THE CHANNEL TUNNEL:

OR,

SUBMARINE RAILWAY

BETWEEN

ENGLAND AND FRANCE.

STATEMENT BY THE COMMITTEE

OF THE

CHANNEL TUNNEL COMPANY

(LIMITED).

LONDON:
SAVILL, EDWARDS & CO., PRINTERS, CHANDOS STREET,
COVENT GARDEN.
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On the 15th January, 1872, a Company called the Channel Tunnel Company, Limited, was incorporated to establish uninterrupted railway communication between Great Britain and Europe.

As a preliminary work, the Company aim, in the first instance, to sink shafts near Dover and Calais, so as to drive galleries extending for about half a mile under the sea, in order more nearly to ascertain the nature of any difficulties which might arise in the construction of a submarine Tunnel between England and France, and to obtain data for estimating with more certainty the cost of such an undertaking. Should the preliminary works prove as successful as the exploration of the locality and investigations of the strata which have already been prosecuted at a considerable expense seem to promise, the Company will proceed to obtain the necessary capital for the completion of the enterprise.

Committees have been formed in the two countries to direct the preliminary work:—Lord Richard Grosvenor, M.P., is Chairman, and Mr. William Hawes, Vice-Chairman, of the English section of the Committee; Monsieur Michel Chevalier is Chairman of the French section; Sir John Hawkshaw, Mr. Brunlees, and M. Thomé de Gamond are the Engineers; the Secretary of the Company, Mr. Bellingham, 5, Victoria Street, Westminster.

The Company has obtained the assent in principle of the

Governments of France and England to a submarine Tunnel to unite the railway systems of both countries. But until the time arrives when it shall be necessary to construct junctions with the railways terminating in Dover, there will be no occasion to apply to the British Parliament.

In France the law requires that a government inquiry should be held in the locality directly interested, before a concession is granted for an enterprise of this nature. Accordingly, the Minister of Public Works ordered an inquiry to be held in the department of the Pas de Calais, and with a view to render the inquiry exhaustive sent a circular to all the Chambers of Commerce in France, asking them to give their opinion on the project.

This commission closed its labours on the 15th December, reporting unanimously as follows :—" Considering that the establishment of a railway which would unite the English railway system with that of France, and, therefore, with that of the whole Continent, presents advantages for the interests of commerce and of civilization the evidence of which has no need to be set forth, the Commission is of opinion that it is its duty to declare the public utility of establishing a submarine railway between France and England." The opinions of the Chambers of Commerce were also favourable.

Those who visited Paris during the Great Exhibition of 1867 will probably recollect that plans and models of a Channel Tunnel, designed by M. Thomé de Gamond, were then exhibited. This engineer began his investigations in 1838, and spent both money and time in studying on the spot the nature of the strata, and in ascertaining the difficulties which would have to be overcome in forming a tunnel between one country and the other, and so constructed as to accommodate railway traffic. He prepared a description, accompanied by maps and plans, which greatly excited the curiosity and attention of the public.

We need not trace the different lines which M. Thomé de Gamond successively proposed, nor enter upon a discussion of various other projects for crossing the Straits, such as the erection of a viaduct high enough to admit of the passage of vessels; the immersion of metallic watertight tubes, resting on the sea bottom; and floating ferries, carrying railway trains.

In 1865, Sir John Hawkshaw, one of the most eminent English engineers, began his practical researches into the nature of the strata beneath the Channel, which confirmed the theories of the geologists, threw new light on the subject, and put the question of a submarine Tunnel in a position to be seriously discussed and considered by the public. Before that time, he had given the subject much consideration, but in that year he caused careful geological surveys and investigations to be made of the Channel, and afterwards in conjunction with the late Mr. Brassey and Mr. George Wythes had borings sunk on each coast. Subsequently, by means of apparatus contrived for the purpose, he examined the bottom of the Channel all across, in a great number of places.

On the English coast Sir John Hawkshaw selected St. Margaret's Bay, a depression in the chalk cliffs about four miles eastward of Dover, as the point of departure; and on the French coast he fixed the position of the Tunnel about three miles to the westward of Calais, nearly midway between Calais and the village of Sangatte. By adopting this line, the Tunnel could be excavated wholly in chalk, and almost wholly in the lower bed of homogeneous chalk. Sir John Hawkshaw discarded intermediate ventilating shafts, and also the artificial port which it had been suggested in one project at least, to establish on a well-known shoal (the Varne) in the middle of the Straits. Works of this nature would be difficult of execution, would be subject to risks, and would be very costly.

