

The Channel Tunnel and Its Early History—I*

Plans for Direct Railway Connection Between England and France

By John Clarke Hawkshaw, M.A.

Now that the Channel tunnel question is again under consideration, I feel that it may be of interest to others if I set down some of my recollections of the work which was done, some fifty years ago, to find out whether the natural conditions to be met with in making a tunnel were such as to warrant the work being begun.

No one who has any correct knowledge of the facts can deny that the most useful and practical work to that end was first begun and carried through to a satisfactory end by my father, the late Sir John Hawkshaw.

Before he undertook the work suggestions had been made and lines for tunnels had been laid down, but these were all based on conjecture, for no one could say through what material such tunnels would pass beneath the sea, and without that knowledge the opinion of an engineer as to the prospects of success in carrying through such a work would be of little value, and any estimate of the cost would be worthless.

I am the only one now remaining of those who were intimately associated with my father in the systematic investigation which he began in the year 1865, and which, when it was concluded, led to the formation of the Channel Tunnel Company, of which Lord Richard Grosvenor was the chairman. I attended meetings in this country and in France, was present at all the trials of machinery for excavating and transporting the chalk, and took part in the calculations, more especially in those for the difficult question of ventilation, which my father left to me to work out. I had had much practical experience in tunnel work. For five years I spent some days every fortnight in going through the Severn tunnel works—a submarine tunnel four and a quarter miles long—and I discussed every detail of this work with my old friend, the late Mr. Thomas Andrew Walker, the contractor. I was also familiar with the work on the Brighton intercepting sewer—a work of my father's—which tested beyond all others our power to deal with water in the chalk.

I have given time to the study of geology since I was a boy, and know the chalk cliffs well in France, and from Dover to Folkestone, where I have worked with a pick and shovel collecting fossils with Griffiths, formerly a well-known dealer in them at Folkestone.

I hope you will pardon these personal remarks, but it is well my hearers should know that I do not come before them without some experience of the subject of which I treat.

It was M. Thomé de Gamond who first, by long and patient study of the geology of the Straits, tried to show that a submarine tunnel could be made between England and France. This careful study was the first step taken in the right direction. Unfortunately he gave no attention, as my father did, to the question of what was the most favorable stratum for tunneling operations—the chalk. He seems to have assumed that the chalk was denuded in the Channel, and so he occupied himself solely with a careful survey of the Eocene strata west of Dover. These beds could be well studied in France in the neighborhood of the Straits, and he obtained some fragments of rock from the summit of the Varne shal, which he correlated with the beds near the French coast. Unfortunately the Eocene beds do not appear on the English coast, and he had to go as far as Oxfordshire to study them in England. He assumed their position under the Channel from his observations made in Oxfordshire and in France, checked to some extent by his fragments from the Varne. It is obvious that any section under the Channel formed on such data must be purely conjectural, and no one knew this better, or was more ready to acknowledge it, than M. Thomé de Gamond, who relied on future borings being taken. He laid down his line of tunnel from Eastwear Bay, east of Folkestone, to Cape Grisnez, hoping to keep in certain beds in the Eocene under the sea. He proposed to make some thirteen islands in the Channel, so as to begin the tunnel at many points by sinking shafts in them.

After my father's inquiry was completed, M. Thomé de Gamond abandoned his own plan and became a member of the committee which adopted my father's.

Sir Francis Fox lately stated at a public meeting that Stephenson, Locke, and Brunel approved of M. Thomé de Gamond's line. If they did so without very wide qualification, they, for once, forgot that caution which is inseparable from all engineering eminence,

and gave an opinion with an insufficient knowledge of facts. Neither M. Thomé de Gamond nor anyone else could at that time tell what material would have to be tunneled through in the line he chose. That being the case, any opinion as to the practicability of such a tunnel could be of little worth, and no estimate of cost could have any approach to accuracy. Other engineers followed M. Thomé de Gamond: Mr. Brunelles and Mr. Low were advocates for a Channel tunnel, but they had no more detailed knowledge of the facts than M. Thomé de Gamond, if as much, though they had more practical knowledge of work underground, Mr. Low being a mining engineer.

