœformis*, *venus*, *cardium*, *tornatella*, *pecten quinquecostatus*, *p. orbicularis*, &c. &c. with fossil coniferous wood pierced by *gastrochæna*; together with a remarkable product, a new and beautiful resin, which partakes of the properties of amber and of retin-asphalt, and is principally marked by its clear red colour, its infusibility, and the difficulty with which it is acted upon by many chemical solvents. I was indebted to Mr. Edward Solly, through the kindness of Dr. Fitton, for a chemical examination of this substance, the results of which are inserted at length in a paper read before the Geological Society, June 7th, 1843, giving an account of an investigation of the strata from the summit of the Chalk escarpment above Saltwood tunnel to the sea at Hythe; or, at right angles both to the range of hills and the direction of the line of Railway in that locality. It may not be uninteresting to insert the result of such examination.

The Upper Green Sand stratum, which at the back of the Isle of Wight is one hundred and four feet thick, is here altogether wanting, it having thinned out at this place.