The bed of chalk, through which Sir John Hawkshaw recommended the Tunnel should be made, is upwards of 500 feet deep on each shore from high-water mark, and the investigations lead to the conclusion that this bed of chalk is continuous and stretches beneath the sea uninterruptedly across the Straits.

One point which it was necessary to determine, and which would materially influence the manner of executing the Tunnel and the cost of the work, was the maximum depth of water in the Straits. This on the line of Tunnel selected by Sir John Hawkshaw nowhere exceeds 180 feet below high-water in the deepest place near the centre of the Channel, gradually diminishing in depth towards the sides. The Channel is shallow therefore, and if we imagine the Church of Notre Dame or Westminster Abbey to be sunk in the deepest part of the Straits, the towers of Notre Dame would project twenty-four feet, and those of the Abbey forty-five feet above the surface of the water.

The Tunnel has been placed by the engineers at such a level that the depth of strata over it will nowhere be less than 200 feet, and this depth, which is desirable for security, will permit the railway approaches to be formed with not unfavourable gradients.

The possibility of travelling beneath the sea without being exposed to an irruption of sea water is shown in the submarine galleries of some mines in Cornwall, Cumberland, and elsewhere. At the Botallack and Levant mines in Cornwall, and at Whitehaven in Cumberland, several galleries are driven under the sea to considerable distances from the coast, and if we add the many side galleries leading from them, we have some scores of miles of hollow way beneath the ocean, some with very little covering to protect them from the sea.

The manager of one of the most important collieries in Cumberland, the Wellington pit, near Whitehaven, having been asked to answer various questions relative to its working has given the following information :—

Questions.	*Answers.*
1. What is the depth of the pit beneath the level of the sea?	1. Five hundred and seventy-four feet.
2. What is the nature of the strata traversed?	2. Sandstone, coal, shale, and fireclay.
3. What is the extent of the galleries in a direct line beneath the sea from the pit?	3. Four thousand yards.
4. What is the total length of the galleries of the mine beneath the sea?	4 Five thousand two hundred and eighty yards.
5. What is the depth of the sea above the mine?	5. Twenty yards.

Questions.	*Answers.*
6. What amount of water is found in the mine beneath the sea? Is it fresh or salt?	6. There is scarcely any water beneath the sea. The little that there is is salt.
7. What thickness of earth is there between the bottom of the sea and the galleries of the mine?	7. The thickness varies from 70 to 200 yards.
8. What amount of work is done by the pumps?	8. The pumps are occupied in raising the land water. The greatest quantity that has been pumped is 489,600 gallons in 24 hours.
9. How is ventilation effected?	9. Partly by a furnace and partly by fan.
10. What is the greatest quantity of coal raised in 24 hours?	10. Eight hundred tons.
11. Have you noticed any difference in the quantity of water finding its way into the mine between high and low water mark?	11. No.
12. Have you been able to ascertain the quantity of sea water finding its way into the galleries?	12. No observations have been made on this point, seeing that only an inappreciable amount of water finds its way in beneath the sea.

In a treatise on Mines and Mining, by Mr. Pryce, published in 1778, he treats especially of mining under the sea, and refers particularly to their freedom from water. He cites the following as an instance:—