For some years before 1865 Sir John Hawkshaw had been considering the practicability of a tunnel under the Channel, but with his sound common sense, and with a modesty for which all who knew him would give him credit, he did not in any way try to influence public opinion, knowing that the facts to hand were quite insufficient to warrant any proper opinion as to the absence of risk of failure.

In 1865 he began, at his own expense, a private inquiry untrammelled by promoters or associates, to acquire as accurate knowledge as was possible of the nature of the material under the sea. A knowledge of this was the key to the problem. The facts which he collected, after several years' work, as to the nature of the bed of the Channel and what lay beneath it, not only enabled him to form an opinion himself, but they first gave the Channel tunnel question a solid basis. From that time on, the possibilities of making a Channel tunnel and its probable cost could be profitably discussed by practical engineers.

I will now proceed to describe the nature of the inquiry which Sir John Hawkshaw thought necessary before venturing to give an opinion.

First, it was necessary to know in detail the kind of material to be met with on the English and French shores of the Channel.

The geology of the coasts was fairly well known, but it was necessary to study the strata also from an engineering point of view—to make sure that identical beds were found on the two sides of the Channel, to note what facilities the strata offered for tunneling work, and the risk to which they would give rise if they allowed of a too free passage of water.

Early in 1865 Sir John obtained the services of Mr. Hartsinck Day, who, besides being a competent geologist, had also a knowledge of surveying.

Mr. Day's attention was directed principally to the Cretaceous beds which Sir John's large experience in tunnel work led him to choose as the most promising material through which to tunnel.

Mr. Day spent several months, in 1865, in examining and surveying the Cretaceous and adjacent beds on the coast in England and France, and prepared a geological map showing their position on both sides of the Channel, and he also made a map based on conjecture as to the position of the beds under the sea. (See plan.)

A glance at a map of the Channel will show that the narrowest part lies between the Foreland (near

Dover) and Sangatte. A tunnel between those places would be the shortest that could be made, but could it be kept wholly in the chalk?

The cliffs of the Foreland were chalk, but to what depth did it extend? Chalk was not visible at Sangatte. At what depth was it to be found, and what was its thickness? To answer these questions Sir John Hawkshaw determined to bore through the chalk on the English and French coasts. The well-known contractors, Mr. Thomas Brassey and Mr. George Wythes, and Mr. Easton, who had done much work in the chalk in search of water for town supplies, were interested in my father's inquiry, and offered to share the cost of these deep borings, which in those days were more costly to carry out than they would be now. The points selected for the borings were St. Margaret's Bay in England, distant four miles east of Dover and about eight miles east of the outcrop of the lowest beds of chalk on the coast, and Ferme Meuron in France, two and a half miles west of Calais and four miles east of the outcrop of the same beds on the French coast.

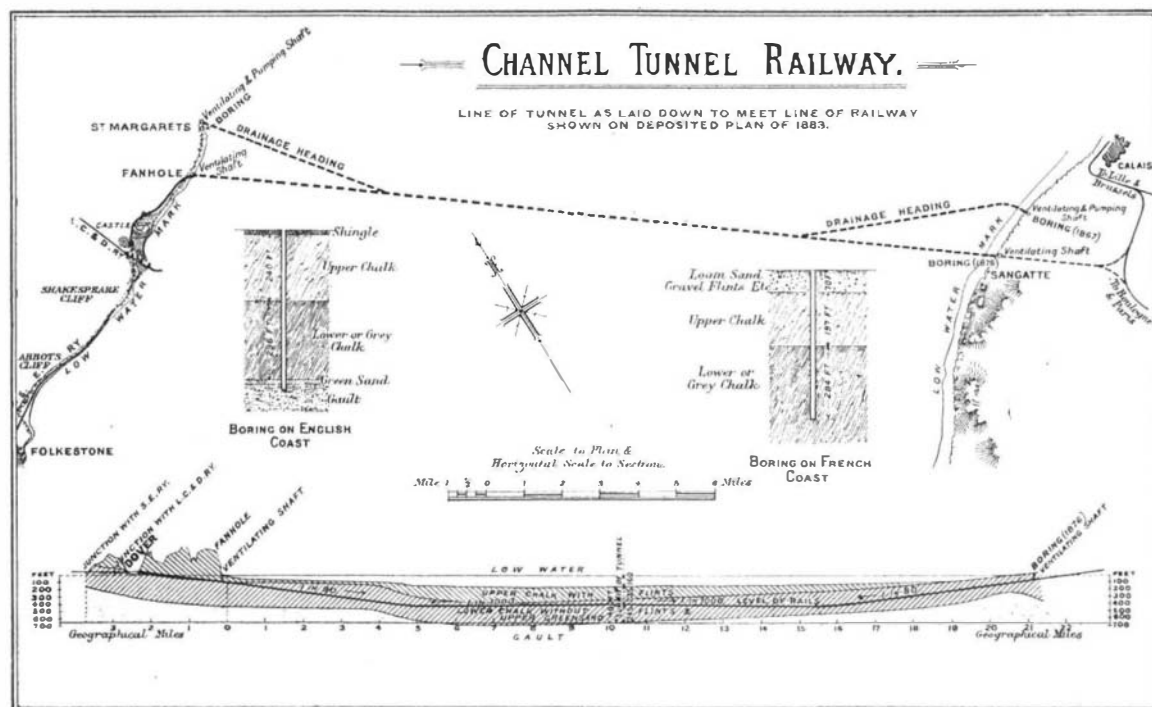
These borings showed that the thickness of the lower chalk does not diminish to any extent as we follow it to the eastward along the coast.

