THURSDAY, JANUARY 20, 1870

THE PROJECTED CHANNEL RAILWAYS

II.

To connect England and France by a railway through a submarine tunnel is not a novel idea. From time to time English and French engineers have revived the plan of tunnelling under the Straits of Dover with some modification or other. Among these the latest and most carefully considered proposition is that by Messrs. Hawkshaw, Brunlees, and Low, in connection with Messrs. Talabot, Chevalier, and Gamond. The scheme of these engineers will be best understood from their report to a committee of promoters, and we will give those passages of the report which are essential for the clear comprehension of the plan :—

"The undersigned engineers, some of whom have been engaged for a series of years in investigating the subject of a tunnel between France and England, having attentively considered those investigations and the facts which they have developed, beg to report thereon jointly for the information of the committee.

"These investigations supported the theory that the Straits of Dover were not opened by a sudden disruption of the earth at that point, but had been produced naturally and slowly by the gradual washing away of the upper chalk ; that the geological formations beneath the Straits remained in the original order of their deposit, and were identical with the formations of the two shores, and were, in fact, the continuation of those formations.

"Mr. Low proposed to dispense entirely with shafts in the sea, and to commence the work by sinking pits on each shore, driving thence, in the first place, two small parallel driftways or galleries from each country, connected at intervals by transverse driftways. By this means the air could be made to circulate as in ordinary coal-mines, and the ventilation be kept perfect at the face of the workings.

"Mr. Low laid his plans before the Emperor of the French in April 1867, and in accordance with the desire of his Majesty, a committee of French and English gentlemen was formed in furtherance of the project.

"For some years past Mr. Hawkshaw's attention had been directed to this subject, and ultimately he was led to test the question, and to ascertain by elaborate investigations whether a submarine tunnel to unite the railways of Great Britain with those of France and the Continent of Europe were practicable.

"Accordingly, at the beginning of the year 1866 a boring was commenced at St. Margaret's Bay, near the South Foreland ; and in March 1866 another boring was commenced on the French coast, at a point about three miles westward of Calais ; and simultaneously with these borings an examination was carried on of that portion of the bottom of the Channel lying between the chalk cliffs on each shore.

"The principal practical and useful results that the borings have determined are, that on the proposed line of the tunnel the depth of the chalk on the English coast is 470 feet below high water, consisting of 175 feet of upper or white chalk and 295 feet of lower or grey chalk ; and that on the French coast the depth of the chalk is 750 feet below high water, consisting of 270 feet of upper or white chalk and 480 feet of lower or grey chalk ; and that the position of the chalk on the bed of the Channel, ascertained from the examination, nearly corresponds with that which the geological inquiry elicited.

"In respect to the execution of the work itself, we consider it proper to drive preliminary driftways or headings under the Channel, the ventilation of which would be accomplished by some of the usual modes adopted in the best coal mines.

"As respects the work itself, the tunnel might be of the ordinary form, and sufficiently large for two lines of railway, and to admit of being worked by locomotive engines, and artificial ventilation could be applied; or, it might be deemed advisable, on subsequent consideration, to adopt two single lines of tunnel. The desirability of adopting other modes of traction may be left for future consideration."

This, then, is the great Tunnel scheme, which a committee of promoters and engineers submitted to his Majesty the Emperor of the French in June 1868 ; and we are informed "His Majesty was pleased to refer the matter to the favourable consideration of his Excellency the Minister of Public Works, who appointed a special commission to inquire into the subject in all its bearings." This special commission reported in March 1869 ; and a summary of this report on the main question is contained in the following three resolutions, viz.—

"I. The commission, after having considered the documents relative to the geology of the Straits, which agree in establishing the continuity, homogeneity, and regularity of level of the *grey chalk* between the two shores of the Channel,

"Are of opinion that driving a submarine tunnel in the lower part of this chalk is an undertaking which presents reasonable chances of success.

"Nevertheless, they would not hide from themselves the fact, that its execution is subject to contingencies which may render success impossible.

"II. These contingencies may be included under two heads : either in meeting with ground particularly treacherous—a circumstance which the known character of the grey chalk renders improbable ; or in an influx of water in a quantity too great to be mastered, and which might find its way in either by infiltration along the plane of the beds, or through cracks crossing the body of the chalk.