"The mine of Huel Cock, in the parish of St. Just, is wrought 80 fathoms in length under the sea, beyond low-water mark; and the sea in some places is but three fathoms over the back of the workings, insomuch that the miners underneath hear the break, flux, efflux, and reflux upon the beach overhead of every wave, which may be said to have had the run of the Atlantic Ocean for many hundred leagues, and consequently is amazingly powerful and boisterous. They also hear the rumbling noise of every nodule and fragment of rock, which are continually rolling upon the submarine stratum, which altogether make a kind of thundering roar that will surprise and fearfully engage the attention of the curious stranger. Add to this that several parts of the lode which were richer than others have been very indiscreetly hulked and worked within four feet of the sea, whereby in violent, stormy weather the noise overhead has been so tremendous that the workmen have many times deserted their labour under the greatest fear lest the sea might break in upon them. This proximity of the sea over the workmen, without their being incommoded by the salt water, is more wonderful than the account which Dr. Stuckley gives of his descending into a coal-pit at Whitehaven 150 fathoms deep, till he came under the very bed of the ocean, where ships were sailing over his head, being at that time deeper underground by the perpendicular than any part of the ocean between England and Ireland. In this case there is a vast thickness of strata between the mine and the sea; but at Huel Cock they have only a crust between them at most; and though in one place they have barely four feet of stratum to preserve them from the raging sea, yet they have rarely more than a little dribble of salt water, which they occasionally stop with oakum or clay, inserted in the crannies through which it issues. In a lead mine in Perran Zabuloe, formerly wrought under the sea, they were sometimes sensible of a capillary stream of salt water, which they likewise prevented by the same means whenever they perceived it."

As before remarked, the Channel Tunnel would be made in chalk, and almost wholly in the lower chalk which crosses the Straits. It is necessary to consider if this chalk, while resisting infiltration from above, would not be saturated by subterranean water in such quantity as to overcome ordinary pumping power.

Wells sunk in the chalk at Dover and Calais and at other places resting on the same strata, have borne comparatively little water. For instance, there are three deep wells on the Heights at Dover—one at the Castle, one in the Citadel on the Western Heights, and one, not in use, at the Main Shaft barracks. The Castle well is 6 ft. in diameter and 363 ft. deep, or 1 ft. 6 in. below low-water mark. It is entirely in chalk, and there is at 15 ft. from the bottom a heading 6 ft. high and 3 ft. wide, extending for 160 ft. in a southerly direction. This heading crosses three fissures which yield water, but the well can be pumped dry in three hours by a 30-horse power engine. The Citadel well is 407 ft. deep, and reaches the low-water level. From halfway down there are but few flint beds, and the chalk is very dense and hard. There are two headings near the bottom in a northerly direction, 30 ft. long and sloping upwards, which yield little or no water. There is another, driven horizontally in a southerly direction, which cuts two fissures and gives a good supply. The water in both wells is perfectly fresh.

A well was sunk at Harwich between July, 1854, and May, 1857, to the depth of 1070 ft., from which no supply of water could be obtained. It passed through 76½ ft. of drift and tertiary strata, 888 ft. of chalk, and 105½ ft. of upper greensand and gault.

The famous Calais well was sunk to 1150 ft. without success; and in the Paris district it is found necessary to bore quite through the chalk before any supply of water can be obtained.

But a better illustration of the possibility of tunnelling in chalk below sea level is to be found at Brighton.

There Sir John Hawkshaw is just completing a tunnel 5¼ miles in length, along the sea shore and in close proximity to the margin of the sea; this tunnel is wholly in the upper chalk, where, from proximity to the surface, the chalk is not very compact, and is 12 feet below high water at one end and 20 feet below at the other.

A considerable quantity of water, chiefly fresh water, has been encountered in the progress of the work; for, passing along the foot of the chalk cliffs, it intercepts the fresh water flowing from the South Downs into the sea, and as much as 8000 to 10,000 gallons and upwards per minute had to be pumped in carrying on the works; but this quantity of water, large as it is, did not prevent the work proceeding.

It is probable, and the engineers anticipate that at the shore end of the Channel Tunnel, especially in constructing the shaft through the upper strata, a considerable quantity of water will be met with, but not sufficient to prevent the execution of the work, where pumping power of ten times the magnitude of that adopted at Brighton could, if necessary, be applied. It is believed, and there appear to be reasonable grounds for such belief, that as the work attains a greater depth in the chalk, and especially after the lower or grey chalk is reached, the quantity of water will diminish, and that in Mid-Channel it will be less than at the sides.

Nothing, probably, could hinder the completion of the work, but open unfilled fissures reaching from the sea to the great depth it is proposed to carry the Tunnel. It is believed that such fissures, if at any time existing, will have been filled in the lapse of ages. Mere percolation of water through chalk would not prevent the accomplishment of the work.*

It has been suggested by an able geologist that the Tunnel should be carried down to the Paleozoic rocks. No doubt it is plain that it is only necessary to go deep enough to render the work of no more significance than if instead of being below the sea it had Mont Cenis above it; but great depth involves approaches of great length or approaches with bad gradients, and either might become inconvenient or impracticable, for other than geological reasons.