That the chalk extended under the Channel no one now doubted.

The all-important and last remaining point to be settled was, would the chalk be found in the Channel on the surface, or at some depth below it covered by superficial deposits? To ascertain this and check Mr. Day's conjectural plan of the geology of the sea-bed, Sir John employed Mr. H. M. Brunel, one of his pupils, who was still at work in his office. In the years 1865 and 1866 Mr. Brunel carried out a marine survey from a small steamer hired for the purpose, taking advantage of any favorable weather by day or by night. The position of each sounding made at night was fixed by taking angles from the stars. The greatest credit is due to Mr. Brunel for the careful way in which he did this survey, and the accuracy with which he worked out the observations fixing his positions. He soon found out that bare chalk was exposed on the bed of the Channel. An ingenious form of sounding-lead was devised. Round a piece of wrought-iron pipe a heavy sounding-lead was cast. The pipe, which had a sharp chisel edge on the lower end projecting some way out below the bottom of the sounding-lead, was driven by the descending weight into the sea-bed, and brought up a small cylinder of chalk or gault clay, often some inches in length.

As the lower beds of chalk differ in appearance and composition from the upper beds, and more markedly from the gault clay and upper greensand, it was possible to map the position of the chalk on the bed of the sea, and, to some extent, its line of junction with the underlying beds of gault and greensand to the westward. It was found that the outcrop of the gault lay further to the west than Mr. Day had shown.

By 1867 Sir John had got all the information he thought necessary, and he prepared plans for an Anglo-French committee, in conjunction with Mr. Brunelles,



* Paper read before the Royal Society of Arts, and published in its Journal.

Mr. Low, and M. Thomé de Gamond, showing a tunnel through the chalk from St. Margaret's Bay in England, to Ferme Mœron in France.

In 1868 the Anglo-French committee applied for a concession from the French government. This led to a long correspondence between the two governments.

After four year's existence as a committee, the English Channel Tunnel Company was incorporated in 1872. This originated the French company, and my father supplied the plans on which their concession was obtained in 1875. By it they were bound to spend \$400,000 in preparatory works of all sorts, such as investigations, pits, galleries, borings, etc. The conduct of these operations was intrusted to Mr. Lavalley, so well known in connection with the Suez Canal works. The geological work was assigned to MM. Potier and Lapparent, mining engineers and able geologists, and they were assisted by M. Larrouse, hydrographer to the French navy. They began by repeating, and extending on a more elaborate scale, the marine survey made ten years before by Sir John Hawkshaw. Using a sounding apparatus of the kind already mentioned, they succeeded in bringing up a great number of specimens of the rocks forming the sea-bed. These soundings confirmed, in all material points, Brunel's survey made ten years before. Furthermore, owing to the great number of soundings that were taken, and to the number of specimens from the bottom that could be identified, it became possible to plot with some accuracy the junction of the lower chalk and gault from shore to shore, except for a short distance where these beds pass beneath the sands of the Varne. A second boring was made at Sangatte, and the results of this work, done in 1875-76, were published in 1875-77 in the form of reports, with maps and sections.