"Apart from these contingencies, the work of excavation in a soft rock like grey chalk appears to be relatively easy and rapid ; and the execution of a tunnel, under the conditions of the project, is but a matter of time and money.

"III. In the actual state of things, and the preparatory investigations being too incomplete to serve as a basis of calculation, the commission will not fix on any figure of expense or the probable time which the execution of the permanent works would require."

Having laid before our readers the Channel Tunnel Scheme in the words of the originators, we shall now proceed to analyse it, and for the purpose we also publish a map forming part of the engineers' report, and which we reduce to a scale of six miles to one inch.

The first important statement with which we meet in the engineers' report is that under section 2, viz., on the theory of the formation of the Straits of Dover. We admit that in all probability the Dover Channel was not produced "by a sudden disruption of the earth at that point," but we cannot endorse the hypothesis that it has been formed by gradually washing away the upper chalk.

In order that the chalk may be washed away more at that point than at others, it is necessary that the current should be stronger. To begin with the operation of washing away, we must have a current, a strong current, which could only flow in a valley or channel, previously formed either by depression of the surface or by the elevation of the land adjoining that surface. Whichever way we take it, the original channel of Dover must, it would seem probable, have been formed by a geological disturbance of the earth's crust.

The current within that geologically-formed channel may have further deepened it, although this is not probable, because at the bottom of a channel from 100 to 200 feet deep, the speed of a current can be but a small fraction of its superficial velocity, and this fraction is assumed to have abraded chalk rock.

Looking at the chart attached to the report of the engineers, we find a series of lines running from the English to the French coast, which are assumed to indicate the position of the strata of various rocks—of the same rocks which compose the hills on either side: so, for example, the district A between the dotted lines is assumed to be that of the upper or white chalk; B, the lower or grey chalk; C, to be the place of a series of strata, such as the upper green sand; the gault, the Folkestone, Sandgate, and Hythe beds; Atterfield clay, &c., &c.

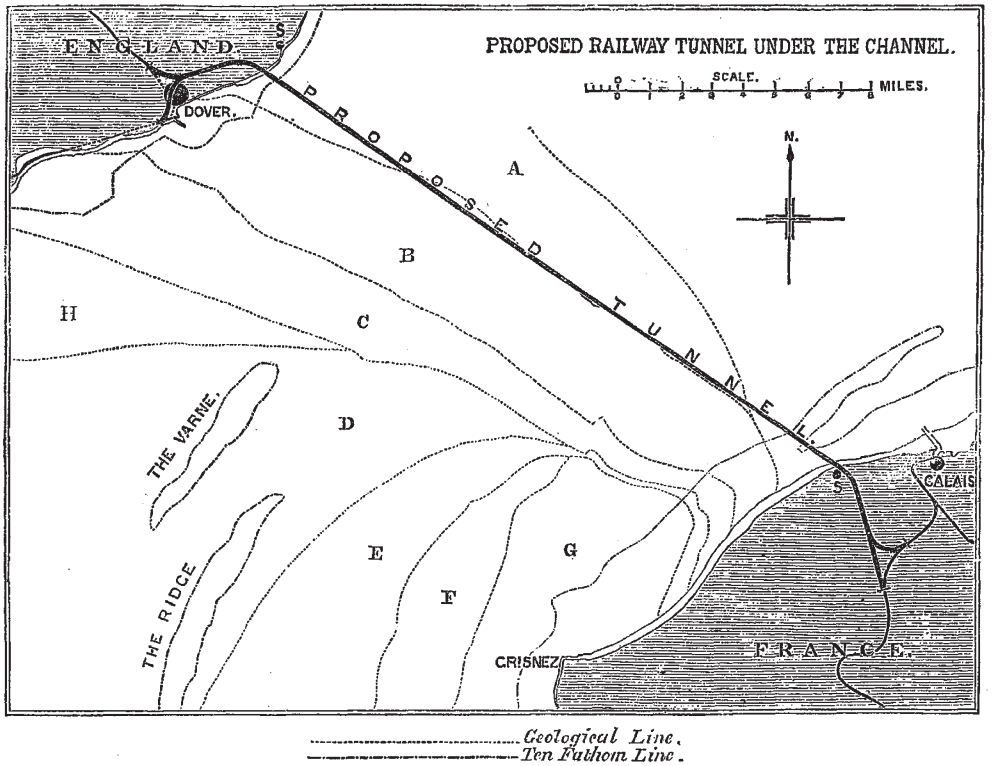
The only question that presents itself to our mind is, whether this chart be correct; whether the geological lines there indicated are the result of test and observation, or whether those lines are based on the theory of the engineers, that the strata of the hills on either side of the Channel pass "undisturbed" in plane surfaces across the Channel, assuming that the strata which formerly occupied the Channel were cut away or carried off; and whether the lines indicated on the map may not principally have been produced by constructing the intersections of those inclined surfaces with the present bottom of the Channel. We fear the geological lines of the diagram were mainly obtained on the above theory of the engineers, and will therefore in a great measure be imaginary.