But although the work might be accomplished without material interruption from water, unless it could be executed in a reasonable time it might not be a commercially advantageous undertaking. Fortunately, engineering science

* An experiment made by Mr. Brunlees, C.E., with a specimen of the lower chalk, shows its perfect impermeability, and points to the extreme improbability of the stratum of lower chalk under the Channel being fissured. The specimen experimented on was a nearly square block containing 210 cubic inches, weighing, when dry, 13 lbs. It absorbed 69 cubic inches of water, and weighed when fully saturated 15 lbs. 8 oz. It was suspended in this condition, and water was poured from time to time into a cavity in the upper surface, but none filtered through. This bed of chalk is very plastic when wet, and if fissures had at any time existed in it, they could only be kept open by being dried or by the continuous passage of a stream of water through them. Neither of these conditions is likely to exist at the bottom of the sea or 200 feet below the bottom.

has been of late years enriched by the invention of a variety of machinery for boring in all kinds of rocks.

Without M. Sommeiller's boring machine it is impossible to say how long it would have taken to pierce through the hard rocks of Mont Cenis, through which the railway now runs between France and Italy, and by employing still more perfect apparatus, M. Favre, the contractor of Geneva, hopes to make a tunnel ten miles long through Mont St. Gothard in harder rock than was found in Mont Cenis.

There is no resemblance between the beds of chalk which lie beneath the Straits of Dover and the masses of granite, schist, quartz, dolomite, and gneiss which compose the chain of the Alps, and machines have been invented which bore through chalk and similar soft rocks with greater rapidity than through hard strata.

Driftways in the chalk were made, even by the means formerly employed, with considerable rapidity and at a low price. At the waterworks at Grays, in Essex, horizontal driftways or headings 6 ft. by 4 ft., were driven in different directions from the well shaft to a total length of 2000 ft. These headings were made by a gang of six men, who were paid 6*s*. a foot forward for the first 50 feet, and 1*s*. a foot extra for every 50 feet advanced. The water flowed in copiously during the work, which was executed with picks and crows, without powder, at the rate of 10 ft. per day of 12 hours. The chalk was wholly of the upper formation, giving out water much more freely than the deeper stratum. At the same speed gangs of six men would accomplish 2080 yards a year, or 38,720 yards (22 miles) in nine years and a quarter. Drier workings, ventilation, more frequent shifts, keeping two men constantly at the face, might increase the rate of progress.

The execution of the tunnel through the chalk at Brighton has cost 7*s*. 6*d*. per cubic yard.

Happily the solution of the problem of the execution of the tunnel in a reasonable time has been simplified by the invention of tunnelling machinery, and the machine of Mr. Dickenson Brunton, which has been tried on a practical scale by the Company in the lower or gray chalk, has been quite successful. This machine works like an augur boring a hole in wood. The chalk is cut off in slices which break up and fall upon an endless band which loads them into waggons behind the machine. The machine was tried by the Company at Messrs. Lee's Cement Works, Snodland, near Rochester, in the Grey or Lower bed of chalk such as underlies the Channel; it made a driftway of seven feet diameter, and it advanced at the rate of a yard to a yard and a quarter per hour. At this rate it would only require two years to drive a driftway of seven or nine feet diameter from one side of the Channel to the other, a machine being employed starting from each side.

Under these circumstances the cost of a heading may be approximately estimated. This cost would consist, 1st, of tunnelling machines, pumps, and pumping engines; 2nd, the hand labour, which would not be considerable, as the machine requires few hands to work it; 3rd, interest on the capital expended during the execution of the work, which might last two years or more.

Taking these three elements of expenditure into consideration, and according to the calculations of experienced contractors, it has been found that the driftway could be executed for £800,000 sterling, if it required only two years to make it. As soon as the driftway was completed the success of the undertaking would be assured. It would furnish the necessary data for an exact estimation of the cost of the whole work and the time necessary for its execution. In fact, all that would be necessary would be to enlarge the driftway to the dimensions of an ordinary railway tunnel.

It has been estimated by some engineers and contractors of considerable experience, that after the driftway was finished, four years' time and four millions of money would complete the work, including the junctions with the English and French railways on either shore.