The researches by the French company brought no very novel facts to light, such as to disturb the main conclusions which had been already arrived at in this country as the result of my father's work, but they made our knowledge more definite in several particulars. Mr. Topley, of the Geological Survey of England, reported to the Channel Tunnel Company in 1878, and advised that the outcrops of the gault, as shown by the French engineers, might be taken, for all practical purposes, as accurate.

In the year 1882 the Channel Tunnel Company sought to obtain parliamentary powers, and deposited plans showing the line of railway on the English side to join a tunnel from Fan Hole to Sangatte 20.8 miles long under the sea. (See plan.) This tunnel ended in Dover, just behind the castle, with the mouth of the tunnel facing the fort, the guns of which could be pointed into it. It appeared to me that this was a very safe place for the tunnel to enter England, but the military authorities thought otherwise. Before the plan was deposited it was submitted to them, and the War Office appointed some of its officers to visit Dover and approve or not the proposed exit of the tunnel. For some reason my father was unable to be present, and I had to act as guide to the deputation. I only remember two of them, Sir Archibald Alison and Sir Andrew Clarke. I was much disappointed when the outlet was condemned, and I well remember Sir Andrew Clarke saying it would be contrary to all precedent to have an opening from without inside a fortress. I had to set to work at once to find another outlet, which I fortunately did in the valley of the Dour, not far above Dover, so that little was added to the length of the tunnel. A new survey was made, and a parliamentary plan was deposited with the new outlet.

In the same year (1882) the South-Eastern Railway

Company sought for parliamentary powers. The chairman of the South-Eastern Railway Company had determined that the Channel tunnel should be a South-Eastern affair. To this my father, who was consulting engineer to that company, had strongly objected. He thought a Channel tunnel ought not to be a one-company affair, and so strongly demurred to the course taken by the railway company that he withdrew from the post he had held for so many years as their consulting engineer.

The plan put forward by the Channel Tunnel Company was a complete scheme, while that put forward by the South-Eastern Railway Company was anything but complete. If Sir Edward Watkin, the chairman, had a definite proposal he did not disclose it. The railway company were tunneling in the grey chalk at Shakespeare Cliff, but in what direction the tunnel would go or how it was proposed to drain or ventilate it, no one knew.

On the other hand, every detail for the completion of the Channel Tunnel Company's work had been considered. Their tunnel was to go in a straight line between Fan Hole and Sangatte, with an exit near Dover, where a junction could be made with the railways of the South-Eastern and Chatham and Dover companies. It was to be provided with drainage headings to drain the tunnel by gravitation from the highest point in the center of the Channel to pumping shafts on the two shores, the positions of which were fixed.

I have just read an article in the *Revue de Deux Mondes* by M. Sartiaux, which seems to indicate that it is now proposed again to put forward the line prepared by Sir E. Watkin from Shakespeare Cliff, and to endeavor to keep the tunnel in the lowest beds of the chalk, not in a straight line or with regular gradients, but following the grey chalk in all its sinuosities. A drainage heading is to be made on a line fixed provisionally, but which may be varied by the knowledge of the strata gained from weekly borings, which will also determine the direction of the main tunnels, and consequently their length and cost. The drainage heading will meet the main tunnels at a point near the middle of the Straits, from which the main tunnels will rise, and the drainage heading will fall toward the shore. They will also diverge from this point so as to keep in the same bed of chalk, which is deeper down as we go up the Channel. Cross adits will be driven from the drainage heading to the main tunnels as their direction is determined by the borings.

Now the making of numerous borings is what a hydraulic engineer would do if he wanted to strike fissures in the chalk to get a water supply. The more borings made the more water he would hope to get, and would most likely not be disappointed.

The grey chalk is not free from water, as we know it on land, and to a certain extent under the sea. I saw many small runs of water in the French works, to which I shall refer later on.