It is probable that the strata which form the hills on either side will also form the bottom of the Channel, at a different elevation; but it would be rash to say how much the difference might be. It will probably vary across the Channel, the thickness of the strata remaining nearly the same; so it may be presumed that chalk will be found within the Dover Straits at certain depths below the bed of the Channel. If this be so, it would not be necessary to divert the tunnel as indicated on the plan. Nothing short of an actual test across the Channel on the line selected for a tunnel could, however, settle the question of stratification, and determine at what depth a special kind of rock, suitable for tunnelling, would be met with.

The operation of driving the tunnel would have to be carried on many hundred feet below the mean level of the Channel, and, apart from other difficulties attending the execution of such an immense tunnel, for which we have no precedent even on a small scale—the first question would be, whether it may be reasonably expected that tunnelling would be practicable under such circumstances without meeting with an insurmountable influx of water.

That we should meet with many fissures and cracks is a matter of course, for it would be difficult to select on a rocky surface a few square yards without indications of fissures. That water will find its way along cracks we know from experience, and as in this instance no water-tight strata intervene between the sea and the rocky material through which it is proposed to drive the tunnel, so, consequently, we must expect that the work of driving the driftways and the tunnel would be "wet." Although the work may be very wet, it will still remain a question of quantity, and not only one of quality; and, accordingly, we must ascertain whether the quantity of water that might find its way into the workings would be unmanageably large.

On this point a great deal of misconception may be found in "professional" papers. It is asserted, that the



A, upper or white chalk. B, lower or grey chalk. C, upper green sand, gault, Folkestone, Sandgate, and Hythe beds. D, region probably occupied by the Hastings sands. E, Neocomian sand. F, Portland stone and sand. G, Kimmeridge clay. H, Weald clay. SS, Borings.

pressure due to a column of 400 or 500 feet of water —which is equal to about 200lb. per square inch—would not only cause infiltration through fissures and cracks, but would in a short time enlarge them, abrade the very rock, and so day by day increase the flow into the driftways. As a general assertion, this evinces a confusion of the static with the dynamic laws of hydraulics.

If we stop the flow from a crack, and if the water cannot be diverted, the full hydrostatic pressure due to the whole column will be established at the very margin of the crack where it was artificially closed. But if we do not stop the flow from it and allow the discharge, the pressure at the margin within the tunnel will by no means be equal to the full hydrostatic column; for, in passing water along a fissure with a certain velocity, by far the largest part of that column will, under ordinary circumstances, be destroyed or consumed in overcoming the friction of the water over the large area of the fissure, and, as a rule, the effective pressure at the end of a fine crack within the tunnel would be only a small fraction of the whole column of water—probably not one per cent., so that no abrasion could take place, and the flow of the water, whatever it might be, would not increase day by day.