Sir John Hawkshaw and the engineers associated with him think it prudent to double this estimate of time and cost, at least until the execution of the preliminary work shall have given them the necessary data for a more exact estimate of the duration and cost of the work.

A Tunnel so long as that proposed would require artificial ventilation, not only during construction, but also after completion. To provide for this necessity would not be difficult, and may be done in different ways.

During the construction of the driftway probably the simplest method would be to draw the air from the far end of the working through pipes by a fan, which would cause fresh air to pour in from the shore ends.

For the construction of the Tunnel itself it would be necessary to provide rapid means of bringing out the excavated chalk, and carrying in bricks, cement, and materials, and this would be readily effected by laying along the space excavated two or more pneumatic tubes, about the size now laid from the Post Office to Holborn and Euston. There would be room enough in the area excavated for this purpose, and along tubes so laid waggons holding one or one and a half cubic yards could readily be passed. These tubes would also provide, or aid in ventilation, and would carry in and bring out the workmen. It is best to assume that the Tunnel when completed will require artificial ventilation; this can be easily provided, and at a moderate cost. As there have been exaggerated notions on this subject, it may be well to add that engines of about 150 horse-power in the aggregate, would in all probability provide sufficient permanent ventilation.

Passing on to consider the probable traffic of a Channel Tunnel, we can only be guided by certain general principles, established by ample experience, with regard to the conveyance of passengers and goods. It is well known that any break in the continuity of a journey materially hinders the flow of traffic, and increases the cost of conveyance beyond what appears to be the actual price of making the changes required. It is for these reasons that a break of gauge in England has been found to be so great an evil. The want of railway communication between England and France has the effect of a break of gauge; and in the case of goods carried by railway in both countries, becomes equivalent to two such breaks. Every passenger suffers the inconvenience and loss of time consequent on the necessary changes, besides suffering the discomfort and distress of the sea voyage; and the price of every article of commerce between the two countries is to some extent enhanced by the sea risks, and the cost of shipment and landing. In winter the traffic in some articles of a fragile or perishable nature is often interrupted or even suspended, to the great loss of traders and the inconvenience of consumers. It has been found, on the other hand, that new facilities for traffic add enormously to the number of passengers, and to the quantity of goods passing between the points at which such new facilities are offered. This has been the result in the case of every English railway, and when two systems have been united, the subsequent gain in traffic has always been out of proportion to the apparent inconvenience and cost of the previous break. The promoters of the Liverpool and Manchester Railway calculated on obtaining about half the passenger traffic of the pre-existing coaches, which had carried from 400 to 500 persons daily. But the line was no sooner opened than it conveyed 1200 persons daily, and this number rose in the course of five years to between 2000 and 3000; now there are three lines of railway carrying yearly a million of passengers. The railway between Paris and Boulogne increased the passenger traffic in a similar manner.

It is, therefore, scarcely possible to doubt that the opening, in whatever particular form, of an easy, direct, and rapid means of communication between two great capitals containing more than six millions of people, not to speak of the provincial populations surrounding them, or of the through traffic to and from other parts of Europe, would be followed by an enormous increase in the number of travellers, and in the quantity of goods to be conveyed.

The present traffic is no indication of the numbers which would pass through the Tunnel. The co-efficient by which the present number might be multiplied is unknown; it might be three or four, or five or six. Still it may be well to make some remarks on the present traffic. In 1869, 353,279 travellers passed between England and France, and at the normal rate of increase the number would reach half a million in 1880.

This is how they were distributed between the more frequented French ports in 1869:—

Route.	Travellers.	Length of sea passage.	Length of journey between London & Paris.	Fares between London and Paris. First. s.	d.	Second. s.	d.	Third. s.	d.
Havre (tidal)	18,936	7 hours	19 hrs. 23m.	31	0	20	0	—	
Dieppe ,, ...	36,594	5 ,,	13 ,,	29	3	21	0	17	0
Boulogne ,, ...	116,248	2 ,,	10 ,,	56	0	42	0	21	0
Calais regular service	155,369	1½ ,,	10 ,, 30	60	0	45	0	21	0

Thus, to avoid half an hour's sea passage, one-fourth more travellers go by Calais rather than Boulogne, though the journey between London and Paris is increased, and the fare is higher, and though the Boulogne traffic includes a considerable number travelling by the Thames route. The same observation applies to the Dieppe route; it is cheap, and the speed is good, but the sea passage lasts five hours, so that only a fourth of the number which go by Calais avail themselves of the Dieppe route. Havre, in respect to Dieppe, is in the same case as Dieppe in respect to Calais. To avoid two hours' sea passage, most of the passengers choose Dieppe, the price being about the same.