In my early engineering work I had some experience of the evil results of borings, on works in progress close on fifty years ago. I was in charge of the construction of the Albert Dock, which was being made for the Hull Dock Company. We had to build a long lock 80 feet wide, on what appeared to be a perfect foundation of about 40 feet of boulder clay, nearly as hard as rock, and quite impervious to water. When the excavations for the lock had nearly reached their ultimate level we were suddenly drowned out one night by an outburst of water in the excavation. Where the water came from it was impossible to say. More pumps were put up and the area excavated was divided

into many small compartments by sheet piling. In the meantime the ground settled in and around the excavation, showing that the water was bringing up material from below. In time we were able to free some of the compartments from water. In one of them, on a clean surface of dark boulder clay, I saw a small hole about 2 inches in diameter full of small grains of white chalk and sand. It was evidently a bore hole, one of many which had been made by rival promoters before the bill for the dock was passed. In the night a jet of water burst up through the bore hole, bringing with it large quantities of clean yellow sand from a bed on the surface of the chalk. This we proved by making a fresh boring through the boulder clay to the chalk. More than one of these borings was no doubt discharging water into the works, and the site had to be abandoned and the dock made shorter to provide a new site for the lock. This incident shows what trouble a few 2-inch borings may bring about in the neighborhood of water-bearing strata.

No doubt extraordinary precautions would be taken in making the proposed borings referred to by M. Sartiaux. But to make a number of borings beneath the sea is to take quite an uncalled for risk. If control of one boring in a tunnel were lost, and the seawater tapped, the work might have to be abandoned.

Where the chalk is 500 feet thick to the east of the outcrop, no borings outside the finished work would be necessary, and with six miles less of tunnels to make the risk of meeting water would diminish.

In settling the line for the tunnel we have to consider on what line will an error in our geological calculations be of least moment in our tunneling operations. The French company's marine and geological survey was made with care and precautions such as were probably never before taken. As long as it deals with the surface of the sea-bottom the reports and accompanying plans and sections probably tell us a true story on which we may rely. But when we pass from the surface of the sea-bed to the strata beneath we go from facts to conjectures. A longitudinal section down the center of the Channel shows the chalk from where it begins, at the outcrop of the gault, dipping at first rapidly beneath the sea, the dip gradually diminishing as we go eastward. Now the part of the section in which error is most likely to be found is in the curve which denotes the base of the chalk near the outcrop. For the curve showing the base of the chalk depends not only on the position of the line on the map, which shows the junction of the chalk and the gault, which is probably in the main correctly plotted, but also on the line which shows the junction of the two lowest beds of chalk of the French geologists (Craie de Rouen and Craie de Moyenne). It would be very rash to take this last line as other than approximate; yet all it could tell us, if it were correctly plotted, would be the dip of the base of the chalk close to the sea-bed; and even to get at that we should have to assume the thickness of the Craie de Rouen from its ascertained thickness on the two coasts. Of the dip a short distance below the sea-bed we really know nothing, and the curve indicating it must be imaginary. If the tunnel is to follow the lower beds of chalk it will have to be near this curved line, and any variations in the curve will necessitate deviations in the line of the tunnel, so that its length might be largely increased. This continual deviation would add largely to the difficulties of construction. Again, the lower the beds in which the tunnel is placed, and the nearer to the outcrop of those beds, the greater will be the risk of water finding its way along the planes of bedding from the outcrop.

As we pass from the outcrop of the chalk and the gault in an easterly direction along the Channel, the chalk increases in thickness. On the Fan Hole-Sangatte line it is 480 feet thick, double the thickness it is on the Shakespeare Cliff line. This was conclusively proved by the borings made by my father. An error which would necessitate a considerable deviation in the Shakespeare Cliff line of tunnel would not affect that on the Fan Hole-Sangatte line, where there is the ample margin for error of 250 vertical feet.

The only reason which has been given for taking the tunnel under the shore line to the west of Dover is, that by so doing it is supposed that it can be made wholly in the lowest or grey beds of chalk. It is asserted that no water, or very little, will be found in these lower beds. Now what are the facts? We are told that little water was found in the heading from Shakespeare Cliff. I cannot speak from personal knowledge as I did not visit that work. In the headings driven at Sangatte, in the corresponding beds in France, water was met with flowing from fissures at the sides and bottom, and not confined to one place, but throughout the headings. The quantity which I saw was not large, the largest spring, perhaps, thirty gallons a minute, but it was enough to prove that those beds are not impermeable.

(To be continued.)