This being a very important question in reference to the proposed tunnel, let us take an example.—Assume a fissure 1 yard long and $\frac{1}{1000}$ part of an inch wide—about the thickness of tissue paper. Let this fissure continue in a vertical direction for a distance of 100 yards, to the bottom of the channel, and assume above that fissure 30 fathoms of water. What quantity of water will find its way through that fissure, and what will be the pressure at its margin within the Tunnel? We assume a clear opening throughout, and yet that fissure could only pass 4 gallons per hour into the tunnel, and the effective pressure at its margin would only be $\frac{1}{300}$ lb. per square inch. The effect of such a crack or opening would therefore be quite insignificant. Let all the circumstances remain the same, but assume the fissure 10 times as wide, viz., $\frac{1}{100}$ part of an inch in the clear: it would then pass into the tunnel 136 gallons per hour, with a marginal pressure of $\frac{1}{25}$ part of a pound per square inch; let it be $\frac{1}{10}$ inch wide in the clear, and it will pass 4,392 gallons per hour, with a marginal pressure of $\frac{2}{5}$ of a pound —and if we assume the fissure 1 inch wide in the clear, it will pass 139,905 gallons per hour, with a marginal pressure of $4\frac{1}{5}$ pounds per square inch.

It then becomes chiefly a question of the *nature* of the fissures with which we may have to deal, and while a fine crack one yard long would only admit an insignificant volume of water into the tunnel, a similar crack one inch wide would be a serious matter, very few of which would drown the drift. But even in the latter case no abrasion of the rock could take place, for a pressure of four pounds per square inch has no effect upon chalk.

But though the fissures within the driftways might be very fine, each passing or oozing out a comparatively small quantity of water, easily to be dealt with within a moderate length of the driftways, their number within a distance of twenty-two miles would be legion, and, we believe, would overpower all appliances. These fissures should not be permitted jointly to send water into the driftways; they should be closed as soon as practicable. How is that to be done? By keeping a water-tight main tunnel close upon the face of the driftway. As soon, however, as the cracks would be closed by the main water-tight tunnel, the full hydrostatic pressure of many hundred feet would be resting on it. The main tunnel would collapse unless it could bear a pressure of about fifteen tons per square foot on its superficial area. This circumstance determines the form and the material of the tunnel. It could not be an ordinary tunnel in any sense. Its form must be circular, and its principal material iron. No brickwork could stand that pressure at whatever thickness, within practicable limits, it might be assumed, because by increasing its thickness its superficial area would also increase. Nor could any brickwork be water-tight against such pressures, and, unless it be so, water will find its way into the tunnel very nearly as fast through the lining as without it.

We cannot, therefore, help differing from the resolution of the engineers that—

"In respect of the execution of the work itself, we consider it proper to drive preliminary driftways or headings under the channel, the ventilation of which would be accomplished by some of the usual modes adopted in the best coal-mines."

We consider this resolution fraught with danger. The driftways could never be accomplished without the aid of the main tunnel; nor would the proposed ventilation through the driftways be adequate. Why should the ventilation be similar to that adopted in our best coal-mines? Is the proposed tunnel to be driven through the coal measures? No, it is to be through the grey chalk, and a ventilation which may be adequate in coal measures would certainly fail in the chalk, from which a large amount of an irrespirable gas would exude. This is another reason why the main tunnel should be kept closely behind the face of the driftway, viz., to exclude the surface of the chalk. And why have two driftways to begin with? Moreover, there is no difficulty in sending into the tunnel through ordinary piping, to the face of the heading, ten times as much pure air by mechanical power as the best mode of ventilating coal-mines could possibly ensure.

The tunnel could only be worked by pneumatic pressure: this is obvious from recent investigations of eminent engineers; it could not be for a double line, because that system is not applicable to it; and the old atmospheric plan failed above ground.

We are of opinion that it is not an unreasonable proposition, to drive a tunnel under the Channel, but that in some measure it must be a venture. If we are to undertake such a venture to gain a magnificent prize, of immense value to the English and French nations, we must be prepared to meet all ordinary eventualities, and we must not fail in the attempt by want of foresight, energy, and by dint of proper means. It will cost a great deal, but not too much, with proper management and a little good fortune. The first step towards accomplishing the object would be to obtain a geological section across the Channel, on one, or perhaps on several lines; not a section constructed upon certain theories and assumptions, but one obtained from actual test of the materials which compose the bed of the Channel, following Mr. Hawkshaw's steps on shore also across the Channel, for which purpose the assistance of the Governments of England and France may be confidently expected.