The contractor for the postal service between England and France, had good reason for saying, therefore, in evidence before a Committee of the House of Commons, that "a few minutes saved in crossing between Dover and Calais, would give his boats the command of the passenger traffic;" and it was with not less reason that Captain Hotham, H.B.M. Consul at Calais, in his report to the Foreign Office, 1868, said, "a regular passage of 1h. 10m. to 1h. 15m. between Dover and Calais, would without doubt assure to that route the transport of passengers to and from the Continent, and greatly increase their number."

Indeed it is impossible to say what would be the number of passengers passing between England and the Continent, when the journey can be made in half an hour in well-lighted carriages, without sea sickness, change of carriage or any of the numerous annoyances which accompany the present system. But it is evident that the number would be largely increased; possibly it may amount to a million, and in a time not remote from this, attain the number of fifteen hundred thousand.

As to goods, the receipts would no doubt be very important. London is the seaport of all the world, receiving and sending forth enormous quantities of all kinds of goods. In regard to many articles of merchandize, and in a great many cases, it will be more advantageous to transport them by railway through the Tunnel than to ship and re-ship them. No doubt the goods on which the higher freights are paid, and which now go through the ports of Boulogne, Calais, Dunkerque, Ostend, and Dieppe, to or from England, would go through the Tunnel. This alone would be a heavy traffic. The quantity of goods passing between England and the Continent through those ports is enormous.* They do not consist solely of fancy goods and manufactured articles, but also of grain, wine, fruit, vegetables, and dairy produce. For many of these things the cheapness of water carriage would be more than counterbalanced by speed of transport, certainty, and even decreased cost of packing. It would cause the quantity of parcels and small freight to be enormously increased.

If the comparison be pursued there are many advantages which tell in favour of a Submarine Tunnel. For example, taking the northern lines out of London, they serve in a great measure the same towns and districts, thus dividing traffic between them, and the remark applies to railways generally in Great Britain; whereas the Channel Tunnel would have no other parallel or neighbouring railway to compete with it. Moreover in railways the average distance travelled by each passenger is only a very few miles, very few indeed compared with the length of many of the systems. But in the case of the Channel Tunnel Railway, the whole line would necessarily be traversed from end to end by each passenger, and much more money taken per head than the average on any other railway.

Further, the Channel Tunnel being an exceptional line, exceptional fares might be demanded, and would be gladly

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* The trade with France, Holland, Belgium, and Germany in 1872 employed nearly 12,000,000 tons of shipping, not including vessels in ballast, over two-thirds of which were steamers. Most of the cargoes passed through the eastern and southern ports.

paid, when it is considered that the line will relieve the traveller from the sea passage so much dreaded by many, and so inconvenient to all.

But, after all, it seems as difficult to measure in this case what the increase of traffic might prove to be, as it was in the change from road to rail in the origin of railways. It is known that whatever miscalculation railway companies made, they only erred in vastly underrating the growth of traffic; and in comparing the Submarine Railway with other railways, while they have this or that populous town at one or other end, the Channel Tunnel will have Great Britain at one end of it and all Europe at the other.

The expense of working the Channel Tunnel Railway will be small when compared with the cost of working ordinary lines. There will be no intermediate stations or junctions. The run through would be unbroken and uninterrupted, and the wear and tear reduced to a minimum. It is true there would be a yearly expenditure for ventilation, but taking this into account it is probable that the working expenses would not be more than one-half, or at the most, two-thirds of the percentage cost of working railways generally.

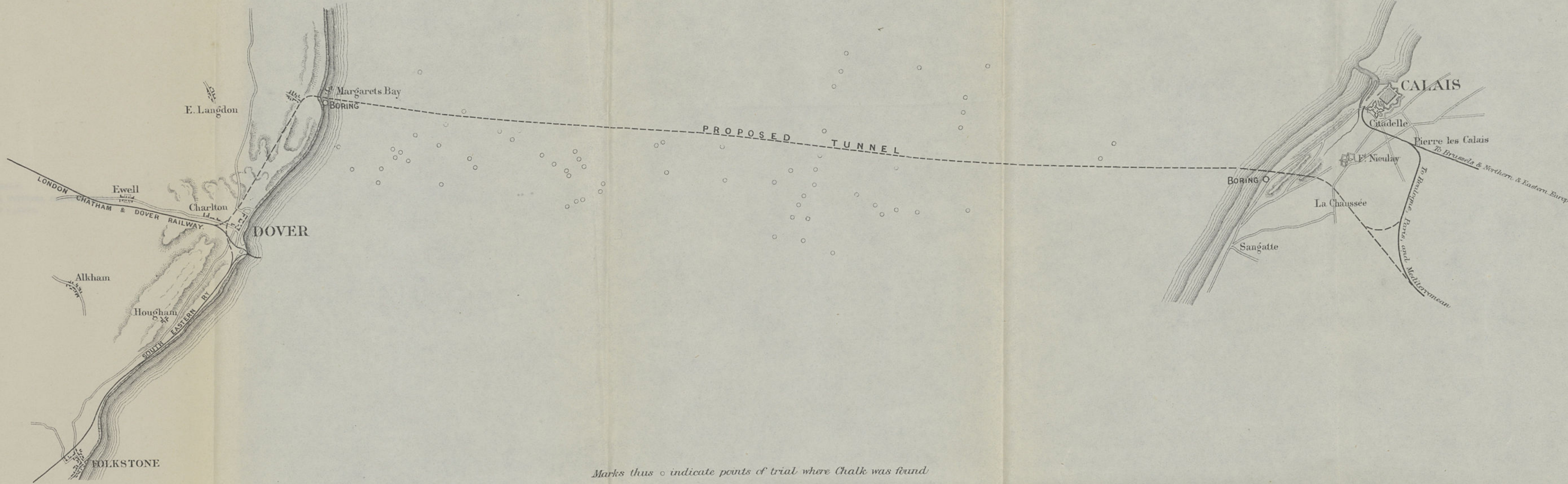
In conclusion, we may remind the reader that all that it is proposed at present to do is to sink two shafts on the coast about one hundred and fifty yards deep, and to drive thence from each shore under the sea an ordinary mining drifting about half a mile long. The cost of this work would be comparatively inconsiderable, and would be a true beginning of the proposed permanent Tunnel.

Marks thus ○ indicate points of trial where Chalk was found

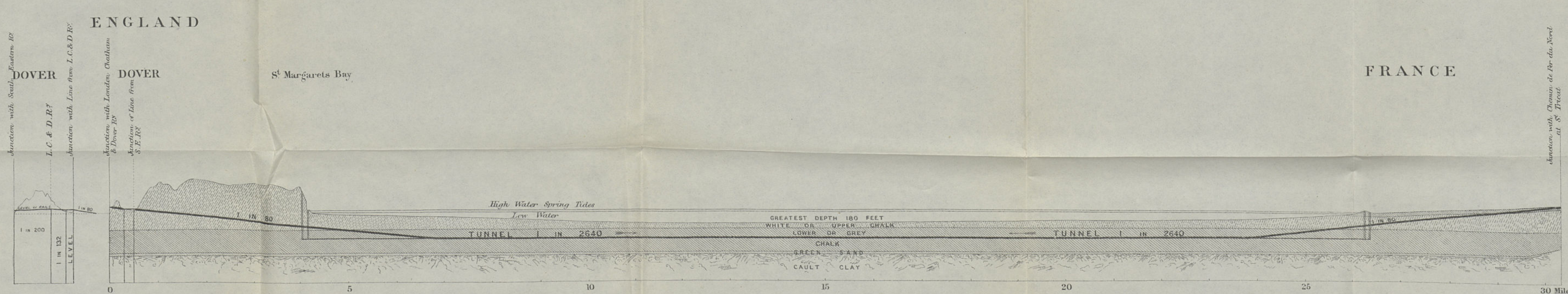
SECTION

CHANNEL TUNNEL RAILWAY.

PLAN



SECTION



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